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THE WORLD BANK ECONOMIC REVIEW

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A Note from the Vice President, Economics and Research, The World Bank

For the past several decades, the World Bank has undertaken a wide-ranging program of research on the problems of developing countries. One objective of this research is to provide an input into the operations of the Bank, both as a lender and as a source of policy analysis and advice. An equally important objective is to draw on the Bank's experience to contribute more broadly to the empirical and analytic foundations for national and international economic policy discussion and decisions. The results of Bank research have hitherto been reported mainly in specialized books and monographs published by the Bank or in articles published in outside academic journals. With this first issue of *The World Bank Economic Review,* the Bank is opening an additional avenue for the dissemination of Bank-supported research to a more extensive readership of economists and social scientists in its member countries.

The *Review* will be a professional journal adhering to the highest standards. It will publish articles that seek, on the basis of technically sound analytical and empirical methods, to illuminate policy choices and processes. Articles will illustrate how professional research can shed light on policy choices but will not become essays in advocacy. In the selection of manuscripts for publication, a predominant concern will be the applicability and relevance of articles for economists in operational or policy positions in developing countries. Care will also be taken to see that authors, in any use of sophisticated mathematical or econometric techniques, make clear the underlying logic of the analysis for readers who have neither the time nor inclination to pursue details of theoretical derivations or methodology.

The emphasis given to application and policy relevance in the selection of articles does not mean, however, that the *Review* should be looked to for authoritative statements of Bank practice or policy positions. The views and interpretations in the articles published will be those of the authors.

The procedures established for the review of manuscripts submitted for publication have been designed to protect the professional objectivity of the editorial process. Before being accepted, every article must be refereed by at least two recognized authorities outside the Bank and approved by two of the three external members of the Editorial Board. In addition, in order to extend the range of contributions from outside sources, particularly from researchers in developing countries, the Editorial Board may invite the submission of an article on a specified topic. Such invited articles will go through the regular refereeing process before being accepted for publication.

The success of the *Review* in achieving its objectives as a professional journal will, we believe, be best measured not simply by the wider distribution of research results but also, and perhaps most importantly, by its contributions to a more fruitful and factually well-founded dialogue among members of the development community in the continuing search for effective policies to accelerate economic growth and ameliorate poverty.

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Special Exchange Rates for Capital Account Transactions

Rudiger Dornbusch

The governments of developing countries are constrained in the effective implementation of domestic policy by the interlinkages of national and international financial markets. Domestic macroeconomic conditions are influenced by the interaction of national and world interest rates and prices, and through the impact of real exchange rates on employment. The domestic responses to changes in these factors are often strong and rapid. In an attempt to sever these ties, governments have adopted dual exchange rate systems in which capital account transactions are conducted at a depreciated exchange rate while an otherwise overvalued rate is maintained for commercial trade. This article suggests that dual rates can indeed be used successfully as a strictly transitory policy to offset sudden shocks in capital markets. The article develops models which indicate why these dual systems are able to prevent inflationary or recessionary pressures caused by a misaligned exchange rate in the short term. While free capital account rates can cut the flow of capital flight, however, a dual rate system cannot prevent a possibly equivalent loss of foreign reserves that will ultimately result because of the impact of the overvaluation of the commercial rate on the trade balance. In the longer term, a dual rate system with a misaligned commercial rate exacerbates the government's deficit; ultimately, real wages must be cut and real interest rates raised to generate sufficient foreign exchange to finance the external debt. Thus a dual rate works well if the commercial rate is maintained close to the equilibrium level.

The starting point for any discussion of special asset transaction exchange rates is the high mobility of capital. Assets markets are linked internationally in terms of risk and expectations-adjusted returns, and that linkage is potentially tight and rapid. That implies severe restrictions on the scope of government strategy. Policies must be such as to give asset holders the world rate of return, or they will seek to purchase assets abroad with one of three results: under a fixed rate, the stock of reserves will be depleted; under a flexible rate, the exchange rate will be depressed to a level where home returns are again in line with those abroad; or because of the threat of these responses, policies will be aligned with the requirements of asset markets rather than with governmental objectives and priorities.

The author is at the Massachusetts Institute of Technology. This article is part of a research project on exotic exchange rate arrangements conducted for the World Bank.

This article examines the experience of various Latin American countries with the use of dual and multiple exchange rate systems to delink these markets, and it develops models to explain the macroeconomic outcomes of such systems. These models analyze the impact of dual rates on the balance of trade, foreign reserves and asset holdings, inflation, the government budget, and the supply of and demand for traded versus nontraded goods. The article also looks at overvaluation and the effects of expected depreciation on interest rates and investment. While the relative benefits of these systems for asset holders and wage earners are apparent at many points in the analysis, this is not an essay in applied welfare economics, and empirical investigation would be required to determine the distributional effects of specific uses of the various types and levels of controls.

Section I briefly describes the ties between domestic and world markets, the rationale for initiation of exchange controls, and the forms such controls may take. Section II looks briefly at the extent of exchange rate differentials which occurred in Mexico and Venezuela in the early 1980s and develops various models of dual market systems. The implications of multiple exchange rates and the development of illegal markets for foreign exchange transactions are examined in section III.

I. Linkages between Markets: Rationale and Methods for Severing the Ties

The problem of asset market integration can be understood by looking at three linkages between an economy and the rest of the world. These are the linkages between interest rates, the interaction of prices, and the impact of real exchange rates on employment. These relationships are shown as:

$$i = i^* + \dot{e}/e + R(\ ) \quad (1)$$

$$P = f(eP^*) \quad (2)$$

$$N = N(eP^*/P) \quad (3)$$

where i and i^* are home and foreign interest rates, $\dot{e}/e$ is the expected rate of depreciation of the exchange rate expressed in domestic currency, and R is the risk premium. P and P^* are home and foreign prices, and N is employment.

Equation 1 states that home interest rates are equal to those abroad, adjusted for anticipated depreciation and the risk premium that emerges from political and exchange rate risk. This equation can be viewed as the constraint on financial policies: in integrated asset markets, the home interest rate must be set high enough or savings will be transferred to foreign assets and the currency will come under attack. Equation 2 points out that domestic prices will be affected by the exchange rate: a rapid depreciation of the exchange rate would cause an increase in home inflation. Equation 3 emphasizes that a change in the (real) exchange rate will influence employment. In the long run, real depreciation is likely to raise employment. But in the short run, the adjustment process may make the effects run the other way.

These three linkages then mean that asset markets are internationally integrated and that this integration places restraints on policy, or that lack of attention to these constraints has negative implications for inflation and for employment. Moreover, because the reactions are strong and rapid, the issues are of foremost importance. They cannot be disregarded, because reserves are often in short supply and depreciation of the exchange rate can be politically difficult; however, running the world to the tune of assets markets may be undesirable. Hence the interest in institutional arrangements that delink assets markets and free policies to be directed to a government's true priorities.

There are any number of examples of countries where exchange rate movements or capital flows became an inconvenience or more for policymakers. For example, in the United States in 1980–85, the dollar appreciation, for safe haven reasons or because of the U.S. monetary-fiscal mix, led to overvaluation and an unprecedented shock to manufacturing. Very soon there was talk of renewing the import surcharge that had been adopted to cope with the overvaluation of the early 1970s, and even a renewal of interest equalization taxes came into discussion.

But, of course, the shock can also run the other way when capital flight leads to a fall of the exchange rate and, as a result, an inflation burst. The best example would be the onset of the German hyperinflation in the 1920s. The "balance of payments school" at that time saw the confidence-induced collapse of the exchange rate as the source of domestic inflation, which in turn led to budget deficits; these deficits reinforced the escalating rate of price increases. For a while, the government managed to stabilize the exchange rate, and prices remained stable. Then a loss in confidence (related to the reparations problem) ensued, and in a few weeks the exchange rate increased sevenfold. The exchange rate depreciation raised import prices, wages, and the budget deficit, which opened all mechanisms for uncontrolled price rises and hyperinflation.

The importance of the capital market integration issue has also been highlighted in the aftermath of the debt problem. Much of the accumulation of Latin American external debt reflects the financing of capital flight (see World Bank 1985). This is strikingly the case for Argentina, Mexico, and Venezuela, where the amounts are extraordinarily large. Once again, the issue arises whether alternative capital market arrangements would have been an effective means to stop capital flight and tax evasion.

There are several ways in which asset markets can be delinked. The first is to decide on the scope for capital controls. One possibility is to maintain the international integration of capital markets (given by equation 1) by keeping interest rates at levels equivalent to international rates, but to delink domestic assets markets, at least partially, from the home economy. The means would be a special, separate exchange rate for financial transactions. Free capital mobility at a fixed or flexible special rate, separate from commercial transactions, would be a way of separating equation 1 from equations 2 and 3. Having more than one exchange rate might make it easier to live with the effects of capital market integration on the exchange rate and the economy.

An alternative is to opt against international integration of asset markets by instituting formal capital control. This may take the form of a prohibition of foreign asset holding by residents. The difficulty is to make that prohibition stick: black markets will emerge, or capital flows will take place implicitly through underinvoicing of exports or overinvoicing of imports in current account transactions. In response, the government may be tempted to quasi-legalize (this is a peculiarly Latin notion) parallel markets for foreign exchange or create domestic equivalents in the form of a dollar-denominated government-issued security or dollar deposits. The effectiveness of capital controls determines here how successfully a government can split markets and isolate the home economy.

A two-way classification helps distinguish the possibilities. First, the rate for asset market transactions may be managed (fixed as a special case) or freely determined. Second, access to the exchange market for capital account transactions may be restricted or completely open. Institutional arrangements fall somewhere within these possible ranges. For example, Mexico in 1983–84 had a heavily managed asset transaction rate with unrestricted access to that market, while Venezuela in the same period also had unrestricted access but considerably less intervention in the rate. Brazil completely restricts access to the official market where the rate is managed. Even Brazil's black market has a somewhat managed rate and an implicit restriction of access by corporations. The remainder of this article examines some of these systems to see what particular problems they solve and what problems they create.

II. Dual Exchange Rates

This section discusses systems in which a significant part of commercial transactions is conducted at a uniform fixed rate, while capital account and selected commercial transactions are conducted at another free or managed rate. The fact that the foreign exchange market is opened to capital account transactions establishes an immediate linkage between financial markets (and expectations therein) and the exchange rate or the level of intervention. By separating financial transactions from commercial transactions, the authorities attempt to maintain the advantages of a managed, stable exchange rate for commercial transactions that is not upset by volatility in international capital flows.

Dual rates are typically established by countries that feel they cannot or do not wish to prohibit capital account transactions altogether. In circumstances where the macroeconomy is highly unstable, capital flows will be very volatile and potentially massive. If foreign exchange reserves are limited, a country has essentially two choices. It can set a uniform rate that is so undervalued that there can only be an expectation of appreciation and hence no threat of capital flight. Or alternatively, the rates can be split so that the capital account rate can depreciate to whatever level required to make the public willing to hold the existing stock of domestic assets.

Each alternative has serious drawbacks: the overdepreciation of a uniform rate represents a shock to real wages and inflation. It poses the question why real wages should be cut merely to stabilize the expectations of wealth holders. But the free rate on capital account also raises questions. Will it distort allocation, as some commercial transactions slip into the free market? Will it be stable in the absence of intervention? Will there ultimately be exchange rate unification?

Figure 1 makes some of these issues more concrete by showing the three different Mexican exchange rates in effect from 1982 to 1984. Figure 2 shows the premium of the New York rate over the controlled rate in Mexico. The huge differential up to January 1983 corresponds to the early experimentation with exchange control of various kinds. Since then, the levels and differentials have been established in a manner such that the Central Bank increasingly has come into a position of managing the two rates, and subsequently the differential has been moderate.

Venezuela's case, by contrast, did not show a settling down (Figure 3). Following a long tradition of fixed exchange rates, in March 1983 the government abandoned pegging the rate except for essential imports. Specifically, capital movements were to be conducted in a free foreign exchange market. The premium of the capital over the fixed rate reached a level, using monthly averages, of more than 260 percent (Figure 4). The volatility of the free rates and the extent of discrepancies between free and controlled rates posed important issues for resource allocation and macroeconomic policy.

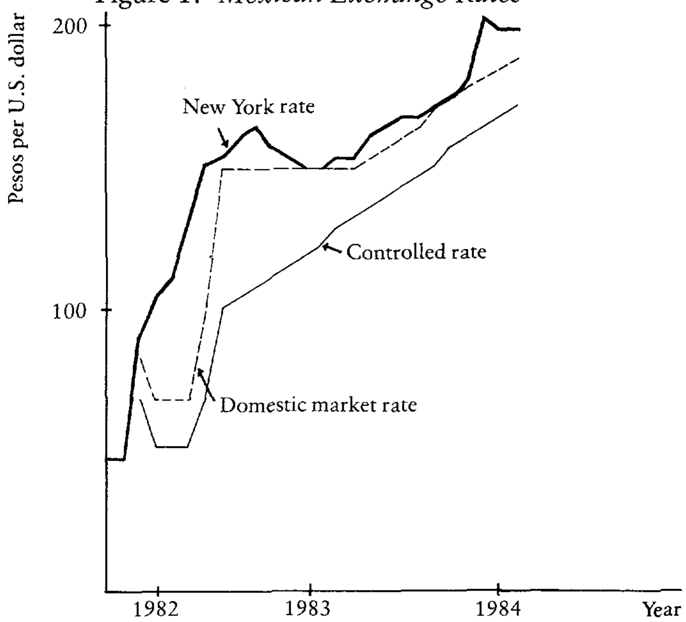
A Model of the Dual Market

This section presents a sequence of models of dual markets that build up progressively the key linkages between asset markets and the macroeconomy. It starts with a model that assumes full employment, a constant commercial exchange rate, purchasing power parity, rational expectations, and only two assets: domestic money and foreign nominal interest-earning assets.[1]

In the asset market, because domestic currency earns no return, the desired ratio of money to foreign assets, M/eK, depends on the rate of return on foreign assets. This rate of return is the sum of the asset's interest rate plus the additional domestic currency value of the foreign exchange earned as the domestic currency depreciates. This expected rate of depreciation is written $\dot{e}/e$, where e represents the unregulated capital account exchange rate. K denotes the stock of foreign

1. For more detailed discussion and derivations, see the appendix.

Figure 1. *Mexican Exchange Rates*

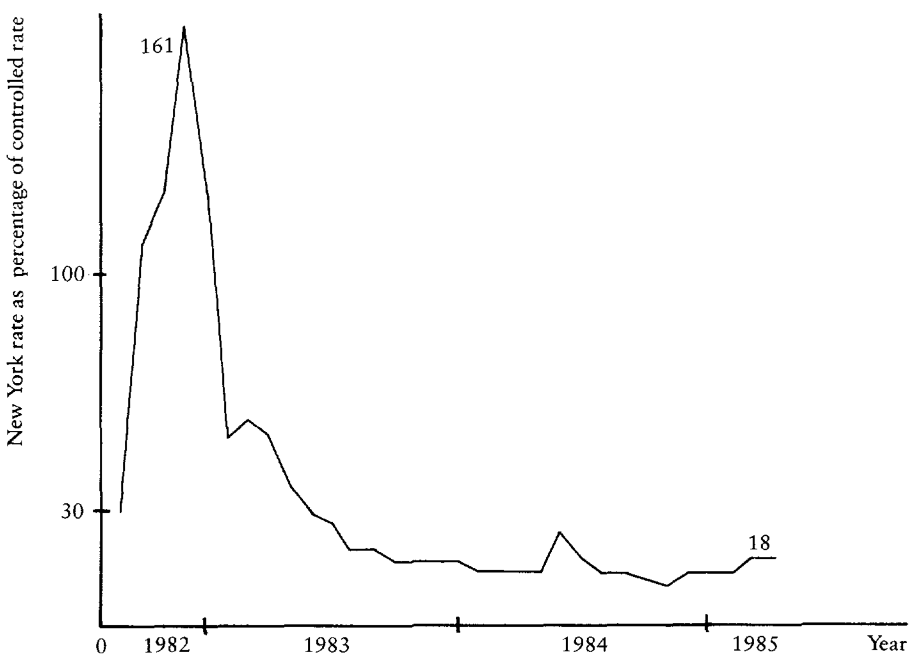


Note: The New York rate is the cable transfer quote rate.

The domestic market rate applies to capital accounts, tourism, and other transactions not covered by the controlled rate.

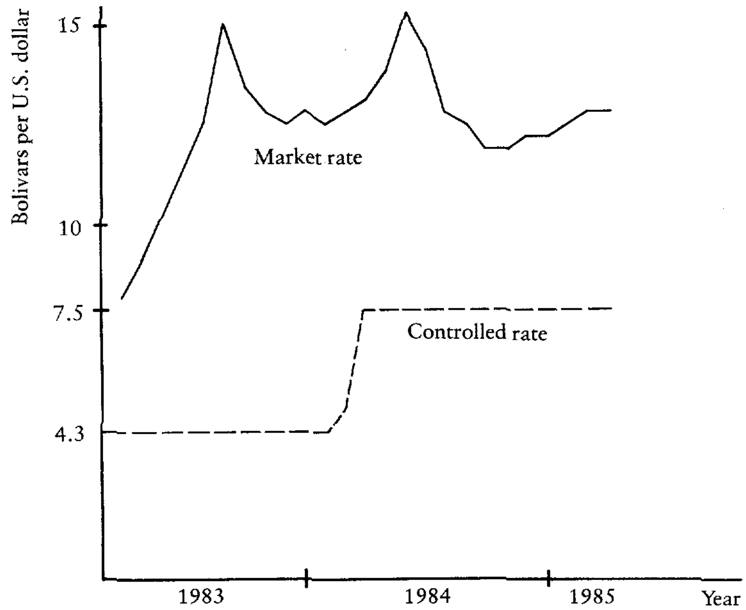
The controlled rate applies to essential imports, most exports, and debt service.

Figure 2. *The Mexican Free Market Premium on Exchange Rates*



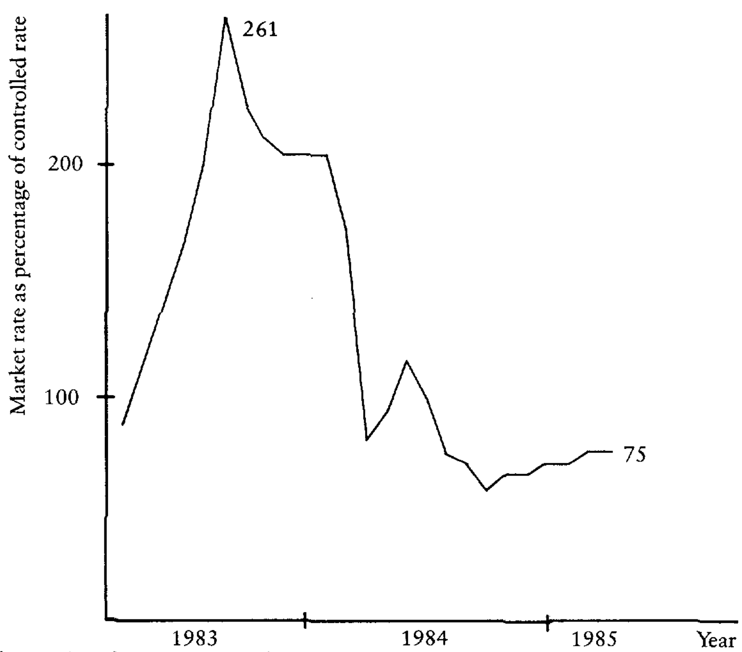
Sources for figures 1 and 2: Banco de Mexico and U.S. Federal Reserve Bank, *Federal Reserve Bulletin*.

Figure 3. *Exchange Rates in Venezuela*



Note: *The market rate applies to capital transactions and all trade except essential imports.* The controlled rate applies to essential imports only.

Figure 4. *The Venezuelan Free Market Premium on Exchange Rates*



Sources for figures 3 and 4: International Monetary Fund, *International Financial Statistics,* and U.S. Federal Reserve Bank, *Federal Reserve Bulletin.*

assets and eK their value in home currency. The desired ratio of money to foreign assets is determined as:

$$(4) \qquad M/eK = L(i^* + \dot{e}/e), \qquad L' < 0$$

or, inverting the equation,

$$(4a) \qquad \dot{e}/e = h(M/eK) - i^*, \qquad h(\ ) = L^{-1}, \qquad h' < 0$$

We focus here on domestic events rather than on the effects on the home economy of foreign interest earnings. But the simplification is one of convenience; it does not fundamentally alter the analysis.[2] Since we are not focusing on foreign asset accumulation, we assume the $i^* = 0$. Hence the value of K remains constant over time except for government intervention, and $\dot{e}/e$ simply equals $h(M/eK)$.

In this model, private savings is composed of both a stock adjustment and a flow component: $S = v\,(w - m - k) + \lambda\, m + (\lambda - \dot{e}/e)k$. The first component is some proportion, v, of the excess of targeted real asset holdings, w, over actual real asset holdings, $(M + eK)/x$ where x denotes the exchange rate for commercial transactions. The second portion is an adjustment made for anticipated capital losses (or gains) on real balances and foreign assets, $[\lambda\, m + (\lambda - \dot{e}/e)\, k]$ with λ being the rate of depreciation of the commercial rate, $\dot{x}/x$. Capital losses are effectively inflation taxes, which reduce the value of nominal money stocks and thus increase the nominal savings needed to meet the real savings target. The impact of an increase in inflation over capital account depreciation $(\lambda > \dot{e}/e)$ will similarly raise nominal savings, while a net depreciation will increase the domestic currency value of foreign assets and thereby reduce the desired rate of savings. Thus, in a steady state, the stock of actual savings may be on target, but individuals will continue to save to compensate for the reduction in real value of savings stocks caused by inflation.

By assuming that taxes and investment are zero, the traditional national income accounts can be revised so that the trade balance, B, will equal private savings, S, less real government spending, G, which is financed by domestic credit creation. If P denotes domestic prices and P^* foreign prices, given purchasing power parity (PPP), $P = x \cdot P^*$. Setting $P^* = 1$ gives $P = x$, which can be applied here without loss of generality. These assumptions, and the composition of private savings described above, are the basis of the following expression for the real trade balance:

$$(5) \qquad B = S - G = v(w - m - k) + \lambda m + (\lambda - \dot{e}/e)k - G$$

where

$$m \equiv M/x, \text{ and } k \equiv eK/x$$

2. Alternative models have been presented (de Macedo 1983, Lizondo 1984, Flood 1978) in which external asset accumulation plays a significant part.

The rate of increase in real domestic currency balances, $\dot{M}/x$, is determined by real government spending, G plus the real trade surplus, B. Thus the change in the real money stock can then be written as:

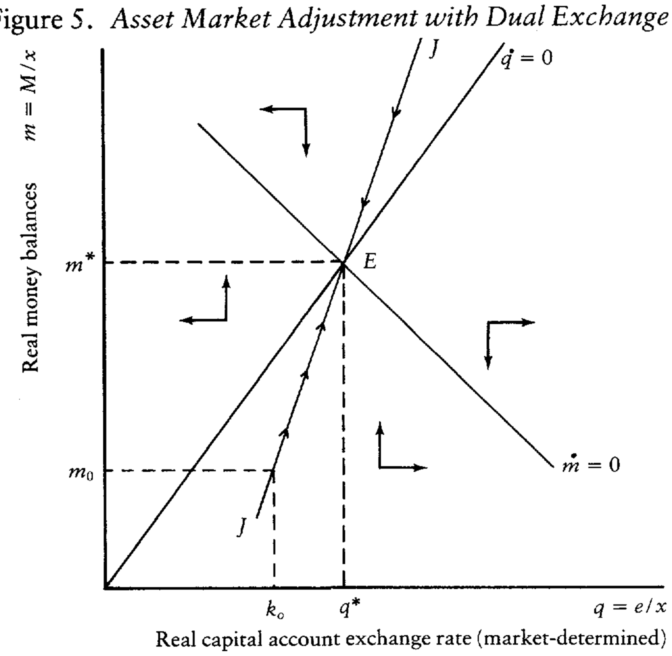
$$\dot{m} = v(w - m - k) + [\lambda - h(\mathrm{m}/k)]k \tag{6}$$

The other dynamic equation of the model describes the evolution of the real capital account rate, $q \equiv e/x$ (given PPP, deflated here by x). Equivalently, the premium of the capital account rate over the commercial rate is written as:

$$\dot{q}/q = \dot{e}/e - \dot{x}/x = h(m/k) - \lambda \tag{7}$$

Figure 5 shows the schedules along which, respectively, real balances are constant ($\dot{m}/0$) and the real capital account rate is constant. The schedule for a constant capital account rate ($q = 0$) is positive because the premium of the capital to commercial account rates must increase to induce people to increase their real money balances, m. An increase in the premium *now* will preclude expectations of further near-future devaluations. Thus investors will not expect an increase in the value of foreign assets in the near future and will be content to hold the larger money balances. The $\dot{m} = 0$ schedule is drawn with a negative slope, although this need not be the case. The arrows indicate the dynamics and, as is conventional in perfect foresight models of this structure, there is a unique

Figure 5. *Asset Market Adjustment with Dual Exchange Rates*



Note:
$k_o = eK_o/x$ = home currency value of foreign assets for a given m_o
JJ = stable asset market adjustment path for a given rate of depreciation of the commercial account exchange rate, λ

stable trajectory, *JJ*. From any initial stock of real balances, say m_0, the economy converges to the long-run equilibrium at *E* along the path *JJ*.[3]

The model is closed by specification of the rate of depreciation of the commercial rate. It is assumed that the commercial exchange rate depreciates at a rate, λ, that is sufficient, in the steady state, to generate the inflation tax revenue with which to finance the given level of real government spending.

Given any initial real money stock such as m_0, there is a unique equilibrium on *JJ* and hence a specific value of foreign assets, q_0K_0. With a given value K_0, there is a unique capital account rate at which the asset markets clear. Over time, the system evolves to the steady state equilibrium at *E*. If real money balances initially are low as at m_0 the path is characterized by rising real money balances and a rising real value of foreign assets or an increasing premium of the capital account rate relative to the commercial rate, e/x. Thus if assets are initially low, savings will be high and there will be trade surpluses that cause the real money stock to rise as the central bank intervenes to sustain the commercial rate. At the same time, the real value of foreign assets is rising because of capital gains.

In the steady state, trade is balanced and the real money stock is constant ($\dot{m} = 0$). The premium of the capital account rate is constant ($\dot{q} = 0$), as the rate depreciates at the same pace as the commercial rate. The seignorage supported by depreciation finances real government spending. The equilibrium dynamics in figure 5 are shown for a given rate of depreciation of the commercial rate, λ. It is interesting now to ask how an increase in the rate of depreciation will affect the premium.

It is readily shown that with money demand inelastic with respect to the rate of inflation, an increase in government spending requires an increase in the rate of depreciation to yield the required increase in the inflation tax revenue. Increased rates of depreciation of the commercial exchange rate will immediately bring about a depreciation of the level of the capital account rate or an increase in the premium. Even in the steady state, the premium will increase.

In the steady state, the capital and commercial rates depreciate at the same rate. An increase in the rate of depreciation of the capital account rate shifts asset holders from money to foreign assets. Given the fixed supply of foreign assets, *K*, only an increase in the premium can bring about the rebalancing of portfolios. The increase in the premium caused by an increased rate of crawl of the commercial rate was demonstrated by Lizondo (1984).

Expectations

Having sketched the effect of a *current* increase in the rate of government spending, the impact of a shift in expectations is now examined. Starting in the steady state, the public anticipates that the government will increase real spending, deficit finance, and depreciation at some known future date. What is the

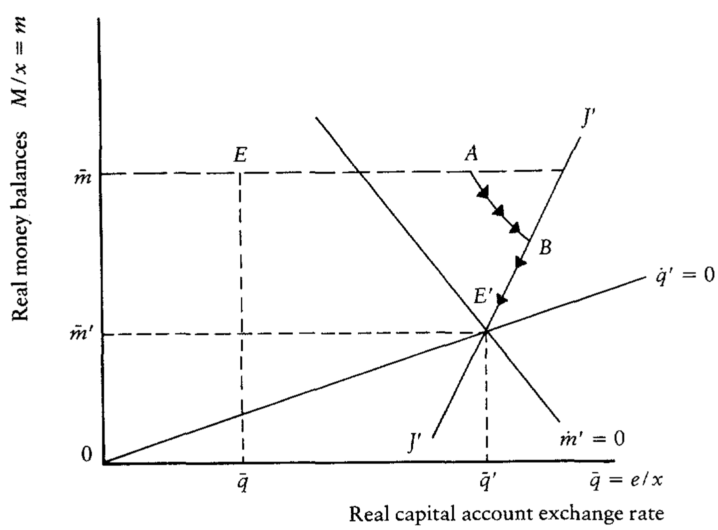
3. For a comprehensive explanation of the dynamics of phase diagrams, see Sheffrin (1983).

path of adjustment to this disturbance? This is an interesting question if one wants to explain the large fluctuations in the data for the dual market premium.

Figure 6 shows the initial equilibrium at point E. As shown in the appendix, an increased steady state rate of depreciation shifts the schedules. The $\dot{q} = 0$ rotates clockwise, and the $\dot{m} = 0$ schedule shifts out and to the right. Only a larger real premium will stabilize relative depreciation rates ($\dot{q} = 0$) for any given value of the money stock.

Now consider the adjustment process. At the moment the expectation of higher future government spending develops, there is an immediate portfolio shift from money to foreign assets, which leads to a jump in the premium from point E to a point like A. The extent of this instantaneous depreciation depends on (among other things) how proximate in time the shift in monetary policy is. If it were almost immediate, the jump would be virtually all the distance to $J'J'$. At point A, despite expectations of a new rate, the dynamics are still governed by the initial monetary policy and thus, with the high level of the premium, the value of foreign assets is high relative to real balances. This can only be an equilibrium if the rate of depreciation of the capital account rate has risen and hence is now higher than that of the commercial rate. Accordingly, the system moves in the direction of point B with the capital rate increasing and real balances declining. In the perfect foresight model, the economy arrives at B

Figure 6. *Adjustment to an Anticipated Increase in Government Spending*

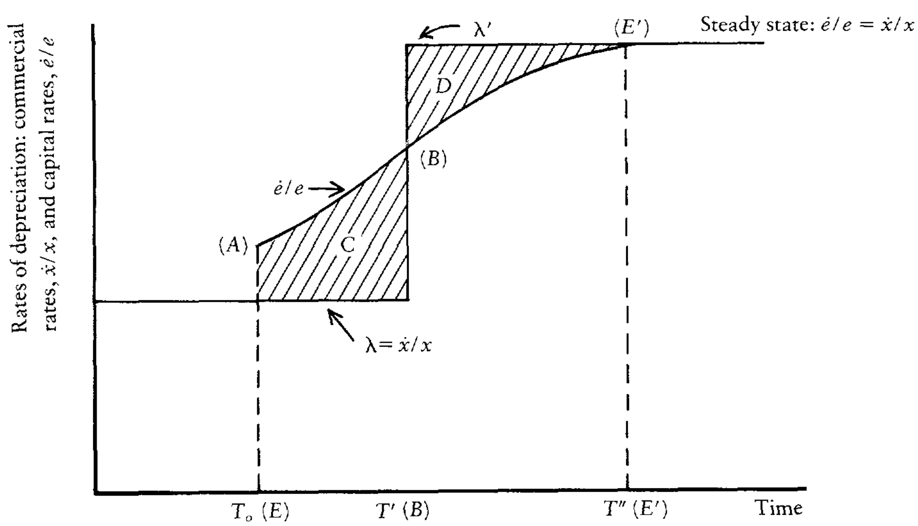


Note:
E = initial equilibrium
A = instantaneous depreciation of capital account rate in response to anticipated commercial rate devaluation
B = value of m and q when new commercial rate is implemented
E' = new equilibrium with depreciated commercial rate
$J'J'$ = adjustment path under new commercial rate

precisely at the time when the more rapid rate of depreciation of the commercial rate is implemented officially. From there on, the movement is along $J'J'$, with some decline in the premium. The new steady state is at point E' with an increased steady state premium $\bar{q}'$.

Note that the rate of depreciation of the capital account rate can be determined from the conditions of monetary equilibrium as shown in equation 4a: $[\dot{e}/e = h(M/ek),\ h' < 0]$. With a declining ratio of real balances to external assets along the path ABE', the rate of depreciation of the capital account rate must be rising throughout, although the increase is less than that of the commercial rate after the new rate is implemented at point B. Figure 7 shows the path of the rate of depreciation of the capital account rate over time. The times T_0 and T' correspond to the initial shift in expectations and the implementation of the new policy (point B). Up to time T_0, we have equal rates of depreciation: $\dot{e}/e = \lambda$. Then, at the time expectations shift, there is a jump in the premium and in the rate of depreciation of the capital account rate, $\dot{e}/e$. Since the rate of depreciation of the commercial rate is still unchanged, the premium is further appreciating until time T'. Now the commercial rate depreciates at the higher rate λ' in excess of the capital account rate, which implies some real appreciation. Over time, the two rates converge to depreciate at the same pace. The increased level of the premium up to the time of the commercial account devaluation, shown

Figure 7. *Expectation and Implementation of Commercial Account Rate Depreciation: An Increased Rate of Crawl*



Note: Letters in parentheses refer to points in figure 6.

$C > D$: increased premium in T_o to T' is greater than the excess of the commercial over the capital rates in T' to T''

T_o = initial expectations of depreciation of commercial rate, λ, at time T'

T' = point of actual government devaluation of commercial rate by area *C* in figure 7, is larger than the amount by which the commercial account rate depreciation exceeds that of the capital account rate after the devaluation, shown here in area *D*.

It is interesting to comment also on the trade balance in the adjustment process. As long as monetary policy is unchanged, following the shift in expectations, there is a trade deficit. The deficit arises because the increase in the premium raises wealth relative to target and the real capital gains lead to dissaving. Furthermore, with declining real money balances, seignorage starts falling short of the initial level of spending, and the trade deficit thus further deteriorates. The expectation of a shift in policy will therefore lead to trade deficits and potential difficulties in sustaining the path of depreciation.

Increased real government spending and deficits financed by money creation have been considered here. The increase in spending can be viewed as either spending on goods and services or as transfers abroad by the government, such as government debt service. In this broader interpretation, the exercise is of interest because it suggests that any disturbance that leads to an increased deficit will provoke an increase in the premium. Moreover, since real government spending in excess of real tax collection is being examined, one can also think of the exercise as a loss of real government revenues caused by reduced taxes or a loss of external resources. From this perspective, for an oil-exporting nation the expectation of a decline in real oil prices, for example, would increase the state enterprise and government budget deficits, imply deficit finance, and hence force a depreciation of the capital account rate. This interpretation is suggestive of the case of Mexico in 1985.

Consider now the effect of intervention. Assume the central bank sells foreign assets or foreign exchange in exchange for domestic money. The impact of such an intervention can be decomposed into two separate effects. The private sector now holds increased foreign assets at each level of the premium. With unchanged real balances, the premium would immediately decline to move the economy back to portfolio balance at point *E* in figure 5 above. But real money balances in private hands have declined as part of the open market operation, just as they would have in the case of a devaluation.

The decline in real balances takes the economy to the southwest of point *E*, on *JJ*, in figure 5. Accordingly, the premium declines proportionately more than the increase in foreign assets. Intervention in the capital account market thus is effective in depressing the premium. Interestingly, it also gives rise to a trade surplus via the wealth effects of the decline in the premium.

Extensions of the Model

The basic model has served to show the linkage between financial policies and the premium in the dual market. But the analysis needs extension if some macroeconomic complications coming from dual markets are to be seen. So far, the dual rate exerts effects only on the value of wealth and hence on income and spending. But in fact the more important channels operate presumably via relative prices and domestic interest rates. These, too, are linked to the free rate, and the important point to recognize is that financial disturbances have macroeconomic effects via the free exchange rate. Furthermore, these effects often occur as a result of expectations.

We now consider the case where some goods—nonessential imports and nontraditional exports—are traded along with capital account transactions in the free market. Essential imports, say food and materials, and traditional exports are traded at a (generally overvalued) fixed rate. Since part of the goods now are traded at the free rate, the aggregate price level is influenced by both the commercial and the free rates. Moreover, the premium of the free rate now sets the relative price of those goods entering via the free market. Instability of asset demands, policies, and expectations now introduces instability in the price level and in relative prices.

Moreover, if the dual rate regime is chosen to defend the foreign exchange reserves, this result may not in fact be achieved. Financial disturbances that lead to an increase in the premium draw production resources into the premium market while inducing consumers to substitute toward the controlled market. A rise in the premium associated with a "flight from domestic money" will still lead to reserve depletion, except that it now takes place via the enlarged trade deficit at the regulated rate rather than via actual capital flows.

It is important to recognize that now the free market no longer involves finding the price at which an existing stock of foreign assets, K, is held. The market now can generate an accumulation or decumulation of foreign assets via current flows. Specifically, we look at the possibility of trade being diverted from the official market to the free market. The central bank faces larger trade deficits and loses reserves, while in the free market, a trade surplus leads to accumulation of foreign assets. One can think of the implications of shifting transactions to the free market as legalizing the capital flight involved in the underinvoicing of exports or in the import smuggling financed by underinvoiced exports.

To demonstrate these results, most of the previous model's structure is maintained. The specification of asset markets remains unchanged. But now the markets for the two classes of goods need to be separated, while the assumption of given world prices and PPP at the relevant exchange rate for each good is maintained. Let the given foreign prices of all goods be unity, so that e and x denote the prices of goods that trade in the home country at the official and free rate, respectively. The aggregate price level, P, is now an expenditure-weighted function of these two prices.[4]

$$P = P(e,x) \tag{8}$$

In the previous equations, P now replaces x as the deflator for assets.

4. The premium and the relative price of goods trading in the free market continue to be denoted by q, where $q = e/x$.

To simplify matters, depreciation of the regulated rate is dispensed with, so that $\lambda = 0$. Because the free market now involves not only stocks but also flows, the trade balances for the official and the free market need to be specified separately. Let B and V now denote trade balances at international prices of the regulated and free markets, respectively.

$$B = B(\alpha, q, a, \dot{e}/e, G), \qquad V = V(\alpha, q, a, \dot{e}/e) \tag{9}$$

where α denotes the fraction of goods traded at the fixed exchange rate and a is actual wealth.

An increase in the free market rate relative to the fixed official rate will deteriorate the official trade balance, B, and improve V, the trade balance in the free market. The reason is that consumers will substitute toward the now relatively cheaper imported goods traded at the official rate while producers will move resources out of production for the official market and into activities that benefit from the free rate. This substitution is one of the most important features of a dual rate regime once commercial transactions are included in the free market.

Formally, the model is now more complex because the real money stock, the stock of foreign assets, and the premium each much be tracked; hence, a simple phase diagram can no longer help. But one can still get a lot of answers by just looking at comparative steady states, since in long-run equilibrium, actual wealth, a, equals planned real wealth, w, and the depreciation of the unregulated exchange rate is zero: $\dot{e}/e = 0$. Thus, as shown in the appendix, the steady state is defined by the following equations:

$$\bar{V}(\alpha, q, w, 0) = 0 \tag{10}$$

$$a \equiv m + K = w \tag{11}$$

$$m / \frac{eK}{P} = L(0) \tag{12}$$

In equations 10 and 11, assets are now deflated by the new expenditure-weighted price level, P, rather than the regulated commercial rate, x. The price level, reflecting the free and official exchange rates, respectively, is given the simple form, $P = e^{1-\alpha} x^{\alpha}$. Substituting equation 11 into 12 now yields the relation between the stock of foreign assets and the premium:

$$m + \frac{Ke}{P} = w \tag{11'}$$

$$m + \frac{Ke}{e^{1-\alpha} x^{\alpha}} = w$$

$$m + \frac{Ke^{\alpha}}{x^{\alpha}} = w, \text{ or}$$

$$(11a) \qquad w = m + Kq^{\alpha}$$

$$(12') \qquad \frac{m}{eK/e^{1-\alpha}x^{\alpha}} = L(0)$$

$$\frac{m}{e^{\alpha}K/x^{\alpha}} = L(0), \text{ or}$$

$$(12a) \qquad m = L(0)\, q^{\alpha}K$$

Substituting 12a into 11a gives:

$$w = [L(0)\, q^{\alpha}K] + Kq^{\alpha}$$

$$(13)^{5} \qquad w = K[L(0) + 1]\, q^{\alpha}$$

Hence for a given target level of wealth, in figure 8 the downward-sloping schedule ww captures both portfolio preferences and saving behavior. Trade balance in the free market, equation 10, is also shown as as a horizontal schedule. The steady state equilibrium for a given w and α is at point E.

Consider now the following policy measure. The government moves some export activity that previously was conducted at the official rate into the free market. The effect of a shift of goods to the free market implies a reduction in the parameter α and a shift of the ww schedule given by:

$$dK/d\alpha = -\,\alpha K/q.$$

Figure 8 shows the effect as a downward shift of the $\bar{V} = 0$ curve. The increased export surplus of the free market raises the stock of foreign assets, K, and must be compensated by a reduced premium so that the schedule for balance in the free market, $\bar{V} = 0$, drops to the position indicated by the dashed lines. (To obtain a downward shift, it must be assumed that

$$\frac{\partial \bar{V}}{\partial q} > 0,$$

so that substitution effects dominate the potentially opposing effect of increased savings undertaken to offset a decline in real wealth caused by the drop in the premium.) Across steady states, the premium declines and the stock of foreign assets rises.

From equations 11 and 12, it can be shown that across steady states, real money balances are constant:

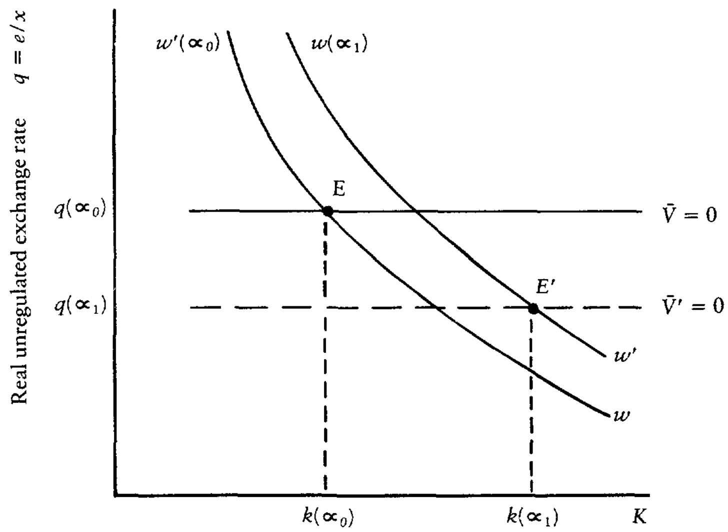
$$(14) \qquad m = \sigma w,\ \sigma \equiv \bar{m}/\bar{w} = L(0)/(1 + L(0))$$

where σ is the steady state ratio of money to wealth in the absence of inflation.

Consider next the effect on the cumulative balance of payments of a change in reserves and the nominal money stock. Since real money balances are unchanged

5. When all goods trade at the commercial rate, x, equation 13 reduces to $w = qK[1 + L(0)]$.

Figure 8. *Trade Diverted to the Free Market*



Note: Given unchanged real money balances ($\dot{m} = 0$),
w = planned real asset holdings
$\bar{V}$ = trade balance of the unregulated market
$\propto$ = the share of goods traded at the fixed exchange rate

across steady states, it is enough to look at the behavior of the price level to know how nominal money changes. The initial shift of some goods to the free market, starting from a situation where all goods are traded at the commercial rate, gives unambiguous results. Since some goods are now shifted from the lower commercial rate to the higher free rate (that is, $q > 1$), the price level must rise. Unchanged real balances in combination with a higher price level then unambiguously imply a cumulative trade surplus, as more exports now sell in world markets at the depreciated exchange rate and import purchases decline in response to the higher domestic currency price. The decline in the premium also decreases wealth and thus spending, which further improves the reserves balance.

But when some goods are already traded at the free rate, a shift of yet further goods to the free market need no longer involve favorable effects on reserves. Now two offsetting effects are at work. The shift of new goods to the free market by itself again raises price levels. But the decline in the premium now lowers the prices of all goods already traded at the free rate and through that channel lowers the price level. If this latter effect is sufficiently important, the price level will fall; hence, reserves must decline in the adjustment process.

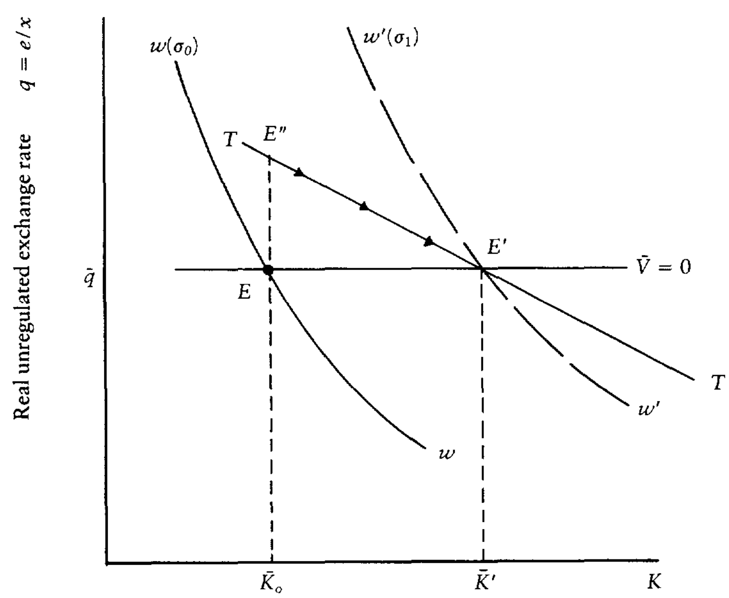
Consider next a portfolio disturbance, specifically a shift out of money reflected in a decline in the steady state ratio of money to wealth, σ (equation 14).

This is, of course, the kind of event against which countries seek to protect themselves with a dual rate. As real money balances fall, if the premium remains unchanged or even declines, there *must* be a cumulative trade deficit at the official rate. The mechanism is the following: the portfolio shift drives up immediately the premium in the free market. As a result, there are two effects on the official trade balance. First, the higher premium diverts resources directly to the production of goods traded in the free market and shifts demand toward the goods traded at the official rate. Second, the rise in the premium raises wealth, which increases spending and thereby also increases the official deficit.

Figure 9 shows the adjustment starting from an initial equilibrium at E. The portfolio shift leads to a rightward movement of ww, and hence E' is the new equilibrium. If the adjustment process is asymptotic, then there will be a path TT along which the economy will travel, starting with an immediate sharp rise of the premium from E to E''. Subsequently, as foreign assets are being accumulated and money balances reduced, portfolio proportions of M and K come more nearly into line with preferences. The process continues until the full adjustment in portfolios has been achieved by changes in nominal money and external assets.

The unambigous effect is that a portfolio shift is fully absorbed by a loss in reserves, even though this occurs via the regulated market rather than as capital

Figure 9. *A Shift Out of Money: The Adjustment Process*



Note:
E = initial equilibrium
E'' = instantaneous increase in unregulated exchange rate
σ = steady state ratio of money to wealth

flight. This conclusion is important because it shows that dual rates can break the speed of capital flight but may not be able to stop an equivalent reserve loss occurring via the impact of the premium on the trade deficit.

III. Triple and Multiple Rates

The Venezuelan case in which the free market premium reached more than 260 percent of the commercial rate was mentioned above. Such a discrepancy is of course a very large distortion. This overvalued rate for some essential imports holds down their prices and thus maintains the real value of wages. But in doing so, it heavily taxes producers of goods traded at the regulated rate. The resulting tendency toward a deficit in the regulated market brings about reserve depletion and thus expectations of devaluation. The expectation then further raises the premium and reinforces the reserve losses.

A typical response to the dilemma is to maintain the regulated rate for essential imports but to shift some exports toward a third market in which the rate is also fixed but at a higher level. In Venezuela, such a multiple system took the form shown in table 1.

The change in the exchange rate structure involved a real depreciation with respect to debt service, services, and imports. The relative prices of these goods and services increased as they were shifted from the lowest rate to an intermediate level involving a 25 percent depreciation. What would one expect to be the impact on the free market premium over the basic rate, e/x? The model developed here can still be used, except that it now has another parameter, $\beta \equiv x'/x$, the ratio of the intermediate rate to the basic rate. The ww schedule would remain unchanged. But there will be an effect on the free market trade balance.

$$\bar{V}(\alpha,\beta,w,q) = 0 \tag{10a}$$

The question is whether splitting the basic rate will increase or reduce the trade surplus of the free market. There are two extreme scenarios that can be envisaged. In the first, resources are primarily transferred from the free market into production in the sector with the new higher official exchange rate, while higher prices in that sector transfer consumer demand into the free market. In

Table 1. *The Venezuelan Multiple Exchange Rate System*

Date	*Exchange rate (Bolivars per $U.S. dollars)*	*Transaction category*
February 1983	4.3	Petroleum exports, debt service, and basic food
	6.0	Most imports
	Unregulated	All other transactions
February 1984	4.3	Basic food
	6.0	Petroleum exports
	7.50	Services, most imports, and debt service
	Unregulated	Nontraditional exports, nonessential imports, and capital account transactions

this case, increased demand and reduced supply create a deficit in the free market, $\bar{V}(\bullet)$ declines at each level of q, and the $\bar{V}(\bullet)$ schedule in figure 8 shifts upward. In addition, with unchanged real money balances, across steady states the third rate would create a cumulative trade surplus at the official rate. Conversely, at the other extreme, the shift primarily worsens the official trade balance while improving the free market surplus, and the premium declines. The price level $P(e,x,x')$ now could fall (depending on the relative weights of the different markets in total domestic trade), and there might be a cumulative loss of reserves, as can be observed from the equation for real balances written here in terms of nominal money and prices:

$$M = P(e,x,x')\,\sigma w \tag{14a}$$

The ambiguity of the effect of the policy move on reserves is, of course, critical. It suggests that an obvious move to increase efficiency—removing some items from a severely undervalued exchange rate—may in fact produce exactly the wrong results for reserves. Moreover, there is no presumption that shifting an activity from one rate to another will in fact improve welfare, as is obvious from the second-best nature of the exercise. This point is important, because it means that increasing the number of rates by shifting activities from the lowest or basic rate toward the more "realistic" free rate does not necessarily reduce distortions in the economy. It may well increase the misallocation (see Harberger 1959).

The Unification Problem

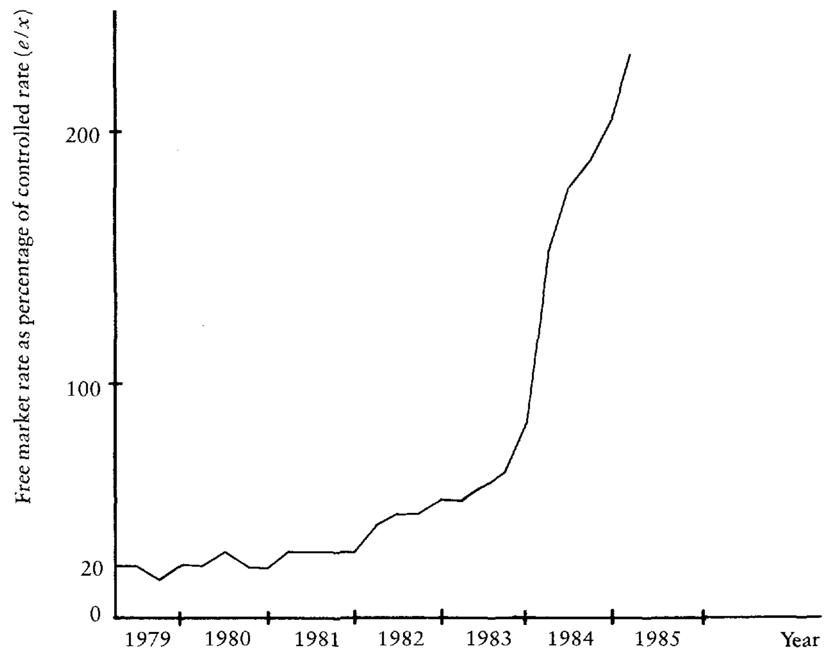
Figure 10 shows the premium of the free rate over the official exchange rate for the Dominican Republic. The official rate is constitutionally fixed at 1 peso per U.S. dollar. An increasing number of transactions are conducted at this rate, and as is apparent, the free rate has progressively moved away from the official rate. The Dominican Republic now faces a problem common in Europe after World War I: should the official exchange rate be restored as a uniform rate, which would require deflation such as the United Kingdom undertook in moving back in 1925 to the prewar parity? Or should a new uniform rate be set that takes into account the level of the free rate, as Poincaré did in 1926 in France?

It is clear that the present system is not viable because it involves huge distortions. In response to the distortions, an increasing number of transactions are shifted to the parallel rate so that the average exchange rate is depreciating over time. Table 2 shows the effects of this reallocation on the effective exchange rate (weighting the trade categories by their appropriate exchange rate).

Much the same problem, though in perhaps less clear-cut terms, arises for a country in which the free rate and the basic rate are so far apart that the resource allocation costs outweigh any macroeconomic benefits.[6] When the dual rate has gone far out of line, the unification of rates becomes an important macroeco-

6. This may be Venezuela's situation but is probably not Mexico's.

Figure 10. *The Premium of the Dominican Republic's Exchange Rates*



Source: International Monetary Fund, *International Financial Statistics Yearbook*.

nomic issue. The expectations about the manner in which unification will be achieved will affect both the premium (and hence the trade deficit) and also interest rates and activity. If the expectation is one of devaluation of the official rate, as must ordinarily be the case, the free market premium will already reflect that expectation and be correspondingly higher, which thereby worsens the trade deficit. Interest rates will reflect the expectation of depreciation of the free rate and thus will rise in the period ahead of the expected depreciation. Therefore, if the devaluation is delayed, real interest rates for activities tied to the official rate increase, and that of course leads to a decline in investment activity. Bankruptcy problems arise as debt service comes to absorb declining real earnings of the sector that is atrophied by the overvalued official rate.

Table 2. *Average Exchange Rates for the Dominican Republic*
(pesos per $U.S. dollar)

Rate	*1982*	*1983*	*1984*[a]
Effective: imports	1.19	1.31	2.18
Effective: exports	1.0	1.15	1.77
Official	1.0	1.0	1.0
Parallel	1.46	1.61	2.75

Source: World Bank data.
a. Estimate.

It is obvious then that a dual rate at a level far from the official rate must be a very transitory policy if it is to be effective. Attempts at unification cannot be avoided, and the real wage problem ultimately cannot be solved by implicit trade taxes and subsidies that infect all markets, especially forward-looking financial markets. A more sensible model is the Mexican solution, in which the dual market is used as a strictly transitory shock absorber. Figure 2 above shows the premium in the free Mexican market relative to the controlled rate. The divergence was kept small, although financial disturbances were allowed to affect the premium. But fundamental macroeconomic changes were reflected in the official rate; the premium stayed on average well below 20 percent.

"Black" Markets

This analysis has focused on cases in which the government sanctions an official free market for all nonpreferential transactions. In some cases, the reaction to the high premium is to exclude certain transactions altogether, in particular capital account transactions, from access to foreign exchange. As a consequence, a black market will immediately spring up and function in a manner identical to the dual market already discussed.

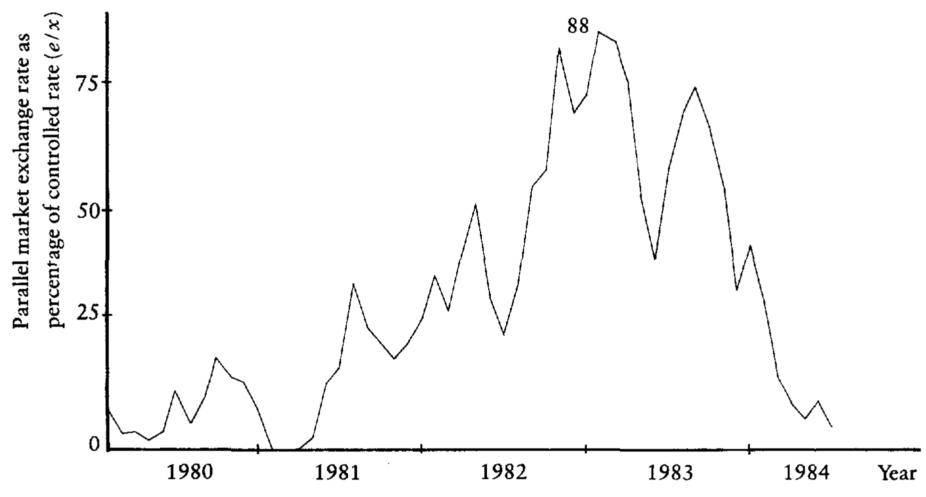
Figure 11 shows the premium in the Brazilian "black" or parallel market in the past few years. It show the same erratic pattern as the Venezuelan dual rate; this pattern reflects expectations about major shifts in politics and financial and official exchange rate policy.

The market brings together all unauthorized foreign exchange transactions: import smuggling and coffee export smuggling undertaken to avoid quotas and/or export taxes, unofficial military export revenue, tourism, and capital account transactions. In Dornbusch and others (1983), it is shown that the market is well-behaved: seasonal factors, interest rates, the official real exchange rate, and anticipation of major devaluations ("maxis") explain the behavior of the premium.[7]

Figure 12 shows the premium in Argentina in the period since Martínez de Hoz. Except for brief periods of unified exchange markets, there has always been a premium. Politics and real interest rates are the main determinants (see Dornbusch and Moura Silva [forthcoming]). The Argentinian example shows how politics can cause a free exchange rate to vary far from PPP. An example is the pre-election period in late 1983: the premium rose to more than 100 percent (in daily data) prior to the election and immediately fell by 40 percentage points on the day after the Alfonsín election. The size and movements of the black-market premium affect resource allocation and inflation and thus pose problems for macroeconomic policy.

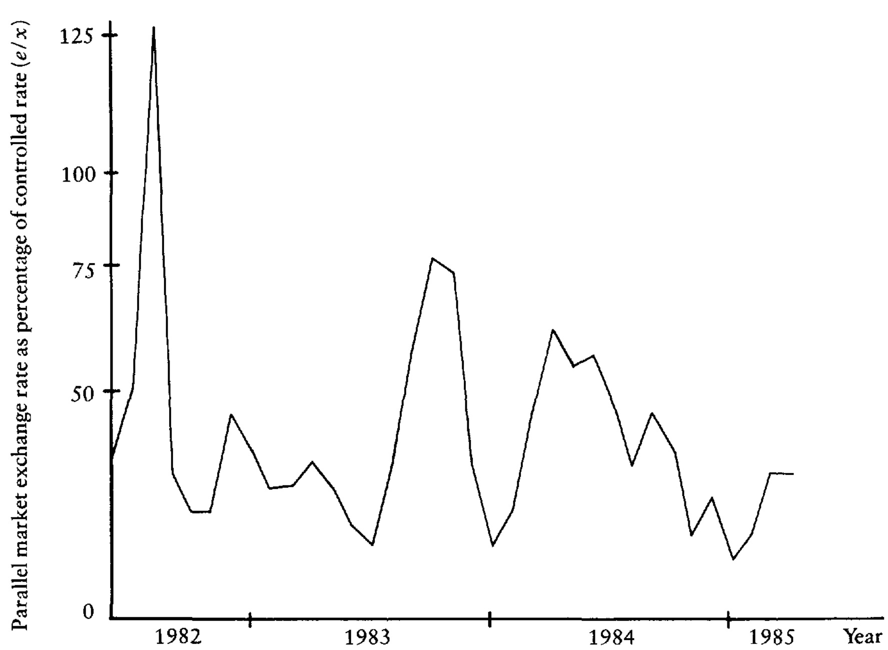
7. In fact, even the bid–ask spreads in the black market can be well explained in terms of the theory of dealership (see Dornbusch and Pechman 1985). Interest rates and the variability of the premium that proxies the extent of news explain the size of the spread.

Figure 11. *The Parallel Market Exchange Rate Premium in Brazil*



Source: Pechman (1984).

Figure 12. *The Parallel Exchange Rate Market Premium in Argentina*



Source: Organizacion Techint.

The traditional view of black markets is to see them as an offshoot of the restriction of commercial transactions. But there is sufficient evidence to support the view that they are closely tied to financial markets. At any point in time, there is a given stock of foreign assets in the hands of domestic residents. Given expected returns on domestic assets, there will be a level of the premium that will establish stock equilibrium. The level of the premium in turn influences the flows into and out of the pool of foreign assets in the hands of the public. These considerations are particularly obvious in the case of Argentina. In July 1982, for example, the government chose to solve the problem of the domestic overindebtedness of firms and of the government by freezing nominal interest rates below the rate of inflation. There was an immediate shift of portfolio holders out of domestic assets into blackmarket dollars. Within a day, the premium shot up to above 100 percent. The high level of the premium in turn encouraged underinvoicing of exports, which deprived the government of foreign exchange and of revenue from export taxes and thereby worsened the financial difficulties of the public sector.

Brazil, similarly, has had periods when the black market showed a large premium, for example, at the outset of the debt crisis in late 1982. The level of the premium was so high that a peculiarly inefficient arbitrage occurred. The government allocated foreign exchange for tourists—$1,000 for every man, woman, or child. Given a premium of nearly 100 percent, mothers with ten babies (who fly free of charge) were able to plunder the central bank by flying to and from Miami to exchange dollars for pesos at the international exchange rate. Lines for passports (required to obtain foreign exchange) were for once even longer than those for food. The large premium may have cost the government as much as one billion U.S. dollars in reserves.

Because the black market is integrated with forward-looking asset markets, it is clear that expectations about future political or economic events will be reflected in the premium even before they materialize. Thus the chance of a Peronist victory pushed up the premium prior to Alfonsín's election. Similarly, anticipated exchange rate action can be seen in the premium. The anticipation of a maxi-devaluation of the official rate, for example, would lead to an immediate rise of the premium in the black market. The increased premium in turn would worsen the financial conditions of the government, not only by posting a visible sign of no confidence but also by drawing resources away from the official asset markets.

An interesting fact, in this context, was the decline of the Brazilian premium in 1984–85 despite large deficits and deteriorating financial conditions. Part of the reason is, of course, the extremely high real interest rate. The rate in Brazil was above 40 percent in real terms and thus more than competitive with any capital gains expected in the black market. But a further element depressing the premium may well have been the fact that the government has ceased purchasing domestic gold, which therefore flowed through the black market. The resulting increased flow of black market dollars kept a lid on the premium and worked to stabilize expectations.

IV. Conclusions

This study of special exchange rate systems for capital account transactions points out two problematic characteristics of international financial markets for government policy. These are, first, the range of ways that successful policy implementation is precluded in an economy which is fully open to the influence of international asset markets and, second, the macroeconomic repercussions of controlled exchange rate systems which can undermine the long-run effectiveness of such schemes.

In these dual exchange rate systems, capital account transactions are conducted at a free rate while commercial trade is maintained at an overvalued exchange rate. The models of dual exchange rate systems developed here examine the outcome when a government uses credit creation and thus commercial account depreciation to fund government spending. This strategy increases capital account depreciation and thus the premium of capital over commercial account rates. When the devaluation is foreseen by asset holders, as is common, that expectation and the subsequent capital account depreciation will create a trade deficit. The increase in the premium raises wealth relative to target levels and leads to dissavings and a movement out of money balances, which fuels the trade deficit. It is clear that this form of inflationary finance is not sustainable in the long run and that it will create distortions in other macroeconomic conditions which may, by a government's own assessment, offset the benefit from the initial spending increase.

The distortionary effects of the dual rate system are substantially offset, however, if the central bank intervenes to protect the value of the currency (through sale of foreign assets). The premium declines in response to increased foreign asset holdings, and the lower premium reduces the real value of foreign assets and thus wealth. Savings will increase, which will result in decreased spending and imports and an improved trade balance. Because of declining real money balances, however, seignorage again is not sufficient to fund increased government spending.

More severe macroeconomic distortions may be introduced when some commercial transactions are transferred to the free market or when relatively large parallel markets emerge. In this case, the free or parallel market rate directly influences domestic prices. Consumers will substitute toward the now relatively cheaper imported goods traded at the official rate, while producers will move resources out of production for the official market and into activities that benefit from the free rate. These movements will increase supply in the free market, while higher demand and a decline in supply in the fixed rate market will create a trade deficit. The central bank faces larger trade deficits and loses reserves, while in the free market, a trade surplus leads to accumulation of foreign assets.

In this situation, there are counteracting influences, and the impact on the price level and on savings (and thus on the deficit) is not clear. The effect of *multiple* exchange rates on the trade balances in the various rate markets is similarly indeterminate. The impact on official reserves will depend on the rates of substitution between the new "midrange" market and the prior fixed and free markets. A partial policy move away from a severely overvalued exchange rate, as a second-best exercise, may actually increase misallocation.

It might be argued that the government is helping workers by sustaining real wages via a low official exchange rate financed by external borrowing. But the deficit is increased by the rising premium: the free market runs a surplus that is privately accumulated, while the government borrows abroad to finance "its" deficit. Those who trade at the free rate, particularly asset holders who can move relatively easily between domestic and international markets, may ultimately be the net beneficiaries of the scheme, not labor.

All these outcomes suggest that the dual rate will be most effective if it is maintained in a range close to the free rate. In this way, the system can buffer the economy from abrupt financial disturbances, but the rate must be allowed to shift in response to fundamental macroeconomic changes.

Appendix. The Dual Exchange Rate Model

The dual exchange rate model assumes a single good, purchasing power parity at the commercial rate, x, and two assets: domestic money and a foreign security (or foreign money). Throughout, λ denotes the rate of depreciation of the official rate and u the depreciation rate in the free market.

The portfolio balance is given by:

$$M/eK = L(\dot{e}/e + i^*), \qquad L' < 0 \tag{1}$$

or, solving for $\dot{e}/e$:

$$\dot{e}/e = h(M/eK) - i^*, \qquad h' < \dot{0} \tag{1a}$$

where e is the capital account rate; M is domestic money; K is the stock of foreign nominal assets; and i^* is the foreign interest rate, which is assumed to be zero.

Wealth is defined as the sum of real balances and foreign assets:

$$a = m + k \tag{2}$$

It is assumed that investment and taxes are zero. A given level of real government spending, G, is financed by domestic credit creation. The growth in the real money stock is determined by the rate of depreciation of the commercial rate, government spending, and the trade surplus, B:

$$\frac{d(M/x)}{\mathrm{dt}} = (G + B) - (M/x)\dot{x}/x \tag{3}$$

The trade surplus is determined by the discrepancy between savings and real government spending. Real savings depends on the gap between target wealth, w, and actual wealth, a, and on anticipated capital gains:

$$S = v(w - a) - (eK/x)(\dot{e}/e - \dot{x}/x) + (M/x)\dot{x}/x \tag{4}$$

Accordingly, savings has a stock adjustment component and a component arising from the capital gains realized from external assets and the inflation losses incurred on real balances.

Noting that the trade surplus is the excess of savings over government spending,

$$B = S - G \tag{5}$$

and hence, using equations 15, 16 and 17:

$$\frac{d(M/x)}{dt} = S = (M/x)\dot{x}/x = v(w - a) + [\lambda - h(M/eK)]k \tag{3a}$$

where $m = M/x$ and m is the steady state level of real balances given a policy of spending at the real rate g; $k = eK/x$; $q = e/x$; and $\lambda = \dot{x}/x$ and λ is the given rate of depreciation of the commercial rate that satisfies the condition of steady state deficit finance:

$$\lambda L(\lambda)\bar{k} = G \tag{6}$$

It is assumed that there is a unique λ to solve equation 6 (see Bruno and Fischer 1985).

The system can be studied in terms of the two differential equations governing the evaluation of the real value of assets:

$$\dot{m} = v(w - m - k) + [\lambda - h\,(m/k)]k \tag{7}$$

$$\dot{q} = q\,[h(m/k) - \lambda] \tag{8}$$

These two schedules and the corresponding dynamics are shown in the phase diagram in figure 5, where it is assumes that $\dot{m} = 0$ is negatively sloped.

For any initial value of the real money stock, m_0, adjustment takes place along the stable trajectory *JJ* to the steady state at *E*. In the adjustment process, a trade surplus is accompanied by a real depreciation of the capital account rate.

Once commercial transactions enter the free market, the system of equations becomes:

$$\dot{m}/m = [v(w - a) - h(m/k)(1 - \alpha)k]/m - \alpha h(m/k) \tag{9}$$

$$\dot{K}/K = V(q,a,\lambda)/K - (1 - \alpha)h(m/k) \tag{10}$$

$$\dot{q}/q = h(m/k) \tag{11}$$

where it is assumed that $\dot{x}/x = 0$ and where α is the share of free market goods in the deflator:

$$P = P(e,x) \tag{12}$$

In the steady state, $h(m/k) = 0$. Thus the steady state system simplifies to:

$$\bar{V}[q,qK[1 + L(0)], 0] = 0 \tag{13}$$

$$m = L(0)qK \tag{14}$$

$$w = K[1 + L(0)]\,\rho\,;\,\rho \equiv q^{\alpha} \tag{15}$$

where the last two equations imply that:

$$m = \sigma w, \qquad \sigma = L(0)/[1 + L(0)] \tag{16}$$

This system is used in the text for comparative statics.

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Growth and Equity in Developing Countries: A Reinterpretation of the Sri Lankan Experience

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In the important debate between the proponents of direct (basic needs) and indirect (economic growth) measures of promoting welfare, Sri Lanka has frequently been cited as one country which has successfully pursued the direct approach—it has raised living standards without much cost in terms of reduced growth. This conclusion, however, is based on analyses which do not account for the initial conditions of the countries being compared. After methodologically incorporating these concerns, neither the improvement in living standards nor the 2.0 percent per capita growth rate during the period of direct policy measures (1960–78) was exceptional. In contrast, during the period of more indirect growth-promoting policies (1977–84), (i) economic growth more than doubled to an average rate of 4.3 percent per capita per annum; (ii) expenditure inequality did not significantly change; (iii) consumption expenditures of the population, and the poor, generally increased; and (iv) several living standard indicators continued to improve.

Growth and equity are two important goals of developing countries. Depending on the fashions of the times, development economists (and policymakers) have variously emphasized the complementarities or trade-offs between these twin objectives of economic development. While there is general agreement that increased equity means an improvement in the living standards of the poor, there is disagreement about the appropriate emphasis to be placed on this goal.

This disagreement can be brought into focus by contrasting two opposing viewpoints. One point of view contends that an attack on poverty requires heavy reliance on direct measures to meet basic needs.[1] An explicit assumption of this approach is that economic growth by itself is too slow to provide substantial

1. Since welfare has several components besides monetary income, economists have tended to look at several nonincome indicators of welfare, such as basic needs (Streeten and Burki 1978), physical quality of life (Grant 1978) and living standards (Isenman 1980, Sen 1981).

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benefits to the poor in a reasonable amount of time. Consequently, governments should provide goods and services directly to the population in order to ensure that the poor receive an equitable share. The other viewpoint (again an extreme version) is that policymakers should reduce government involvement in the provision of goods and services and concentrate instead on increasing long-term economic growth. The explicit assumption here is that such growth will raise the incomes of all people (including the poor) and thus raise their standards of living. The former method, which can be described as the direct approach, emphasizes government intervention and equity, while the latter, which can be called the indirect approach, emphasizes economic growth and less government intervention.[2]

Among developing countries, Sri Lanka is frequently cited as a country which has successfully implemented the direct approach to raising economic welfare while still maintaining a respectable rate of economic growth. In recent years, it has been argued that the large social expenditures of the Sri Lankan government are the chief cause of its high standard of living as indicated by the long life expectancy, low infant mortality, and high level of literacy of the country's population (in particular, see Isenman 1980; Sen 1981, forthcoming). Ironically, however, just as economists began praising Sri Lanka's extensive array of social welfare programs, a new Sri Lankan government was elected in 1977 which began to reduce such expenditures and switch to the indirect strategy of providing for economic welfare, that is, placing a greater weight on the objective of economic growth.

The wealth of data available on Sri Lanka, when combined with the shift in its economic policies, provides a unique opportunity to assess the relative merits of the direct and indirect approaches to improving the economic welfare of low-income groups. Economic development is a complex process, and this article is not intended to provide definitive answers to the difficult policy questions involved. In addition, seven years (1977–84) is a rather short period of time from which to judge the longer-term effects of these changes in economic policies. What this article does seek to provide is a discussion and analysis of some of the methodological issues that are involved in making an assessment of the relative success or failure of policies in different countries or policy regimes. To make this assessment, this article analyzes Sri Lanka's performance both relative to that of other developing countries and with respect to its own initial level of development.[3] Particular attention is given to the living standards of the population and the welfare of the poor.

I. Living Standards: A Comparative Framework

Sri Lanka has become one of the most frequently cited examples of the successful use of the direct approach to the raising of living standards. According to

2. See Bhagwati (1986) for a lucid discussion of these two schools of thought.

3. Much of this analysis reflects our earlier work on this topic, in particular Bhalla and Glewwe (1985), Glewwe (1986a), and Bhalla (forthcoming).

several measures (life expectancy, infant mortality, literacy, absolute levels of expenditures of the poor), Sri Lanka has achieved better standards than most, if not all, of its comparator countries. Given this evidence, two questions need to be answered: Was Sri Lanka indeed an exceptional performer? If it was, what were the determinants, and particularly the policy determinants, of this exceptional performance?

The first question might be answered if a structural model could be estimated for each of the several indicators of living standards. Estimation of the life expectancy model, for example, would require data on female literacy, public health systems, private expenditures on health, and social expenditures (and the effectiveness of such expenditures) on disease eradication (such as malaria). Such data are not easily available for a particular country, let alone for a set of countries. Consequently, a structural model is difficult to estimate.

This same data constraint has affected other attempts at modeling intercountry behavior. As an alternative, researchers have tended to emphasize the establishment of "stylized facts" to interpret cross-country differences. This endeavor has led to analyses of patterns of development (Chenery and Syrquin 1975); of the relationship between income inequality, income levels, and growth rates of income (Ahluwalia 1976); and of the relationship between living standards and income (Isenman 1980; Sen 1981; Streeten 1981).

In this pursuit of stylized facts, a regression of the following form is typically estimated:

$$H_{it} = f(Y_{it}, Z_{it}) \tag{1}$$

where H_{it} represents some measure of living standards (or inequality) for a country i at time period t, Y represents per capita income, and Z represents a vector of nonincome determinants of H.[4] Often, Z_{it} is not included for lack of data, and the estimated equation is of the form

$$H_{it} = f(Y_{it}) + e_{it} \tag{1'}$$

where $f(Y)$ represents a particular functional form and e_{it} is the residual. If for purposes of analysis $f(Y_{it})$ is represented by a linear relationship, one obtains

$$H_{it} = (\alpha_t + \beta_o) + \beta Y_{it} + e_{it} \tag{2}$$

where α_t is a time-effect for time t and β_o is a constant term. Note that equation 2 cannot yield a separate estimate for β_o.

Though equation 2 applies across time, the more usual approach is to estimate it for a single time period. While the residual in equation 2, e_{it}, can inform one about a country's comparative level of living standards given its income level, it cannot, however, indicate anything about what *caused* the particular status to be observed. Additional information is needed to interpret the nature of the residual in equation 2, and the causes of relative achievement. In other words, the

4. It is likely that there is a simultaneous relationship between H and Y; though recognized, this issue is ignored in this paper.

implicit assumption is that e_{it} contains the effects of omitted variables; and in particular the effects of omitted policy variables. The contribution of these omitted variables (for example, social expenditures) may lead to a particular country being observed as an outlier. Formally, if E_{it} represents social expenditures,[5] and δ the average impact of such expenditures, equation 2 becomes

$$(3) \qquad H_{it} = (\alpha_t + \beta_o) + \beta Y_{it} + \delta E_{it} + u'_{it}$$

where the estimated residual is

$$e_{it} = \delta E_{it} + u'_{it}$$

and u'_{it} is a random error term.

If the omitted variable E_{it} is observed to be exceptionally large for a particular country, then according to equation 3, an exceptionally large residual e_{it} will also be observed. Hence, large social expenditures for Sri Lanka can lead to its being an outlier in terms of achievement of living standards. This sort of causal connection seems to be implied in the conclusion reached by Isenman and Sen on the basis of an estimate of equation 3.[6] Sen notes: "Regarding the causation of this superior performance, attention has tended to concentrate on Sri Lanka's program of food subsidy and other social services" (1981, p. 301). Similarly, Isenman states: "Sri Lanka's record on social indicators suggests that expenditure over a number of years as a high percentage of the total government budget can lead to striking progress in the underlying social objectives of the economic development process" (1980, p. 251).

One important reason why equation 3 may be an inappropriate basis for deriving conclusions about recent policy-induced performance is that such regressions ignore the effect of "initial conditions."[7] Findings can vary because of country-specific factors like climate or diet. These "fixed effects," which are assumed to be time-invariant, can cause differences in observed living standards and yet have little to do with per capita income or social expenditure. Fixed effects may also arise because of *past* policy. Consider the following example. The time pattern of crude death rates in Sri Lanka is as follows: 1946, 20.2 per thousand; 1947, 14.3; 1953, 10.9; 1960, 8.6; and 1978, 6.6. One interpretation of this sequence of death rates is that a structural or technological change took place in Sri Lanka from 1946 to 1947. Such a change plausibly could be identified with the successful malaria eradication campaign that occurred in Sri Lanka in 1946. If this change did not take place in other countries, and if this technological advantage persists through time, then a six-point (20.2 versus 14.3) advantage in terms of death rates will be observed for Sri Lanka in 1950,

5. Obviously, unless one believes in no lags, E_{it} is a weighted sum of recent expenditures with presumably different weights being given to its investment and maintenance components.

6. The actual equation estimated is $\ln H = \alpha + \beta \ln Y$; the nature of the functional form, however, is irrelevant to the present argument.

7. This is in addition to the general criticism that cross-country data analysis is inappropriate per se because of inherent inaccuracies in data, noncomparability of economic systems, and so forth.

1960, 1975, and 1995. Thus, a cross-country regression for 1975 may show Sri Lanka to be an outlier, by six points, but it would be incorrect to attribute this exceptional status to Sri Lankan expenditure policies *after* 1947.[8]

Formally, initial conditions (λ_i) can be incorporated into the analysis thus:

$$(4) \qquad H_{it} = \alpha_t + \beta Y_t + \delta E_{it} + \lambda_i + u''_{it}$$

where λ_i is a country-specific and time-invariant fixed effect and u''_{it} is a random error term. Note that β_o is no longer in the equation. This is because it represented equal fixed effects for all countries; equation 4 allows these fixed effects to differ. In all other aspects, equation 4 and its assumptions are identical to the equations which are generally estimated. It is important to emphasize the nature of the variable representing initial conditions or fixed effects λ_i. If equation 4 is estimated for the time period 1940 to 1950, then the malaria eradication campaign of 1946 is not a fixed effect. If, however, the equation is estimated for 1950 to 1970, then the six-point contribution of the malaria campaign becomes a fixed effect for the latter equation.

With fixed effects, the estimated residual of equation 4 is

$$e_{it} = \delta E_{it} + \lambda_i + u''_{it}$$

Thus, cross-country differences in e_{it} can no longer be attributed to differences in social expenditures, E_{it}; they may instead be caused by differences in initial conditions, λ_i.

A second problem with using equation 3 is that ignoring differences in fixed effects implies that such effects are presumed to be identical across countries and equal to β_o. If this is not the case, and if fixed effects are correlated with per capita income, then the estimate β will be biased and will yield incorrect estimates of predicted changes in H_{it} caused by assumed changes in Y_{it}.[9]

Given the importance of controlling for initial conditions, the question remains: How can λ_i be estimated? Alternatively, how can the effect of λ_i be removed from equation 4? One method of "purging" the residual of initial conditions is to estimate a model relating first differences of variables in equation 4 or a *change–change* regression:

$$(5) \qquad dH = H_{i,t+1} - H_{it} = \alpha_{t+1} - \alpha_t + \beta(Y_{i,t+1} - Y_{it}) + \lambda_i - \lambda_i + u^*$$

where $u^* = \delta(E_{i,t+1} - E_{it}) + u''_{i,t+1} - u''_{it}$

Note that λ_i drops out so that the residual is composed of just the difference in the omitted variable, social expenditures, and a random error term.

8. The implicit assumption is that the expenditures needed to maintain a particular level of H_{it} (death rate) are much smaller than the initial capital expenditure needed to improve H_{it}. Isenman *does* discuss in detail the initial conditions prevailing in Sri Lanka but fails to incorporate the effects of these initial conditions into his regression estimates.

9. As discussed later, the log–log relationship between life expectancy and income ($\ln H = \alpha + \beta \ln Y$) yields a *negative* estimate for β once initial conditions are incorporated into the regression.

It is the residual of equation 5, and not the residual of 3, that may be useful in assessing country performance over time. Consequently, if a stylized fact methodology is pursued, then at a minimum, equations like 5, rather than 3, need to be estimated and interpreted.

Initial Conditions in Sri Lanka

In the case of Sri Lanka, an examination of initial conditions reveals two often ignored facts: it had exceptional living standards as early as the initial postwar period, if not before; and it was a surprisingly rich developing country (in monetary terms) in 1950 and 1960.

Table 1 documents the historical data for Sri Lanka since 1881. Literacy was already relatively high (21.7 percent) in the late nineteenth century, and "primary education was made nominally (although not in practice) compulsory in 1901" (Isenman 1980, p. 238). As noted earlier, the malaria-eradication policy of 1946 was largely responsible for reducing the death rate from 20 per thousand in 1946 to 14 per thousand in 1947.

Other Sri Lankan social indicators were also exceptional at the time of its independence in 1948. Though comparable data are not easily available, the following three measures stand out. First, life expectancy at birth of a Sri Lankan in 1948 (54 years) was almost identical to that of a Japanese (57.5 years) and higher than an Indian's in *1981* (51 years).[10] Second, the 1950 Sri Lankan unadjusted school enrollment ratio (primary and secondary school enrollments as a percentage of the population aged 5–19 years), 54 percent, was among the highest in the developing world in 1950. In India, the rate was 19 percent; in the Republic of Korea, 43 percent; and in the Philippines, 59 percent. By 1979, Sri Lanka's enrollment rate, 74 percent, had fallen behind Korea's, 94 percent, and had failed to keep pace with that of the Philippines, 85 percent. Third, even in 1950, Sri Lanka had an impressively low level of infant mortality—82 deaths per thousand live births. By contrast, the Philippines had 102 deaths and Malaysia, 91. In 1977, the corresponding numbers were Sri Lanka, 42; the Philippines, 65; and Malaysia, 32.[11] Thus, at the time of its independence in 1948, Sri Lanka enjoyed reasonably high living standards—a life expectancy of 50 years, a literacy rate of 58 percent, and an infant mortality rate of 92 deaths per thousand. These accomplishments are put into a comparative perspective by noting that the above figures for Sri Lanka for *1948* correspond to the following *average* figures for the East Asian countries (the most successful of the developing countries) for *1960:* a life expectancy of 53 years, a literacy rate of 59.5 percent, and an infant mortality rate of 94 per thousand.

It is also important to recognize how relatively well off Sri Lanka was both at

10. Sources of data are various United Nations and World Bank documents.

11. The 1977 figure for Sri Lanka does not match that reported in table 1 because it comes from a different source—table 1 is based on Alailima (1985) for time series Sri Lanka data, whereas comparative cross-country data are from various *World Development Reports*, World Bank.

Table 1. *Social Expenditures and Living Standards in Sri Lanka, 1881–1982*

Year	*Social expenditures per capita (Rs)*[a]	*Social expenditures per capita (Rs)*[a]	*Life expectancy (years)*	*Crude death rate (per thousand)*	*Infant mortality rate (per thousand)*[b]	*Total fertility rate*	*Primary school enrollment (percentage of age group)*	*Literacy rate (percent)*[c]	*Crude birth-rate (per thousand)*
1881								17.4	
1891								21.7	
1901–04					170			26.4	
1920–24			31.7		192			39.9	
1930–34					165				
1940				20.6	149				35.7
1945				21.9	140			57.8	35.9
1950	62[d]	66[d]	56.5	12.6	82				40.2
1955	43	49	59.3	11.0	71			65.4	37.3
1960	85	98	62	8.6	57	5.3	95		36.6
1965	91	97	63.5	8.2	53		93	71.6	33.1
1970	103	103	64	7.5	48			78.5	29.4
1975	128	144		8.5	45	4.2	77		27.8
1978	189	253	69	6.6	37	3.6	94		28.5
1982	84[e]	119[e]	69	5.9	32	3.4	103	86.5	26.3

Sources: Central Bank of Ceylon (1970, 1974, 1983, 1984), IMF (various years [b]), World Bank (various years), and Alailima (1985).

a. Social expenditures include net food subsidies, health, education, housing, community and social welfare services, and nonfood subsidy transfers. The second column is deflated by the gross domestic product (GDP) deflator and the third column by the inaccurate (for the 1970s) consumer price index.

b. Infant mortality rate figures are from Alailima (1985) and are different in some years from the source of cross-country data, World Bank (1983) (for example, the Sri Lanka figure for 1960 in the latter source is reported to be 71 rather than 57).

c. Literacy figures are for 1946, 1953, 1963, 1971 and 1981.

d. Data are for 1951.

e. Data are for 1984.

the time of independence and in the early 1960s. In 1950, Sri Lanka's per capita income according to purchasing-power-adjusted exchange rates—Kravis figures, denoted by $K[12]—was only 18 percent less than that of Japan ($K669 versus $K810 in 1975 prices). In 1960, its per capita income (1960 prices and exchange rates) of $152 was more than twice that of its neighbor India ($68), 50 percent more than Thailand ($97), and equal to that of Korea ($154). Kravis figures show Sri Lanka ($K961) to have been richer than Brazil ($K912) and Korea ($K631) and about equal to Colombia ($K1,070) and Turkey ($K1,044) in 1960.

Sri Lanka's high living standards, both in 1948 and in 1960, should caution one against causally linking social expenditures (post-1948 or post-1960) with the "exceptional" status of Sri Lanka in the late 1970s. That judgment requires an examination of whether Sri Lanka's post-1948 *performance* was exceptional and whether social expenditures played an important role in that performance.

Cross-Country Analysis of Living Standards

In a comparative analysis of country performance, the more widely used indicators of living standards are the following: life expectancy, death rate, infant mortality, fertility, primary schooling, and adult literacy. These six indicators, which provide reasonable (though imperfect) information about the effects of direct social welfare policies, are analyzed below. Before this can be done, however, four issues need to be addressed: the time period of analysis; the countries to be considered; the specification of the functional relationships between living-standard indicators and income; and statistical procedures to be used to assess whether a country is exceptional according to a particular criterion.

Time Period of Analysis

Estimation of change–change regressions (equation 5) requires comparative data for at least two points in time. If these points are chosen sufficiently far apart, then a meaningful relationship can be estimated. Since comparative data on a number of variables are required, the choice of a period of analysis was dictated by data constraints and chosen to be 1960 and 1978.[13]

If the data for 1960 to 1978 are used, the differences in country performance prior to 1960 are ignored. This is unfortunate but unavoidable. Ideally, one would like data for as long a period as possible, perhaps since the 1930s—a time

12. Kravis dollar figures are in 1975 international prices and are as reported in Summers and Heston (1984). Because purchasing power parity (Kravis 1982) and conventional income figures often differ substantially, all analyses reported in this article were conducted for both definitions of income.

13. Comparative data are available for 1960 in World Bank (various years). The sample of developing countries for which consistent data are available prior to 1960 is small and not sufficient for econometric analysis. To correspond with the switch from direct to indirect Sri Lankan economic policies, 1978 is the end point chosen.

period prior to the expansionary Sri Lankan social welfare policies of the 1940s. Even this might not be enough, for it would leave unexplained the relatively high literacy rate (greater than 40 percent) and low death rate (20.6 per thousand) that was observed in Sri Lanka in 1940.[14]

Given that an ideal data set is unavailable, the choice of a period for a meaningful analysis of cross-country performance should satisfy two important conditions: the time period must be long enough for expenditure policies to have an effect, and the period should include episodes of policy change in order to analyze the effects of policy shifts.

In the case of Sri Lanka, it is likely that eighteen years (1960 to 1978) is a sufficiently long time for social expenditure policies to have an impact and for differences in achievement to be observed. Furthermore, 1960 is coincidentally a good cutoff point for marking a "beginning" or a shift in Sri Lankan policies. As Fields notes, "It happens that the early 1960s mark a turning point in economic and social policy: Sri Lanka moved from an open to a closed economy and then approached welfare statism" (1980, p. 195). Social expenditures started accelerating in the late 1950s. Yearly data suggest that average real per capita expenditures on social programs from 1960 to 1969 were 65 percent higher than those from 1951 to 1959.[15] And although the rate of growth in expenditures decreased, the average 1970–78 level was still 39 percent higher than in the 1960s. Thus, Sri Lanka's commitment to the maintenance and improvement of living standards—whether measured relative to its own gross national product (GNP) or relative to those of other countries—remained high. Such cross-country data are, unfortunately, only available for the period 1973 onward. Of the countries reported on in table 2, Sri Lanka's share of GNP devoted to social expenditures—11 percent in 1973—was exceeded only by that of Egypt (International Monetary Fund, various years [a]).

The end year, 1978, corresponds with the shift in policies which occurred with the advent of the new government in November 1977. Thus, it seems that the period from 1960 to 1978 is a particularly appropriate reference period for analysis of Sri Lankan performance. As noted in tables 1 and 2, living standards, social expenditures, and per capita income increased during this period. Whether the changes in living standards were exceptional relative to those of other countries will be examined below.

14. What these statistics emphasize is that a complete understanding of the comparative Sri Lankan experience vis-à-vis living standards is unlikely to emerge from cross-country data on living standards, or income, or social expenditures over the last twenty or forty years. And these figures reiterate the importance of allowing for different fixed effects (initial conditions).

15. The GDP deflator is used to deflate nominal expenditures. Social welfare programs in Sri Lanka include food subsidies, and a weighted index (GDP and consumer price index) may be preferable. However, as discussed later, the official consumer price index is extremely unreliable for the 1970s and shows unrealistically low inflation rates. For consistency, therefore, the approximate GDP deflator is used.

Table 2. *Levels of Income and Growth Rate Per Capita, 1960–78*

Economy	*GDP per capita* 1960	*GDP per capita* 1978	*Kravis dollars per capita* 1960	*Kravis dollars per capita* 1978	*Growth rate, 1960–78* GDP	*Growth rate, 1960–78* Kravis
Afghanistan	121	128	366	405	0.4	0.6
Algeria	254	353	1,209	1,989	2.3	2.8
Angola	149	100	934	767	1.2	−1.1
Bangladesh	59	66	355	432	−0.4	1.1
Benin	84	89	437	419	0.4	−0.2
Bolivia	134	204	684	1,151	2.2	2.9
Brazil	243	550	912	1,982	4.9	4.4
Burma	59	75	248	340	1.0	1.8
Burundi	67	97	482	374	2.2	−1.4
Cameroon	103	152	546	903	2.9	2.8
Central African Rep.	69	76	528	531	0.7	0.0
Chad	59	52	493	403	−1.0	−1.1
Colombia	256	434	1,070	1,803	3.0	2.9
Congo	138	176	653	1,030	1.0	2.6
Côte d'Ivoire	165	275	762	1,376	2.5	3.3
Dominican Rep.	238	409	926	1,487	3.5	2.7
Egypt	160	286	541	1,019	3.3	3.6
El Salvador	221	321	756	1,130	1.8	2.3
Ethiopia	47	60	278	331	1.5	1.0
Ghana	179	158	1,009	946	−0.5	−0.4
Guatemala	263	416	919	1,419	2.9	2.4
Haiti	75	76	363	436	0.2	1.0
Honduras	173	220	736	1,001	1.1	1.7
India	73	96	428	514	1.4	1.0
Indonesia	92	177	370	636	4.1	3.1
Kenya	97	152	378	481	2.2	1.3
Korea	153	488	631	2,053	6.9	6.8
Malaysia	280	588	888	1,856	3.9	4.2
Morocco	175	265	596	1,264	2.5	4.3
Nepal	41	44	345	402	0.8	0.9
Nicaragua	238	434	897	1,290	2.3	2.0
Pakistan	81	134	404	629	2.8	2.5
Paraguay	167	296	828	1,508	2.6	3.4
Peru	249	315	1,200	1,704	2.0	2.0
Philippines	254	409	644	983	2.6	2.4
Senegal	174	177	922	720	−0.4	−1.4
Sri Lanka	152	226	961	778	2.0	−1.2
Sudan	102	128	753	865	0.1	0.8
Taiwan	149	505	733	2,246	6.6	6.4
Tanzania	59	86	285	493	2.7	3.1
Thailand	95	219	446	1,121	4.6	5.3
Uganda	78	73	569	582	0.7	0.1
Zambia	213	227	657	703	1.2	0.4
Zimbabwe	232	253	880	883	1.2	0.0

Source: GDP figures are World Bank data. Kravis income numbers were obtained from Summers and Heston (1984).

Note: GDP figures are in 1960 prices and exchange rates, and Kravis numbers are in 1975 international prices.

Selection of Comparator Economies

What economies should be chosen to provide a perspective on Sri Lankan performance? Since a maintained hypothesis is that through time Sri Lanka performed better than its comparators, a useful criterion for selection might be those economies that were at broadly similar income levels in some selected base year. Since the base year is to be 1960, economies were chosen if their per capita income level was no more than double that of Sri Lanka ($153) at prevailing exchange rates and prices in 1960 (table 2).[16] Constraining the selection of economies by a predetermined income level should not introduce a bias, since in all the regressions, income is an exogenous variable.[17]

Functional Relationships between Indicators and Income

The models being considered (equations 3 and 5) are formulated in terms of stylized facts and are ones in which income is a proxy for several variables. Theory does not provide an a priori relationship between living standards (H) and income (Y).

The choice of functional form relating H and Y therefore is bound to be somewhat arbitrary. One functional form is the log–log relationship:[18]

$$\ln H_{it} = \alpha_t + \beta \ln Y_{it} \qquad (6)$$

Also plausible is a semi-log relationship ($H = \alpha + \beta \ln Y$). An intuitively appealing functional form, however, is a logistic relationship between H and Y:

$$H_{it} = \frac{K}{1 + e^{-[\alpha_t + f(Y_{it})]}} \qquad (7)$$

The logistic relationship is particularly useful for those indicators that have a physical limit, for example, life expectancy. (The physical limit is reflected by K in equation 7). In contrast, the log–log relationship assumes that the same income growth is associated with the same percentage increase in life expectancy regardless of whether it is from 50 to 60 years or from 70 to 80 years—obviously an untenable assumption. Conversely, the logistic form has the drawback that knowledge of the ceiling (or floor in the case of a variable like infant mortality) is needed for its estimation.

Once a level–level functional form is decided upon, a change–change relationship can easily be derived. For example, the corresponding difference equations for equations 6 and 7 are

$$d\ln H = \ln H_{iT} - \ln H_{it} = (\alpha_T - \alpha_t) + \beta\,(\ln Y_{iT} - \ln Y_{it}) \qquad (6')$$

16. Since a major part of the analysis is to evaluate the performance of countries over time, the major oil exporters (for example, Iran, Iraq, and Nigeria) were excluded from the analysis.

17. In other words, the assumption is made that a piecewise linear relationship exists between living standards and income. And if income is an exogenous variable, then exclusion of a country from analysis may affect the efficiency of estimation but does not affect the unbiasedness of the coefficients.

18. Indeed, this functional relationship is the one used by Isenman and Sen.

and [assuming $f(Y)$ takes the form βY]

$$(7') \qquad 1\text{n}\left(\frac{K - H_{iT}}{H_{iT}}\right) - 1\text{n}\left(\frac{K - H_{it}}{H_{it}}\right) = -(\alpha_T - \alpha_t) - \beta_T Y_T + \beta_t Y_t$$

Note that in these difference equations, the estimate of the constant term $(\alpha_T - \alpha_t)$ represents an exogenous effect (time, technology) common to all countries. Furthermore, the residual in these equations, as noted earlier, will not be influenced by initial conditions, λ_i.

These difference equations can be refined to include one additional hypothesis—namely, that the exogenous element $(\alpha_T - \alpha_t)$ is not the same for all countries but is rather a function of initial conditions. For example, cheaper methods to eradicate malaria may have no impact on a country that has already eradicated malaria. Thus $(\alpha_T - \alpha_t)$ need not be a constant. How the impact of technology is conditioned by time is a matter of specification. One equation which reflects a diminishing impact of time for countries with better initial conditions is

$$(8) \qquad d1\text{n}H = (\alpha_T - \alpha_t) \cdot \frac{1}{1\text{n}H_{it}} + \beta(1nY_{iT} - 1\text{n}Y_{it})$$

Statistical Procedures for Assessing Outliers

For each nonincome indicator, "level" regressions (such as equation 3) and change–change regressions (such as equation 5) can be estimated for the selected group of countries. If it is assumed that residuals represent permanent differences among countries, then level regressions can be used to test whether Sri Lanka was an exception relative to its income level *at that point in time,* while the change–change regression can be used to test whether Sri Lanka's performance was exceptional *during a given period of time.* Since being an exception is measured by the residual—the difference between the actual value of the left-hand side variable and its predicted value—relevant statistical techniques have to be used for determining whether the residual of a particular equation is an outlier. Since the residual is a random variable and not a parametric constant, the appropriate statistical technique is the use of a tolerance interval for an observation (forecast error and/or noncentral t tests) rather than a confidence interval for a parameter (conventional t tests). These statistical tests have been applied to the results reported in this paper (see Srinivasan 1979 and Bhalla 1984 for details).

Estimation and Results

Several models of both the level–level and change–change form were estimated for 1960, 1978, and the time period from 1960 to 1978.[19] The level–level

19. For the logistic model, the following ceiling (floor) levels, K, were assumed: life expectancy, 76 years; death rate, 6 per thousand; infant mortality, 20; fertility, 2; primary school, 115 percent; and literacy, 100 percent. The results incidentally, are not sensitive to plausible variations in K. All models were estimated for both the conventional and the Kravis definition of income. Since results do not differ, only the results for the conventional definition of income are reported.

regressions for 1960 and 1978 yield similar results. They indicate that in 1960, Sri Lanka was an outlier for three of the six indicators—life expectancy, death rate, and infant mortality.[20] This conclusion was not dependent on functional form, but the outlier status was modified somewhat by the use of the more stringent noncentral *t* statistic. A 99 percent tolerance interval suggested Sri Lanka was not, but a 95 percent tolerance interval suggested that Sri Lanka was an outlier. In the case of fertility, the outlier status for Sri Lanka is dependent on the functional form—the log–log form suggested it was not, the logistic form indicated that it was. Regarding the related education indicators—adult literacy and primary schooling—Sri Lanka was not an outlier according to any criterion.[21]

It appears that in 1960 Sri Lanka was a positive outlier among the sample countries for fertility and mortality but not for education. What was Sri Lanka's relative position in terms of these indicators eighteen years later? Did it improve its relative position?

Results according to the change–change regressions are reported in table 3. Strikingly different results are now obtained. In the case of the log–log functional form and weighting for initial conditions (equation 8), Sri Lanka is not an outlier for any of the six indicators chosen. Though not significant, Sri Lanka does worse than expected for life expectancy, death rate, primary schooling, and literacy, and better than expected for infant mortality and fertility. In *none* of these cases, though, is Sri Lanka's performance significantly different. If the logistic form is used (but one which does not weight initial conditions as the log–log form can), then Sri Lanka's performance in terms of life expectancy and death rate appears more favorable. However, though forecast error calculations suggest that Sri Lanka is an exception in terms of life expectancy, the tolerance interval calculations suggest that it is not (see table 3 and Bhalla 1984). Fertility and infant mortality were observed to be better than average, and regardless of the functional form or statistical tests, Sri Lanka performs worse than average for the education variables.

These results highlight both the importance of functional forms and the importance of initial conditions. For example, implausible results are generated by the log–log functional form. When a change–change regression is estimated (that is, the correlation between fixed effects and per capita income is removed), the results indicate that income change has a *negative* impact on changes in life expectancy and primary schooling.[22]

20. See Bhalla (1984) for details.

21. The importance of functional forms was indicated by the difference in the result for these two indicators according to the log–log and logistic form. Sri Lanka was observed to be worse than average according to the log–log form; the preferred logistic form indicated that Sri Lanka was a positive deviant but not significantly so.

22. This result is also obtained if the constant term is not weighted for initial conditions and if the regressions are run with per capita income replaced by Kravis income.

Table 3. *First Differences of Models Relating Indicators and Income*

Indicator and model[a]	Coefficient on time ($\alpha_T - \alpha_t$)	Coefficient on income change (model I) or 1978 income (model II)	Coefficient on 1960 income (model II)	Sri Lanka error[b]	(SEE) Standard error of estimate	Forecast error[c]
Life expectancy						
Model I	0.695	−0.032		−0.0487	0.0315	
	(27.143)	(−2.198)				
Model II	−0.397	−0.00112	0.00093	−0.291	0.138	0.1396
	(−8.265)	(−4.369)	(1.780)			
Death Rate						
Model I	−1.121	−0.0159		0.111	0.119	
	(−12.887)	(−0.252)				
Model II	−0.0727	−0.00118	0.00124	−0.359	0.0906	0.0916
	(−2.308)	(−7.017)	(3.602)			
Infant mortality						
Model I	−1.710	−0.316		−0.0228	0.134	
	(−11.048)	(−4.703)				
Model II	−0.0419	−0.00114	0.00136	−0.1258	0.0704	
	(−1.713)	(−8.677)	(5.083)			
Fertility rate						
Model I	0.0211	−0.424		−0.231	0.157	
	(0.292)	(−5.300)				
Model II	−0.0300	−0.00216	0.00282	−0.248	0.145	
	(−0.522)	(−7.591)	(4.890)			
Primary school						
Model I	2.375	−0.523		−0.206	0.287	
	(11.040)	(−4.080)				
Model II	−1.237	0.00217	−0.00156	0.525	0.739	
	(−4.740)	(1.524)	(−0.543)			
Literacy						
Model I	1.696	−0.0415		−0.337	0.354	
	(8.275)	(−0.270)				
Model II	−0.974	−0.00153	0.00301	0.695	0.570	
	(−4.656)	(−1.387)	(1.325)			

Note: For all variables, 1960 and 1978 data are taken, except infant mortality (1960 and 1982) and primary schooling (1960 and 1977). Figures in parentheses are *t* statistics for the parameter estimates.

a. Model I represents equation 8 and model II represents equation 7′.

b. Sri Lanka error represents the difference between the actual and predicted value for Sri Lanka.

c. Only for death rate is Sri Lanka an outlier according to both forecast error and the noncentral *t* statistic. Forecast errors (and noncentral *t* statistics) are not calculated for models for which Sri Lanka is clearly not an exception.

To summarize the regression results, the use of one time-period level–level regression suggests that Sri Lanka had higher living standards than its comparators. This result holds for 1960 (Bhalla 1984) and 1975 (Isenman 1980; Sen 1981). However, this result tells us little about when and why this higher level was achieved. Historical data suggest that even prior to the expansion of social expenditures (and the introduction of food subsidies) in the early 1940s, Sri Lanka had exceptionally high living standards. Consequently, one-period regressions for 1960 or 1975 may be capturing the effects of early achievement (initial conditions) and not entirely those of social expenditures.

If, however, interest is in the comparative nature of *improvement* in living standards, then the results suggest that Sri Lanka's performance for the time period from 1960 to 1978 was, statistically speaking, not better than average. Indeed, in some cases, it has done worse (though never significantly so) than a typical country since 1960. This performance is somewhat surprising, especially given the large increases in social expenditures in Sri Lanka in the post-1950s time period. Of course, in a cross-country regression, it is Sri Lanka's *comparative* expenditure pattern that is relevant in interpreting the residuals. Unfortunately, social expenditure data of the form presented for Sri Lanka (table 1) are not available for most developing countries for most of the 1960s and the early 1970s. However, given the percentage increase in real expenditures observed for Sri Lanka during the post-1950s time period, it is likely that such expenditure changes were greater than average.

It should be emphasized that this conclusion of nonexceptional performance is *not* dependent on functional forms. As noted above, different functional forms make some difference to the estimates of particular equations but not to the general result. Furthermore, the choice of income variable also does not affect the conclusion—results are similar when income is measured in Kravis dollars. Finally, noneconometric tests (for example, the shortfall criterion, as used by Sen 1981) yield similar results (see Bhalla 1984). It appears that the results are quite robust; Sri Lanka was not a comparatively exceptional performer in terms of improvement in living standards during the time period from 1960 to 1978.

In principle, the same methodology for assessing comparative performance could be conducted for the shorter time period from 1977 to 1984. The Sri Lankan policies of this period have generally emphasized economic growth and a reduction in social expenditures; it would, therefore, be useful to examine Sri Lanka's comparative performance under the new policy regime. Though statistical tests are not conducted, the following characteristics of performance are observed: primary school enrollment in Sri Lanka actually *declined* from a level of 95 percent in 1960 to 86 percent in 1977 and *increased* from this level to 103 percent in 1984; infant mortality declined at a faster rate *after* 1977, dropping from 42 per thousand in 1977 to 32 in 1982, compared with the decline from 57 in 1960 to 42 in 1977.[23] This improved performance is noteworthy, for it is likely that is represents improvements in the living standards of the poor. Thus, though not conclusive, the evidence does suggest that the growth orientation of the economy from 1977 to 1984 was accompanied by improvement in the living standards of the population and of the poor.

Effect of Initial Conditions—a Numerical Example

The importance of controlling for initial conditions can be illustrated by the following numerical example. Sen (1981) discusses in detail Sri Lanka's exceptional performance in terms of life expectancy, as measured by its large residual

23. Data are from Alailima (1985), which are based on *Statistical Abstracts,* published by the Sri Lanka Department of Census and Statistics. Also see note b, table 1.

Table 4. *Years Needed to Match Social Welfare Achievements of Sri Lanka through the Growth of Income*

Growth assumption[a]	*Growth rate of per capita* GNP *per year*[a]	*Sen's income-based longevity increases (power fit)* without *initial conditions (years)*[a]	*"New" income-based longevity increases (logistic fit)* with *initial conditions (years)*[b]
No change in growth rate	2.00	152	46
Full transfer at 1970–76 capital output ratio	4.01	77	16
Full transfer at 1961–70 capital output ratio	5.37	58	6

a. The title, growth assumption, and the first and second columns are identical to Sen (1981, table 4, p. 305).

b. The third column is based on a change–change regression reported in table 4, model II for life expectancy. The years of lead are as of the terminal date of analysis 1975 (second column) and 1978 (third column).

for a cross-country level–level regression for 1975. He then states: "The question has been frequently asked whether a poor country like Sri Lanka can afford to have such a high volume of social welfare expenditure, and it has also been argued that its growth rate may have been negatively influenced by the allocation of resources to these programs. . . . But the question is whether the growth rate would have been much higher in the absence of these programs" (p. 302).

Thus, a clear trade-off between social expenditures and growth is recognized. Table 4 reproduces portions of Sen's calculations which suggest that the high life expectancy enjoyed in Sri Lanka is a result of its welfare-oriented (direct) strategies. For example, Sen's results as given in the second column of the table suggest that if Sri Lanka's GDP grew at a 2 percent annual rate, it would take 152 years to achieve income levels corresponding to its life expectancy level of 69 years in 1975. Hence, Sen's conclusion, "The overall impression is one of a long haul in matching social welfare achievements of Sri Lanka with income growth" (1981, p. 305).

The third column represents the calculations according to the methodology that incorporates the influence of initial conditions.[24] In other words, the third column reports the number of years it would take Sri Lanka to reach a life expectancy of 69 years (1978 level) *given* its income level ($152 per capita) and its life expectancy (62 years) in 1960. Since time is measured from 1960, the "lead" that Sri Lanka enjoys in *1978* is net of eighteen years progress.

24. These calculations are for the logistic form (equation 5). Unfortunately, a direct comparison with Sen's log–log model cannot be conducted, since, as reported in table 3, a *negative* relationship is observed between changes in life expectancy and changes in per capita income.

These results highlight the dangers of ignoring initial conditions. Instead of a lead of 152 years, Sri Lanka enjoys a lead of only 46 years if it continues to grow at only 2 percent a year. At the alternative growth rate of 4.01 percent (somewhat less than Sri Lanka's growth rate since 1978), Sri Lanka's lead in 1978 is reduced to only 16 years. In contrast, Sen's estimate of the lead according to a level–level regression and a growth rate of 4.01 percent is 77 years. Thus, a conclusion of a "long haul" based on a regression which excluded initial conditions is reduced to a "short haul" of only sixteen years when such conditions (fixed effects) are incorporated into the analysis.

II. Economic Growth in Sri Lanka, 1960–84

The new government which came to power in Sri Lanka in late 1977 implemented a comprehensive set of economic policies which marked a distinct shift from the direct to the indirect approach to raising welfare. This shift requires a review of the policies in place before and after 1977 and the performance of the Sri Lankan economy during both periods.

During the 1950s and 1960s, Sri Lanka's economic policies were characterized by increasing government intervention in the economy and high and increasing social welfare expenditures (see table 1). Active government involvement in the economy intensified in 1970 when a new government was elected. The prior weekly ration of rice (two pounds free per person per week) was supplemented by another two pounds per week at a subsidized price. Other goods were distributed at low prices, and rationing of wheat flour and sugar was introduced. Land reform effectively transferred much of the estate sector from private ownership to the government. Several private enterprises were nationalized, and a number of government-owned "business undertakings" were established. In general, government enterprises were heavily subsidized and protected from competing foreign imports by means of a dual exchange rate system and import licenses. These "direct measure" policies were continued until a new government won the popular mandate in late 1977.

The policy regime adopted since 1977 has significantly reduced government intervention in the economy, although there have been fluctuations in the government's commitment to the new set of policies. The exchange rate was unified and devalued, and controls on foreign exchange and the financial sector were reduced. Both foreign investment and foreign aid were successfully solicited. Import restrictions were reduced, and new exports (that is, other than tea and rubber) were promoted. These measures, aimed at increasing growth, were coupled with a reduction in social expenditures. The rice ration system was altered so that only the poorest half of the population was eligible for rations, and many other subsidies were reduced or eliminated.

There is substantial evidence that the *growth* objectives of the government were achieved. The average per capita growth rate of 1.3 percent from 1970 to

Table 5. *Average Rates of Real Economic Growth, 1960–84*

Sector, product, or growth measure	*1960–65*	*1965–70*	*1970–77*	*1977–84*
Agriculture	2.7	4.2	2.2	3.8
Industry	5.2	7.3	1.6	5.6
Services (including construction)	4.6	7.3	3.2	6.1
Total GDP	4.0	5.4	2.9	6.0
GDP per capita	1.5	3.0	1.3	4.3
GDP per capita, Kravis	−3.8	0.2	−1.1	3.5[a]

Sources: Central Bank of Ceylon (1970, 1974, 1983, 1984), Peebles (1984), and Summers and Heston (1984).

Note: Prior to 1979, data are from Peebles (1984), and the deflator is based on 1959 factor cost prices. Data after 1970 are from Central Bank of Ceylon (1970, 1974, 1983, 1984) and the deflator is based on 1970 factor cost prices.

a. 1977–80.

1977 reached 4.3 percent from 1977 to 1984.[25] It is interesting to note that the poor economic performance in the early 1970s began before the oil price hikes in late 1973 and that the high rates of economic growth since 1977 continued even during the second dramatic rise in oil prices in 1979. Furthermore, the growth since 1977 seems to have been shared by all major sectors of the economy (table 5). It also appears that the growth strategy was relatively equity-oriented, to the extent that it was of a labor-intensive variety. Agriculture (particularly paddy cultivation), construction, services, and textile manufacturing are all relatively labor-intensive, and all have enjoyed high rates of growth since 1977.

That the pre-1977 period was characterized by economic stagnation and/or slow growth is also revealed by figures for Kravis's adjusted purchasing-power parity figures (data are from Summers and Heston 1984). The average GDP growth rate for the 1960–78 period was −1.2 percent—a surprisingly large decline. Only 6 other countries (of the 44 countries reported in table 2) show a negative growth rate for the 1960–78 period. A recovery since 1977 is also captured by the Kravis data; the annual rate of per capita economic growth from 1977 to 1980 was 3.5 percent (in Kravis 1975 dollars).

As part of the post-1977 growth strategy, Sri Lanka has successfully focused on promoting production of paddy, tea, and industrial exports and on increases in employment. Paddy production grew by 84 percent from 1976 to 1984, and rice imports, which had been a major drain on foreign exchange, fell from 43 percent of production in 1970–77 to 13 percent in 1978–82 and to only 2 percent in 1984. In addition, this increased production has led to a large decline in the relative price of rice; an occurrence which disproportionately benefits the major rice consumers—the poor.[26] Recently, some increase in the production of Sri Lanka's major traditional export crop—tea—has occurred. Production, which had stagnated since 1960, reached 208,000 tons in 1984, up from an

25. There is some evidence that the rate of growth might be overstated during the period from 1970 to 1977 (see Bhalla and Glewwe 1985).

26. For example, the consumer price of rice rose by 91 percent from 1978 to 1984, while the increase for the food price index during the same period was 170 percent (Bhalla and Glewwe 1985).

Table 6. *Employment Data from Household Surveys, 1963 to 1981–82*

Year and survey	*Labor force (percentage of population)*	*Employment (percentage of population)*	*Unemployment (percentage of labor force)*
1963 CFS	52.1	27.4	13.8
1969–70 SES	55.6	29.4	14.0
1973 CFS	53.2	25.8	24.0
1978–79 CFS	56.9	31.6	15.0
1980–81 SES	58.1	30.4	13.6
1981–82 CFS	57.1	30.3	11.7

Sources: Central Bank of Ceylon (various years), Sri Lankan Department of Census and Statistics (various years).

Note: CFS, Consumer Finance Survey; SES, Socio-Economic Survey. The labor force is defined as the proportion of the total population between the ages of 14 and 55 years.

average level of 192,000 tons in 1980–83 and 197,000 in 1959–61. This may, in part, have been caused by the 27 percent real price increase enjoyed by tea producers from 1975–77 to 1982–84. Promotion of export-oriented manufactures also led to growth in that sector, and combined with a decline in traditional agricultural exports, this created a rise in the share of manufactured goods in total exports from 11.8 percent in 1975 to 34.1 percent in 1984 (Central Bank of Ceylon 1983, 1984).

Statistics on employment in developing countries are generally weak, yet available data indicate that employment has been higher and unemployment lower in the post-1977 period (see table 6). Since 1977, employment (as a share of population) has remained above 30 percent, compared with a range of 25.8 percent to 29.4 percent from 1963 to 1973. Unemployment rates, which were 24 percent in early 1973 and 22 percent in 1975,[27] dropped to 13.6 percent by 1980–81 and were only 11.7 percent in 1981–82.

This section has presented a broad picture of the Sri Lankan economy from 1960 to 1984. The next section will focus on the effects of the post-1977 policies on the poor and on the overall level of economic inequality.

III. Changes in Inequality and Poverty

The labor-intensive orientation of the post-1977 growth led to substantial employment gains from which the poor were likely to gain. As part of the economic reforms instituted since 1977, however, direct provisions of food to the population were reduced. The elaborate food-rationing scheme was replaced by a food stamp system, and universal eligibility for food rations was replaced by an income criterion so that only households earning less than Rs300 per month in 1979 were eligible. Since incomes were based on self-declaration, some leakage to wealthier households was inevitable. The targeting of the program

27. Full survey data for 1975 were not available to the authors and thus are not cited in table 6 (Government of Sri Lanka 1975).

Table 7. *Receipt of Food Stamps by Expenditure Quintiles, 1981–82*

Per capita expenditure quintile	*Percentage receiving food stamps*
1	79.6
2	65.8
3	50.7
4	36.7
5	15.0
All	49.6

Source: Estimated from the 1981–82 Consumer Finance Survey by Edirisinghe (1985).

Note: Quintile 1 is poorest.

was generally effective in reaching the poor—almost 70 percent of the bottom half of the population received food stamps (table 7).[28] Effective targeting has also meant a reduction in net food subsidies; these have declined from a level of 14 percent of government expenditures in 1970 to 11 percent in 1979 and to less than 4 percent in 1984.

As part of the policy of reducing food subsidies, the government kept constant the *nominal* value of food stamps. The real value of these transfers deteriorated, and by 1982 the value of the subsidy received by eligible households was about half its 1979 value (see price index in table 8). However, if the comparison is made with the earlier rice rations, this is an exaggeration of the real decline in purchasing power. The relative price of rice has declined since 1979—while overall food prices have increased by 130 percent, rice prices have only increased by 76 percent. The average recipient of food stamps in 1982 could purchase only six pounds of rice per month, which compares with nine pounds in 1979—a decline of 33 percent.

It is clear that the change from general food subsidies to targeted food stamps was a major one. Given that the value of food stamps was fixed in nominal terms and that only 50 percent of the population received these transfers, there is a real possibility that the welfare level of the population declined. Conversely, the economy did grow at a faster rate, and employment gains were evident. The question remains—what did the poor and the overall population gain to compensate them for their loss of government transfers?

To answer this question, a detailed analysis of the available data is required, and particular attention must be paid to the reliability of the data.

28. An important and most unfortunate exception to this targeting are the estate workers, who comprise about 6 percent of the total population and are among the poorest workers in Sri Lanka (Sahn 1985; Bhalla and Glewwe 1985). Only 13 percent of such households received food stamps, compared with 57 percent in the rural areas and 33 percent in the urban areas (Edirisinghe 1985). Since they are subject to minimum wages, and thus their incomes are known, self-declaration of income was not an option available to the estate workers.

Intertemporal Welfare Comparisons: Is 1969–70 an Appropriate Comparator?

National-accounts data do not contain information on the *distribution* of income (or consumption), and (as discussed in Bhalla and Glewwe 1985) estimates of nominal expenditures from these data and the official price index are inconsistent with the information given by household survey data. Fortunately, detailed household survey data are available for the years 1963, 1969–70, 1973, 1978–79, 1980–81, and 1981–82.[29] These data, which contain a wealth of information on the levels and distribution of consumer expenditures and income, are analyzed below.

Since 1969–70 was the first year for which survey data were available on computer tape, it necessarily became a benchmark for comparison. Consequently, most analyses report on changes *since* 1970. This would be appropriate if 1969–70 were a typical or trend year for expenditures and income.

As it turns out, 1969–70 is an *unfortunate* base year for comparison of consumer welfare and of food expenditures. Because food purchases account for almost 60 percent of total expenditures and a third of food expenditures are devoted to rice, short-term changes in rice availability and prices can have an appreciable effect on welfare. The weather was favorable in 1969–70, and rice yields in that year were 6 percent above the peak 1968–69 averages and were the highest level achieved in Sri Lanka until 1979. (In terms of production, 1970 levels were 17 percent above the record crop of the previous year.)

In addition, 1970 was an election year, and there does seem to be an increase in food availability during electoral periods in Sri Lanka. This hypothesis was tested by relating rice availability per capita and election years (1960, 1965, 1970, and 1977). An econometric investigation gives the following results:[30]

$$\ln Rice = \underset{(5.8)}{-25.8} + \underset{(7.4)}{0.017} \cdot Time + \underset{(1.03)}{0.08} \cdot 1960 + \underset{(1.23)}{0.096} \cdot 1965 + \underset{(1.90)}{0.148} \cdot 1970 + \underset{(1.62)}{0.13} \cdot 1977$$

$$\bar{R}^2 = 0.74$$

This equation confirms, in a striking fashion, the electoral rice cycle. The coefficients for election years are positive and are significant for the 1970 and 1977 election years. The unusual nature of 1970 is further underlined by the large coefficient observed (0.148), which indicates that rice availability was 15 percent above trend. It should be noted that the above equation was estimated for *net* availability of rice. Thus, the effects of changes in stocks caused by good weather have already been removed from the data. In that sense, any excesses in availability that are observed point to the existence of an electoral food cycle.

The above trend rice availability levels for 1970 are confirmed by the analysis of import data. Annual rice imports from 1968 to 1972 were successively 349, 264, 534, 339, and 266 metric tons. The average for these years is 350 metric

29. The 1963 survey results, however, are not available on computer tapes.

30. A full presentation of the electoral food cycle is given in Bhalla and Glewwe (1985).

tons, which suggests an import level of 184 metric tons above the trend in 1970. This is strikingly close to the excess availability derived from the estimated equation reported above—196 metric tons.

Wheat imports and availability also rose sharply in 1970. A conservative estimate (of deviation from a simple four-year average for 1969–72) suggests an increase of 8 kilograms per capita per year or almost 25 percent above trend.

According to conservative estimates by Bhalla and Glewwe (1985), the transitory monetary gains accruing to the population from the additional availability of wheat and rice in 1970 amounted to Rs2.34 per capita per month. The average food expenditure in the 1969–70 Socio-Economic Survey was Rs 34.7. Thus this estimate of transitory welfare gain in 1969–70 (which is a lower-bound estimate since the prices of rice and wheat are assumed to stay constant) represents approximately 7 percent of average food expenditures. In terms of the lowest quintile, the transitory welfare effects are 12 percent for food and 8.5 percent for total expenditures, respectively. Thus the transitory effect turns out to be quite large in 1970. For example, the implications of transitory food expenditures for calculations of absolute poverty turn out to be strikingly large—a food expenditure poverty line of Rs23.34 (given the additional Rs2.34 monetary gain) rather than Rs21 in 1969–70 implies an increase in the rate of absolute poverty (head count method) from 11 to 19 percent.

Table 8. *Expenditures and Price Index, Sri Lanka, 1963 to 1981–82*

	Survey data						*National accounts data, total expenditures*[b,d]	
	Price index[a]		*Food expenditures*[b,c]		*Total expenditures*[b]			
Year	*Food*	*Total*	*Nominal*	*Real*	*Nominal*	*Real*	*Nominal*	*Real*
1963	77.1	79.4	23.9	31.0	39.6	49.8	42	53
1969–70	100.0	100.0	34.7	34.7	59.7	59.7	66	66
1973	127.2	127.3	35.5	27.9	61.4	48.2	90	59
1978–79	334.2	311.5	92.5	27.7	171.6	55.1	233	72
1980–81	487.7	458.6	156.9	32.2	240.8	52.5	383	73
1981–82	584.9	564.7	168.4	28.8	299.6	53.1	434	76

Source: Based on data from Bhalla and Glewwe (1985).

a. Food and total price indexes are from Bhalla and Glewwe (1985), which presents rates of inflation on an annual basis. Adjustments, however, had to be made to these rates in order to conform with the period of the survey. For the January–February 1973 survey, special tabulations done by the Department of Census and Statistics were used. For the annual surveys, the price index corresponding to the survey months has been computed under the assumption that within each survey year monthly price increases occur at a constant rate.

b. Expenditure data are written as rupees per capita per month.

c. Food expenditure data are exclusive of alcohol, liquor, and tobacco. Expenditures prior to 1978–79 have been adjusted to reflect market prices of subsidized items.

d. National accounts data are for calendar years. The price index for these years is as follows: 1970 = 100, 1973 = 151.5, 1979 = 323.6, 1981 = 524.4, 1982 = 570.9.

Table 9. *Food and Total Expenditures, Poorest 40 percent of Population*
(rupees per capita per month)

	Food		*Total*	
Year	*Nominal*	*Real*	*Nominal*	*Real*
1969–70	23.2	23.2	35.3	35.3
1973	24.0	18.9	35.5	27.9
1978–79	59.0	17.7	95.9	30.8
1980–81	97.4	20.0	136.4	29.7
1981–82	107.7	18.4	164.4	29.1

Source: Based on data from Bhalla and Glewwe (1985).
Note: In each survey, individuals were ranked according to per capita food expenditure. The price deflator is as reported in table 8.

Food and Total Expenditures from 1963 to 1981–82

Having cautioned against inferring trends from the 1969–70 data, one can now analyze the equity performance of the Sri Lankan economy. Tables 8 and 9 contain data from the six surveys conducted from 1963 to 1981–82.[31] Nominal and real levels of both food and total expenditures are presented for the population as a whole and for the poorest 40 percent of the population. This poorest 40 percent is determined on the basis of per capita food expenditures.

The national accounts data in table 8 show a peak in total expenditures per capita in 1970, with a decline of 10 percent in 1973 (and probably an even more severe decline in 1974 and 1975) and a recovery from 1978 onward.[32] The 1978 consumption level is 18 percent above its 1973 level, and the 1982 consumption level is about 7 percent above the 1978 level and 15 percent above the 1970 level. The survey data in table 8 show similar trends. As before, 1969–70 is observed to be a peak year in terms of food consumption.[33] If the transitory elements are excluded from the 1970 survey, however, then 1963 and 1970 represent almost equal food expenditures. As an alternative to adjusting for the bumper nature of 1969–70, there is some justification for using the 1973 survey as a basis for comparison. This survey was conducted in January and February 1973, before the oil and commodity price increases of 1973–74. Given the advent of a new government in 1970, the 1973 data might be more representative of trends under that government. With 1973 as the base year, no increase in

31. All nominal expenditures are deflated by the Bhalla and Glewwe (1985) DCS price index, which has been constructed with the help of the Department of Census and Statistics (DCS), Sri Lanka. The official Colombo Consumer Price Index shows unrealistically low inflation rates for 1970 to 1978. It registers an increase of only 65 percent in contrast to one of 170 percent given by the DCS index.

32. Unfortunately, the Bhalla and Glewwe DCS price index contains very rough estimates of price levels for 1971, 1972, and 1974–77.

33. Food balance sheet data support this conclusion. Sri Lanka's rice availability and total caloric intake in 1970 were higher than that of any year until 1983.

food consumption of the population as a whole is evident in 1978–79, although some increase is evident thereafter. Total expenditure figures suggest a 9–10 percent increase between 1973 and the early 1980s.

The results for the poorest 40 percent of the population given in table 9 follow the general pattern noted above. Total consumption in the early 1980s registers a 4 percent increase over 1973, while food expenditure increases by 6 percent from 1973 to 1980–81 but then declines by 8 percent in 1981–82.[34]

Thus, a general picture that emerges from tables 8 and 9 is that growth in national income has *not* been accompanied by a decline in the consumption of the overall population or of the bottom 40 percent.[35] Even the wealthiest 60 percent of the population, who lost the most with the introduction of the food stamp scheme, did not suffer a loss in food consumption; in real terms, their food consumption was Rs34 in 1973 and Rs36 in 1981–82 (using 1969–70 prices). As emphasized earlier, year-to-year fluctuations contain transitory elements which need to be removed before firm conclusions about trends can be drawn. The general pattern suggests that food consumption held steady during the years immediately following economic reforms and, more importantly, following the reduction or withdrawal of food subsidies. If national accounts data are utilized (and if the magnitude of measurement errors are similar for the bottom 40 percent and the rest of the population), then one finds that consumption levels for the poorest members of the population have increased since 1977.

One final point regarding trends in consumption in the pre-1977 and post-1977 phases: food expenditures, based on adjusted 1963 survey data, averaged Rs23.9 per capita per month.[36] This translates into Rs31 in 1969–70 prices, which is almost 11 percent higher than food expenditures observed in 1973 and higher than every subsequent year except 1969–70 and 1980–81. Although a detailed analysis cannot be conducted with the 1963 data, it does appear as if the 1963 to 1977 period did not witness any "trend" increase in consumer welfare as measured by food (or total) expenditures. Indeed, if anything, a decline is observed.

In summary, tables 8 and 9 indicate an *absence* of a decline in food consumption following the reduction of food subsidies and the implementation of the food stamp program in 1979. Employment gains, better targeting of food transfers, and the large expansion in rice output (and the corresponding decline in its relative price) are important contributors to the maintenance (if not an increase) of consumption levels.

34. Ideally, separate price deflators would be calculated for the bottom 40 percent and the total population. It is likely that the above changes in consumption for the poor are lower-bound estimates since the relative price of rice has been declining since 1979.

35. Different population groups within the bottom 40 percent (for example, estate workers) may show different trends.

36. The reported figure is Rs20.27 per capita. This figure, however, is adjusted upward to reflect market prices for subsidized rice.

Inequality in Sri Lanka since 1969–70: The Findings

Economists have often been concerned about the impact of economic growth on inequality *independent* of the impact of such growth on the absolute levels of living. The concern with inequality usually entails an evaluation of the distribution of incomes (for example, UNICEF 1985). Unfortunately, in most survey data, there is likely to be a larger variance and a greater bias (understatement) in reported incomes than in reported expenditures. Furthermore, permanent-income considerations would suggest that consumption is a better indicator of welfare than income. For both these reasons, consumption levels and consumption distributions are preferable indicators of equity.

The level of equity attributed to a particular distribution of income or expenditures is commonly measured by indicators which take the value of zero if the distribution is completely egalitarian and register larger positive values as the distribution becomes less equal. As measures differ in sensitivity to different types of inequality (for example, extreme wealth or extreme poverty), three measures of inequality were used. They are Theil's measure of inequality (T), Theil's second measure of inequality (L), and the variance of the logarithm of income or expenditures (LV).[37] They are defined as follows:

$$T = \sum_i \frac{Y_i}{Y} \ln\left(\frac{Y_i N}{Y}\right)$$

$$L = \sum_i \frac{1}{N} \ln\left(\frac{Y}{Y_i N}\right)$$

$$LV = \frac{1}{N} \sum_i \left[\ln(Y_i) - \frac{1}{N} \sum_i \ln(Y_i)\right]^2$$

where Y_i is the income of individual i, Y is total income, and N is the total population.

The use of expenditure data gives strikingly different results about inequality than those given by income data (table 10). Between 1969–70 and 1973, all income measures register a decline in the level of inequality. In contrast, two expenditure inequality measures (T and L) increase while the log-variance measure shows a slight decline. Between 1973 and 1978–79, all inequality measures for both income and expenditures show a worsening situation. However, after 1979, measures of income and expenditure inequality diverge. The three income measures show a continued deterioration of equity in 1980–81, and the T and L income measures indicate that this decline continued in 1981–82. The expenditure measures, however, show a marked improvement in equity between 1978–79 and 1980–81, with some reversal of this improvement in 1981–82.

37. For a detailed discussion of these measures and of the measurement of inequality, see Glewwe (forthcoming).

Table 10. *Income and Expenditure Inequality, 1969–70 to 1981–82*

Inequality measure	*1969–70*	*1973*	*1978–79*	*1980–81*	*1981–82*
Income					
T	0.2128	0.2029	0.3153	0.3211	0.4091
L	0.1774	0.1685	0.2410	0.2744	0.2888
LV	0.3028	0.2832	0.3818	0.4796	0.4362
Expenditure					
T	0.1811	0.2705	0.2888	0.1754	0.2249
L	0.1518	0.1718	0.2004	0.1517	0.1820
LV	0.2593	0.2463	0.3006	0.2674	0.3065

Sources: Consumer Finance Surveys, Central Bank, 1973, 1978–79, 1981–82. Socio-Economic Surveys, Sri Lankan Department of Census and Statistics, 1969–70, 1980–81.

Note: Larger values indicate a greater degree of inequality.

These results on expenditure inequality, together with those on absolute expenditure levels noted above, suggest that most sectors of the economy have shared in the economic growth that has occurred since the economic reforms of 1978. Clearly, too much should not be read into the figures on expenditure inequality. It is plausible that in recent years there has been a greater underreporting of expenditures (such as on durables) on the part of the rich than the poor. Allowance for this would increase the levels of inequality. According to a rough average of the 1969–70, 1973, 1980–81, and 1981–82 data, the survey figures (which are generally reliable) reveal a level of expenditure inequality in a targeted food stamp scheme which is not much different than that in a regime of universal subsidies. If the data on levels (tables 8 and 9) and inequality (table 10) are substantially correct, then they imply that growth has indeed trickled down; that is, food subsidies have been replaced by labor income.

IV. Conclusion

In this article, alternative methodologies of analyzing cross-country performance in terms of living standards were discussed. The methodology offered emphasized the inclusion of the role of initial conditions in evaluating country performances over time. Furthermore, the paper emphasized the importance of using consumer expenditure data, rather than the conventionally used income data, for analyzing changes in inequality.

The discussion in the paper was largely based on the Sri Lankan experience since 1960. Sri Lanka has had contrasting policies during the two time periods; direct equity-oriented policies were emphasized before 1977, while the post-1977 period has generally emphasized economic growth. It is of considerable interest, therefore, to evaluate the impact on living standards and equity of these policy changes.

In a cross-country comparison, Sri Lanka emerges as a country with relatively high living standards in the late 1970s. This result, however, cannot be used to support the conclusion that Sri Lankan policies since 1960 (or even since independence in 1948) were responsible for this success. Comparison with other countries shows Sri Lanka to be relatively exceptional in 1960, 1948, and perhaps even earlier.

The results regarding the comparative part of this study are as follows. It was demonstrated that the conclusion pertaining to Sri Lanka's "exceptional" status in the mid-1970s may have resulted from a methodology which ignored the important effect of initial conditions. When such initial conditions are incorporated into the analysis, a different result emerges—Sri Lankan performance in terms of achievement of living standards is observed to be comparatively nonexceptional for the time period from 1960 to 1973. Since large increases (and levels) in social welfare expenditures are observed in Sri Lanka during the post-1950s period, the results suggest that the direct approach for increasing welfare was not particularly effective from 1960 to 1978. Indeed, it was noted that since 1977, living standards of the poor and the population in terms of two important indicators—primary school enrollment and infant mortality—have increased at a *faster* rate than was the case from 1960 to 1977.

While it is beyond the scope of this article to study the causes of growth (or lack thereof) in the pre- and post-1977 time periods, it is apparent that the two policy regimes—1960–77 and 1977–84—show different results regarding economic growth. In the latter period, economic growth more than doubled, and all the major sectors (agriculture, industry, and services) participated. Further, employment gains from 1977 to 1984 were large, and in 1981–82 the unemployment rate was at a historic low.

Available data on household expenditures suggest that expenditure levels of the population have also increased from those observed in the pre-1977 years. Furthermore, inequality in expenditures in the early 1980s was not much different than that observed during the large government expenditures and food subsidy regime of the early 1970s. In addition, the poor (defined as the bottom 40 percent of the population) have not lost with the introduction of economic reforms. Food and total expenditures of the poor are above those observed in early 1973. This result is encouraging, for it suggests that the poor may have been somewhat compensated for their loss in government transfers through increases in jobs and income.

In the introduction, two contrasting approaches to raising economic welfare were noted—the direct or basic needs approach and the indirect or economic growth approach. While it is unlikely that a government can (or should) take either of the extreme alternatives, the nature of the appropriate mix is also unknown. At the risk of exaggeration, the pre-1977 Sri Lankan economic regime may be characterized as an extreme version of the direct approach. This study shows that the results are not very encouraging; the period is characterized by little per capita growth, nonexceptional improvement in living standards, and little (if not negative) change in food and total expenditures.

The time period subsequent to 1977 may be labeled (again in an exaggerated manner) as a "growth only" phase. Food subsidies were administered through a more efficient, targeted food stamp program and were only gradually decreased over the years. Furthermore, the growth was of a labor-intensive kind. Thus, this phase was not as onerous as it could have been. The analysis suggests that it also produced positive results. Food consumption was maintained, per capita consumption expenditures increased, strong economic growth was initiated and maintained, and there are indications that living standards have improved. Much more can, and will, be learned from the interesting Sri Lankan experience; the evidence examined in this paper, however, suggests that the post-1977 policies have not been detrimental to equity objectives and may offer more promise than those which they replaced.

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A New Method for Estimating the Effects of Fuel Taxes: An Application to Thailand

G. A. Hughes

This article proposes a new methodology for estimating the impact of fuel price and tax changes on the general price level and the distribution of income and applies a model to Thailand using data for 1975–76 and 1981–82. Because the model allows for pricing under international competition where tax increases must be partially absorbed in reduced factor income rather than always being passed on in higher consumer prices, the results are significantly different from those generated by the more conventional cost-plus pricing rule. The inflationary impact of fuel tax changes is slight because of both the openness of the economy and the low energy intensity of manufacturing and other production in Thailand. In contrast, taxes on imports engender price increases not only for imports but also for goods which substitute for imports. The model also indicates that the net effects of taxes on petroleum products (other than kerosene) are progressive in their distributional impact, relative to a tax on imports or consumption. A main policy conclusion of the study is that fuel taxes could be used to increase both equity and allocative efficiency without inducing significant inflationary responses. It follows that in the current circumstances of falling world oil prices, developing countries could generate revenues needed for structural adjustment by increasing fuel taxes to maintain domestic petroleum price levels.

In many developing countries, the effective ad valorem rate of tax on petroleum products fell significantly during the 1970s (Hughes 1986b). The reasons for this decline are many and doubtless vary from country to country, but among them is the fear that raising petroleum product prices either would have an adverse impact on the price level or would worsen the distribution of income. In contrast, many developed countries rely upon petroleum taxes as a significant source of government revenue, and it has often been suggested that gasoline and other fuel taxes are an appropriate method of financing the costs of road networks. These various policies and proposals reflect widely differing views of the

G. A. Hughes is at the University of Edinburgh. The author is grateful to Esra Bennathan, David Newbery, and Nick Stern for their suggestions and to the National Statistical Office and the National Energy Administration, Bangkok, which gave access to the data used in this study. The research on which the paper is based was carried out under a World Bank research project on pricing and taxing transport fuels in developing countries.

inflationary and distributional impact of fuel taxes. Hence, as part of a research project sponsored by the Transportation Department of the World Bank, I have developed a new methodology for estimating the impact of taxes on items such as fuels which are primarily used as intermediate inputs into the production of other goods and services. In this article, I outline this methodology and apply it to Thailand.

Thailand is quite typical of a large number of developing countries in that it relies primarily upon imported oil and petroleum products to meet its commercial energy requirements. Petroleum accounted for 85 to 90 percent of commercial energy demand and 65 to 70 percent of total energy demand in the late 1970s. Hydroelectricity and lignite accounted for most of the residual demand for commercial energy, while fuelwood and bagasse represent the principal noncommercial sources of energy. The population of Thailand was 46 million in 1980, and its average gross national product (GNP) per capita of $600 was very close to the median value for all developing countries. The country's size and lack of domestic energy resources meant that in 1980 it was the fifth largest net importer of petroleum among the developing countries; however, it should be noted that its position may change somewhat during the late 1980s because of the development of natural gas fields in the Gulf of Thailand and also possible exploitation of large-scale lignite reserves. The proportion of the population living in urban areas is relatively low (14 percent in 1980), though this is partly the result of a restrictive official definition of urban areas. The influence of the urban population on policy is nonetheless very important because of its concentration in the capital city, Bangkok.

If one compares the average values of the ratios of domestic to border prices for a sample of developing countries, one finds that from 1970 to 1973 Thailand levied substantially lower taxes on gasoline (with a ratio of 3.61) and diesel oil than the average, while for kerosene (with a 2.74 ratio) it was close to the average. By 1978–82 the gap had narrowed considerably so that Thailand was only slightly lower than the average for gasoline (at 2.17), while for both kerosene (1.25) and diesel oil it was slightly above the average. Inevitably, the results of the analysis presented in this article must depend upon the particular circumstances, consumer preferences, and production technologies characteristic of the country examined. Nonetheless, Thailand seems representative of a large group of oil-importing developing countries, and in summarizing my empirical findings I will attempt to highlight conclusions which are likely to be valid for such countries.

Investigation of the effect of changing taxes on petroleum products involves two separate steps. First, one needs a model to predict how the change in fuel taxes will affect producer and consumer prices of other commodities and also the impact on wage rates and factor incomes. Second, one must examine the effect of these price and income changes upon the real income and welfare levels of households. The work in both stages has to be based on highly disaggregated data on industries and commodities if it is to reveal the differential impact of fuel taxes on different industries or various categories of household.

Despite a decade of large increases in fuel prices, there has been relatively little research into the microeconomic impact of fuel price changes on other prices and the distribution of income. For developed countries, studies by Catsambas (1982) of petroleum taxation in the United States (which supersede earlier studies by the U.S. Congressional Budget Office [1979] and by Common [1985] of the effects of higher energy prices in the United Kingdom) come closest to the approach adopted in this article. There are also some more specific studies of natural resource pricing and taxation policies which apply similar methods of analysis—for example, Archibald and Gillingham (1981) on alternative methods of conserving gasoline and YoungDay and Fight (1979) on timber pricing. For developing countries, consultants' studies of petroleum pricing in Egypt, Peru, and the Philippines have attempted to investigate the impact of energy prices in a disaggregated framework (see Pearce and Edwards 1984; Julius 1985). All these studies, however, suffer from two limitations, which this study attempts to surmount. First, they rely upon a simplistic model of price determination which is familiar from closed economy input-output analysis. Section II outlines a more general framework for analyzing the impact of fuel taxes on producer and consumer prices which underlies the empirical work reported in section IV. Second, the earlier studies rely upon aggregate or average data for household consumption, and such data cannot reveal the extent to which the impact of tax changes differs between households. In this study, it was possible to assess the importance of such differential effects by using individual data from large-scale household budget surveys.

The analysis described below represents a compromise between complexity and simplicity and hence has certain limitations. To preserve the degree of disaggregation, it was obviously impossible to construct a full general equilibrium model of the impact of fuel taxes. The model is essentially linear and as such gives a local approximation which is accurate for relatively small tax or price changes. The reasons for using a linear model which does not attempt to solve for wages and other variables in the manner of a general equilibrium model are simplicity and the judgment that the benefits of disaggregation are more important than those of incorporating pricing feedback into the model. The question of simplicity is far from trivial because one of the objectives was to provide a practical model which could be adapted easily to assess the impact of alternative fuel price policies in other countries. The approach adopted here is very similar in spirit to that of Ahmad and Stern (1986) in their analysis of tax reform in India. Some of the tax changes which are examined here are certainly not marginal. It should therefore be remembered that the concavity of cost and expenditure functions—reflecting the fact the individual inputs or consumption goods can be substituted—ensures that the model will *overestimate* the impact of these changes. In some parallel work, I have introduced substitution between different fuels and energy, other material inputs, and value added in response to changes in relative prices in order to estimate changes in the volume of energy consumption (Hughes 1986c), but this is only possible in a model with a relatively small number of sectors.

The accuracy of a linear approximation to a full general equilibrium model depends on the size of the contemplated changes in relative prices. The reforms discussed in this study involve large tax changes for some or all petroleum products. However, they have been chosen so that the scope for tax-induced substitution between fuels is limited in the short run. For instance, the amount of gasoline used as an intermediate input in the nontransport sectors is tiny and the extent of substitution of diesel for gasoline can be controlled by import duties and license fees on diesel and gasoline engine vehicles. Higher fuel prices overall will encourage firms to conserve energy, but since fuel inputs represent less than 8 percent of total intermediate inputs after netting out transactions between energy industries, one would not expect them to lead to major changes in the general structure of relative prices. This point will be reinforced later in the article, but it should be clear that the analysis of the impact of fuel taxes need not require the use of fully disaggregated cost functions.

The analysis treats the activities of petroleum refining and other aspects of energy production as if they were either entirely controlled by the government or carried out offshore. Hence, the government is assumed to have complete control over the ex-refinery price of petroleum products. Any change in fuel taxes is fully reflected in fuel prices, so there is no interesting distinction between the two when one investigates the impact of policy changes. This rules out the possibility that a part of the burden of increased fuel taxes may be borne by oil companies. Since Thailand is neither a large importer of oil in world terms nor particularly important in relation to the major refining facilities in Singapore, this assumption seems reasonable.

I. Price Determination

Most disaggregated models of the impact of fuel prices have assumed that changes in costs will be passed on completely as price changes. I shall refer to this pricing rule as cost-plus pricing. For marginal changes in relative prices, the rule may be justified by considering the unit cost function $c_i(p,w,v)$ for the ith output, where p is the vector of goods prices, w the vector of factor prices, v the vector of energy prices, and t is a vector of producer taxes per unit of output. Under competitive conditions, one would expect that

$$\Delta p_i = \sum_j \frac{\partial c_i(p,w,v)}{\partial p_j}\Delta p_j + \sum_k \frac{\partial c_i(p,w,v)}{\partial w_k}\Delta w_k + \sum_f \frac{\partial c_i(p,w,v)}{\partial v_f}\Delta v_f + \Delta t_i$$

that is,

$$\Delta p_i = \sum_j a_{ij}\Delta p_j + \sum_k b_{ik}\Delta w_k + \sum_f g_{if}\Delta v_f + \Delta t_i \tag{1}$$

since the input requirement for intermediate good j per unit output of i, a_{ij} is $\partial c_i(p,w,v)/\partial p_j$ and the corresponding input requirements for factor k and fuel f

are defined similarly.[1] This formulation can be generalized by introducing substitution between factors and other inputs or by assuming that specific coefficients respond to price changes—for example, the energy conservation equation (39) in Pearce and Edwards (1984). However, even when more general specifications are used, the equations rest upon the fundamental assumption that changes in prices are linked to changes in the cost of production.

While the cost-plus pricing rule may be appropriate for many nontraded goods and services, it is not plausible for the considerable number of agricultural and industrial commodities with prices that are—in various ways—linked to the level of world prices or are effectively controlled by the government. For example, in Thailand the cost of production of paddy is not the dominant factor in determining the domestic price of rice. One can argue whether its price is directly controlled by the government or is determined by the export price less various export duties directly under government control. The distinction between the two formulations is unimportant in this case; what is important is the fact that exogenous influences may be the crucial determinant of domestic prices.

The other pricing rules may all be regarded as special cases of a general pricing equation linking the producer price of good i to some price p_i^* which may be exogenously determined. The general equation is:

$$(2) \qquad \Delta p_i = \Delta p_i^* + \sum_j \alpha_{ij} \Delta p_j + \sum_k \beta_{ik} \Delta w_k + \sum_f \gamma_{if} \Delta v_f + \Delta t_i$$

The coefficients α_{ij}, β_{ik}, and γ_{if} are included in the equation for two reasons. First, the prices p_i and p_i^* may refer to items which are similar but are priced on different bases so that, for example, one must allow for differences between the transport, distribution, or packaging costs for export and domestic sales.

Second, the prices p_i and p_i^* may refer to different items with prices closely linked by market competition through substitution or complementarity in production or consumption. It is also assumed that there are cost-plus activities which determine the relationship between the two prices. The examples of the links between the prices of cassava and tapioca meal and of powder and liquid milk given below illustrate the types of pricing behavior that may be represented by this equation. In these cases, the α_{ij} and other coefficients include processing or other manufacturing costs as well as transport and distribution margins.

Two simple applications of this general pricing equation yield:

- *The traded-goods pricing rule:* for a traded or trade-competing good, the price of i may be directly linked to the price of competing traded goods, so that, in equation 2,

$$(3) \qquad \Delta p_i^* = \Delta q_i$$

1. In practice, it is desirable, if possible, to distinguish between intermediate inputs of domestic and imported items, so that $\sum_j a_{ij} \Delta p_j$ is replaced by $\sum_j a_{ij}^d \Delta p_j + \sum_j a_{ij}^m \Delta q_j$ where the superscripts d and m denote domestic and imported inputs and q_j is the port-gate price of imports of j.

where q_i equals the port-gate price of good i, that is, either the CIF (cost, insurance, and freight) price plus import duties or the FOB (free on board) price minus export taxes.

- *The government-controlled pricing rule:* It is assumed that

$$\Delta p_i^* = \Delta \bar{p}_i \tag{4}$$

where $\bar{p}_i$ denotes the government-controlled price for sector i for price-controlled goods, or for commodities for which key inputs or substitutes are price-controlled.

Tapioca and milk powder serve to illustrate the variety of cases which can be covered by these two pricing rules. Thailand is a major exporter of tapioca meal, which is produced by milling cassava. The demand for cassava by the tapioca-milling sector determines the farm-gate price of cassava. Tapioca milling is reasonably treated as a cost-plus activity, so cassava will be treated as a traded good as well as tapioca. Similar considerations apply to rice and paddy.

Similarly, suppose that a country imports milk powder for reconstituted liquid milk that is sold in competition with domestic milk. Again, assuming that this reconstitution is a cost-plus activity, competition will fix the producer price of domestic milk by reference to the cost of imported milk powder. In each case, one could replace the border prices by a government-controlled price without altering the remainder of the pricing equations.

The final pricing category consists of nontraded goods with prices determined by competitive market forces. These goods compete with traded and controlled-price agricultural goods for land and other scarce agricultural resources on the production side, while on the demand side they are substitutes for the same or other commodities in household consumption. Hence, the prices of these "market-clearing nontraded goods" will be linked to the prices of other traded and controlled price items.[2]

The complete set of pricing equations may be expressed as a single matrix equation:

$$\Delta p = G_1 \Delta p + G_2 \Delta q + G_3 \Delta w + G_4 \Delta v + G_5 \Delta \bar{p} + G_6 \Delta t \tag{5}$$

so that

$$\Delta p = H_2 \Delta q + H_3 \Delta w + H_4 \Delta v + H_5 \Delta \bar{p} + H_6 \Delta t \tag{6}$$

where $H_2 = [I - G_1]^{-1} G_2$, and so forth, and $[I-G]$ is similar to the technology matrix in standard input-output analysis. By comparison, the cost-plus pricing model can be expressed as:

$$\Delta p^c = G_1^c \Delta p + G_2^c \Delta q + G_3^c \Delta w + G_4^c \Delta v + \Delta t \tag{7}$$

2. The derivation of a pricing equation—for this case in the form of equation 2—is given in a background paper available from the author at the Department of Economics, University of Edinburgh, Edinburgh EH8 9JH, Scotland. This paper also gives details of the more general versions of the other pricing equations used in constructing the pricing model for Thailand.

so that

$$\Delta p^c = H_2^c \Delta q + H_3^c \Delta w + H_4^c \Delta v + H_6^c \Delta t \tag{8}$$

where $H_2^c = [I - G_1^c]^{-1} G_2^c$, and so forth. The G_i^c matrixes are obtained by applying the cost-plus pricing equation to all sectors. Thus, the rows of G_i and G_i^c will be identical in the case of sectors for which cost-plus pricing is assumed to apply in the general pricing model, but otherwise they will differ.

Up to this point, it has not been important to distinguish between producer or purchaser prices. For reasons of data availability and manipulation, it is more convenient to let Δp_i refer to the change in the producer price (ex-factory or ex-farm) of good *i*. Consequently, a further set of equations is needed to express consumer prices in terms of producer prices. For good *i*, the change in the consumer price, r_i, is given by:

$$\Delta r_i = \sigma_i \Delta p_i + (1 - \sigma_i) \Delta q_i + \sum_j d_{ij} \Delta p_j + \Delta \tau_i \tag{9}$$

The parameter σ_i reflects the degree of competitiveness or complementarity between domestic and imported goods for sector *i* in final consumption, while τ_i is the sales tax on the sector. The marketing cost term, $d_{ij} \Delta p_j$, represents the change in the cost of good or service *j* involved in getting good *i* from the producer to the consumer. I have assumed that these costs are identical for traded and domestic goods, but the model can easily incorporate changes in this assumption.

The pricing rules imply that in the sectors for which cost-plus pricing is not assumed there must be some changes in factor incomes if the vectors of price changes and changes in unit costs of production differ. Suppose that in each sector there are certain immobile factors of production and that all pure profits and similar factor payments π_i can be attributed to these factors. Thus, the change in profits will be

$$\Delta \pi_i = \Delta p_i - \Delta c_i \tag{10}$$

where Δc_i is the change in the unit cost of production; that is,

$$\Delta c_i = \sum_j a_{ij} \Delta p_j + \sum_k b_{ik} \Delta w_k + \sum_f g_{if} \Delta v_f + \Delta t_i \tag{11}$$

In the long run, one would expect a sector to cease production if it is consistently unprofitable. This implies that a sector which persistently makes financial losses will continue to operate only if these are offset by some form of government subsidy so that $t_i < 0$ and $\pi_i = 0$.

In recognition of the general equilibrium character of the problem to be studied, it would be desirable to incorporate some feedback from prices to wages and other factor payments. Changes in fuel prices will affect output prices and hence the demand for labor and for other factors of production as well as the replacement cost of the capital stock in each sector. The model could be extended to include these feedbacks by adding equations of the general form

$$\Delta(Bw) = f(\Delta p) \tag{12}$$

However, the problems of specifying and estimating such a relationship are formidable. Instead, I will discuss later the consequences of making alternative assumptions about the link between Δp and Δw.

II. The Pricing Model for Thailand

The basic data for the application of the model are contained in the 1975 and 1982 Thai input-output tables at producer prices (NESDB 1980; Chulalongkorn University Social Research Institute 1985). Both sources present information for interindustry transactions for 180 sectors and include data on imported intermediate inputs, trade, and transport margins. The 1982 table was supplemented by further disaggregation of the energy sectors which gave data on the utilization of specific fuels. It was impractical to work with the full set of disaggregated sectors, so these were combined to give a 73-sector breakdown.

All petroleum products were covered by one of the 73 sectors—petroleum refining. After investigation of Thai energy data for 1975, five fuel categories were identified for the analysis of fuel inputs—that is, the g_{if} coefficients in equation 1. These were: (i) gasoline and aviation fuel, (ii) kerosene, (iii) diesel oil and gas oil, (iv) heavy fuel oil, (v) liquified petroleum gas (LPG), and miscellaneous petroleum products. The discussion will focus upon the impact of changes in petroleum product prices or taxes on the general level of prices and on income distribution in Thailand. The results of a larger model, including ten separate fuels based on 1982 data (Hughes 1986c), will occasionally be referred to here in order to indicate the robustness of conclusions drawn from the two models discussed.

Data on the composition of petroleum products used in different sectors were available for 1982. For 1975, however, the disaggregation of petroleum product inputs involved the compilation of data from a variety of sources supplemented by data from other countries. It was also necessary to split transport margins on final sales between the three modes of transport—railways, coastal and inland water, and road freight. Transport margins on intermediate transactions had already been disaggregated in the preparation of the input-output tables at producer prices. A constrained least-squares procedure combined with a limited amount of external information on transport patterns was used to perform this disaggregation.

The most important step in the construction of the pricing models was the allocation of sectors to the various pricing rules. After some investigation, I decided not to treat any sectors as being subject to government price controls—except, of course, for petroleum products, which are treated separately. This decision might be disputed for certain cases—for example, electricity (for which cost-plus pricing was assumed), rice, and cassava (whose prices were assumed to be determined ultimately by net export prices). In these cases, the assumption is that the government would, as in the past, prefer to influence prices via the manipulation of trade taxes and/or specific taxes and subsidies. The overall

Table 1. *Input-output Sectors by Pricing Rule, Thailand*

Sectoral characteristics	Pricing rule classification: Cost-plus	Traded	Market-clearing nontraded
1975			
Sectors (number)	44	26	3
Domestic output (percent)	71	25	4
Intermediate demand (percent)	56	43	1
Final demand (percent)	73	22	5
1981			
Sectors (number)	44	26	3
Domestic output (percent)	73	24	3
Intermediate demand (percent)	62	37	1
Final demand (percent)	75	22	3

Source: Author's calculations.

distribution of sectors, output, and demand between the remaining three pricing rules is shown in table 1. The cost-plus rule applies to a majority of sectors, while the twenty-six sectors covered by the traded goods pricing rule are predominantly agricultural or natural-resource-based. Because of the importance of services in total consumption expenditures, sectors subject to cost-plus pricing are more important in fulfilling final demand than in meeting the input needs of other sectors. It follows, therefore, that abandoning the cost-plus pricing assumption for all sectors will influence sectoral cost structures as well as the prices charged to final consumers. Details of the sectors covered by the traded and market nontraded pricing rules are given in appendix A (a complete, numbered list of all sectors is given in appendix B).

The relevant coefficients for most of the sectors not subject to cost-plus pricing could be estimated quite straightforwardly from input-output and other data. However, two pairs of nontraded sectors presented particular difficulties, which deserve a brief discussion:

- Sectors 4 through 6 are agricultural products which compete with ultimately traded goods such as paddy, cassava, fibers, and tobacco for production resources and with some of these in consumption. In the absence of direct information on the relative magnitudes of their own-price and cross-price elasticities, these parameters were derived from evidence on the rice market. Wong (1978) estimated price elasticities for rice using composite indexes of competing crop prices to obtain the cross-price elasticities. For both long- and short-run estimates, the sum of the cross-price elasticities was approximately half the sum of own-price elasticities. I have assumed that a similar relationship will hold for the two sectors under consideration and that the magnitude of the response to the individual competing products is determined by the share of each item in total production in that sector.

- Sector 17—charcoal and firewood—covers items with price behavior that is difficult to model satisfactorily and even more difficult to quantify empirically. The complications arise because this sector competes, to a limited extent, in production with logging and wood manufacturing for scarce timber resources and in consumption with kerosene, especially in rural areas. In the absence of proper information about substitution in supply and demand, I have been obliged to make the somewhat arbitrary assumption that it is substitution in consumption which dominates, so that the consumer price of charcoal and firewood is linked to that of kerosene with an elasticity of 0.5.

III. The Impact of Fuel Taxes on Prices

The model can be used to investigate various types of tax changes. The taxes discussed in this article have been chosen to illustrate various aspects of the impact of fuel taxes in Thailand.

First, there are three general taxes designed to collect a fixed amount of government revenue in different ways:

R1. A uniform ad valorem sales tax on all petroleum products
R2. An import sales tax on the landed price (including existing customs duties) of all imported goods
R3. An export duty on the FOB value of all exports.

These are of interest if the government needs to reduce its budget deficit by some predetermined percentage of gross domestic product (GDP) in order to achieve macroeconomic or structural adjustment. Alternatively, they allow us to examine the effects of a revenue-neutral tax reform under which some taxes are increased and others reduced. Similarly, if it is assumed that prices are independent of the composition of aggregate demand, this approach can be used to investigate the effects of a switch from private to public expenditure via a balanced budget increase in indirect taxes and government expenditure, such as for road building.

The tax rates for the general taxes have been calculated on the basis of collecting net revenue—after allowing for the higher cost of government purchases—amounting to 1 percent of total final demand, on the assumption that the aggregate consumption of all products remains unchanged.[3] The two trade taxes have been chosen for the comparison because many countries facing a balance of trade deficit choose to increase import duties. In Thailand, export

3. It has been assumed that 25 percent of gross fixed investment is financed by the government—which is a typical figure for Thailand in the late 1970s and early 1980s—so that the increase in government expenditure caused by the price changes is the sum of the extra cost of government consumption plus one-quarter of the extra cost of gross investment, assuming that the volume and composition of government consumption and gross investment is not altered by relative price changes.

duties—especially the rice premium—have also been a major source of revenue in the past. Another consideration is that an import sales tax combined with a matching export subsidy is equivalent to a real devaluation of the same amount, though the former option will not be strictly revenue-neutral if the trade balance is not zero. Thus the model allows comparison of the impact of fuel taxes, of a devaluation, and of trade taxes, all as means of structural adjustment.

The second category of taxes consists of excise duties imposed upon specific fuels:

R4. An excise tax on motor gasoline and aviation fuel
R5. An excise tax on kerosene
R6. An excise tax on diesel oil and gas oil.

Again to facilitate comparisons, the tax rates will be computed on the basis of raising a predetermined amount of government revenue, so that it is possible to examine the consequences of, for example, introducing cross-subsidies in setting fuel prices by raising the price of one fuel and using the extra revenue to lower the price of another fuel.

The tax rates for the specific fuel excise duties have been calculated on the basis of collecting net revenue—as defined above—equal to 0.25 percent of total final demand. As will be shown, this procedure implies very large tax rates in the case of kerosene, so that the assumption of unchanged demand is hardly plausible. It would have been possible to have set a lower net revenue target—say, 0.1 percent of total final demand—but the effects of some of the resulting taxes are so small as to be within the margins of error in the data. Hence, the figures are reported in order to indicate the direction and relative magnitudes of the impact of specific fuel taxes, but they should not be interpreted as forecasts of the actual impact of the larger tax changes, because substitution will ensure that the model will overestimate their impact during any period other than the very short run.

In order to judge the magnitudes of the fuel taxes required to raise the fixed amount of revenue in each year, it is useful to note the structure of petroleum product prices in Thailand in 1975 and 1982 by comparison with CIF border prices. These are shown in table 2; the indexes in the table refer to indexes of the relative price of each product, with regular gasoline = 100. The ratio of the domestic purchaser price to the border price for a fuel gives a broad indication of the extent to which the fuel is taxed or subsidized. It should be remembered, however, that transport and distribution margins would imply ratios of between 1.05 and 1.15 for different products even in the absence of any taxes or subsidies. It is very difficult to establish a border price for heavy fuel oil, so this item will be omitted from the discussion of implicit taxes and subsidies.

The figures show that in 1975 all the products were taxed with the usual pattern of heavier taxes on gasoline than other fuels. By 1982 the pattern had changed; there had been a considerable increase in the taxes imposed on gasoline, whereas the tax on motor diesel oil had been reduced and those on kerosene and industrial diesel oil had been converted into substantial subsidies. For politi-

Table 2. *Petroleum Product Prices, Thailand*

	Domestic purchaser prices (U.S. dollars per gallon)				*Ratio of domestic price to import (CIF border) price*	
	1975		*1982*			
Product	*Price*	*Index*	*Price*	*Index*	*1975*	*1982*
Premium gasoline	0.68	106	2.21	118	1.62	2.13
Regular gasoline	0.64	100	1.88	100	1.70	1.94
Kerosene	0.45	70	1.01	54	1.24	0.91
Motor diesel oil	0.43	68	1.22	65	1.26	1.14
Industrial diesel oil	0.43	67	0.77	41	1.32	0.73
Heavy fuel oil	0.27	42	0.72	38	n.a.	n.a.

n.a. Not available.

Note: Prices shown are midyear prices at official exchange rates.

Sources: Domestic price from National Energy Administration, Bangkok. Border prices computed from *Petroleum Economist* prices posted in Singapore plus freight and other charges to Bangkok.

cal and economic reasons following the second oil price shock of 1979–80, the Thai government was reluctant to allow a rapid increase in the prices of fuels other than gasoline. Hence, gasoline—especially premium gasoline—was made to bear a disproportionate share of the price increases, while taxes on kerosene and industrial diesel oil were converted into subsidies and the tax on motor diesel oil was virtually eliminated.

The tax rates on petroleum products were calculated with reference to the producer (ex-refinery) prices of petroleum according to the amount required to raise the predetermined amounts of net revenue under the various reforms. It is therefore not very instructive to discuss the tax rates themselves, so instead table 3 shows the percentage changes in purchaser prices resulting from the imposition of these taxes.[4] The reduction between 1975 and 1982 in the size of the fuel price rises necessary to generate the given revenue for petroleum products and individual fuels reflects the general increase in the prices of petroleum products relative to other items during this period. Furthermore, in the case of kerosene, the switch in pricing policy together with other factors had the effect of encouraging consumption to grow at 9 percent per year in volume from 1975 to 1982, whereas the total consumption of petroleum products grew only 3.1 percent per year. Hence, the price rise associated with the kerosene excise fell from 175 percent in 1975 to 76 percent in 1982.

In either year, the kerosene excise would have led to a very large shift in the price of kerosene relative to other fuels, so that the caveat that the model overestimates the impact of the taxes on prices and real incomes is particularly important in this case. Such price rises for a single fuel would prompt quite rapid substitution away from kerosene in favor of diesel oil among producers and in favor of LPG, electricity, charcoal, and firewood among consumers. Thus, it is

4. In the cases of gasoline, kerosene, motor diesel oil, and LPG, the "purchaser price" refers to the retail price, whereas for jet fuel, industrial diesel oil, and heavy fuel oil it refers to the wholesale price.

Table 3. *Changes in Purchaser Prices Associated with Imposition of Taxes to Raise Fixed Net Revenue, Thailand*
(percent)

Tax reform	*1975*	*1982*
General taxes[a]		
R1. All petroleum products	20.0	14.3
R2. Import sales tax	8.7	8.8
R3. Export sales tax[b]	−9.9	−7.1
Fuel excise taxes[c]		
R4. Gasoline	13.0	9.4
R5. Kerosene	174.5	75.8
R6. Diesel oil	14.0	9.2

a. To raise net revenue equal to 1 percent of total final demand.

b. An export sales tax leads to a decline in the domestic wholesale price of exported goods. The figures indicate the magnitude of that price fall resulting from each tax reform.

c. To raise net revenue equal to 0.25 percent of total final demand.

Source: Author's calculations.

clear that the kerosene excise would fall well short of its revenue target while calculations based on the assumption that no substitution will occur will significantly overstate the magnitude of its impact. It is more difficult to assess whether the qualitative character of conclusions based upon this model would be affected by substitution because much depends upon the alternative fuels available—that is, who among those worst affected by the kerosene price rise has access to local sources of charcoal, firewood, electricity, or bottled gas.

The import sales tax required to collect net revenue equal to 1 percent of total final demand is virtually the same in both years, but the export sales tax fell quite substantially. This is because in 1975 the value of merchandise imports was equal to 1.31 times the value of merchandise exports, whereas this ratio had fallen to 1.11 by 1982. Because petroleum-related products constituted such a large share of total imports (31 percent by 1982), crude oil and petroleum products have been excluded from the tax base of the import sales tax in order to distinguish analytically between the impact of fuel taxes and the import sales tax. In addition, services have been excluded from the tax base because of the difficulty of taxing imports of services. Thus in 1982 a higher tax on imports than on exports is required to generate the same revenue.

The percentage changes in producer and consumer indexes associated with the tax reforms are shown for both the general pricing model and the cost-plus pricing model in table 4, while appendix B lists the percentage changes in the producer prices under the general pricing model for the individual sectors. Note that the changes in the overall price index are scaled by the requirement that the general tax reforms collect net revenue equivalent to 1 percent of total final demand and that the excise taxes collect 0.25 percent of demand. Since private consumption was 53 percent of total demand in 1982, it would require a 1.88 percent tax on consumption (and thus an equal increase in consumer prices) to

Table 4. *Changes in Price Indexes under Alternative Tax Reforms, Thailand*
(percent)

	General pricing model				*Cost-plus pricing model*			
	Producer prices		*Consumer prices*		*Producer prices*		*Consumer prices*	
Tax reform	*1975*	*1982*	*1975*	*1982*	*1975*	*1982*	*1975*	*1982*
General taxes[a]								
R1. All petroleum products	1.23	1.35	0.87	1.19	1.47	1.68	0.91	1.25
R2. Import sales tax	1.38	1.35	0.89	1.02	0.70	0.75	0.65	0.77
R3. Export sales tax	−3.07	−2.10	−1.82	−1.28	−0.06	−0.04	−0.07	−0.04
Uniform consumption tax			1.67	1.89				
Fuel excise taxes[b]								
R4. Gasoline	0.28	0.32	0.20	0.30	0.33	0.39	0.22	0.34
R5. Kerosene	0.69	0.59	1.23	1.15	0.23	0.27	0.34	0.34
R6. Diesel oil	0.26	0.26	0.19	0.24	0.35	0.38	0.24	0.32
Uniform consumption tax			0.42	0.47				

a. To raise net revenue equal to 1 percent of total final demand.
b. To raise net revenue equal to 0.25 percent of total final demand.
Source: Author's calculations.

generate the revenue produced by the general taxes (R1 to R3). In 1975, the equivalent rate was 1.67, while the comparable rates for the fuel excises would be 0.42 in 1975 and 0.47 in 1982. Consumer price changes significantly below 1 percent for the general taxes, or 0.25 percent for fuel excises indicate that the pricing system has the effect of shifting the tax burdens backward onto factor incomes either directly, by affecting the profitability of various activities, or indirectly, by increasing the relative cost of investment. This means, of course, that the effects of any tax increase go substantially beyond the direct impact on prices and real incomes, though it should be remembered that both government expenditure and a part of gross investment are protected by the assumption that the taxes collect equal net, rather than gross, revenue.

According to the general pricing model, the taxes on all petroleum products and on imports have a fairly similar impact on the indexes of both consumer and producer prices. This is in complete contrast to the results of the cost-plus pricing model, which suggests that the tax on all petroleum products would have a much greater impact on the general price level than the import sales tax. The differences arise because the general model assumes that producers of import-competing goods will increase their prices in line with the price of the imports with which they compete, whereas the cost-plus model is based on the assumption that higher prices for imported goods will only affect the price indexes via the cost of imported inputs into domestic production or via direct consumption of imported goods. For the tax on petroleum products, the cost-plus model assumes that producers can pass on the higher cost of fuel inputs into production, whereas the general model does not allow this in the case of sectors producing exported or import-competing goods. The difference between the two models is even more marked in the case of the export tax, which has a negligible impact on domestic prices in the cost-plus model but which implies a substantial fall in both producer and consumer price indexes in the general model.

The results illustrate the importance of distinguishing between cost-plus pricing and a framework in which many prices are determined by exogenous factors. As a rule, the contrast between the two models is more substantial for the change in the producer price index than for the change in the consumer price index. This is because nontraded items, for which cost-plus pricing applies in both cases, have a considerably greater weight in consumption than in output. A further implication of the difference between the two models is that the income and other effects associated with the taxes are significantly different under the alternative sets of assumptions. By definition, cost-plus pricing implies that profits and self-employment income are not directly affected by the taxes. The lower increase in the producer price index under the general pricing model than with cost-plus pricing implies that the tax on all petroleum products is likely to cause a net reduction in such income. This outcome is not certain because some sectors will gain, relative to the cost-plus framework, from smaller cost increases so that there will be a fairly mixed pattern of gains as well as losses among the various non-cost-plus sectors. For the trade taxes, the patterns of gains and losses are simpler since they will correspond to the consequences of imposing tariff or export duties. The figures show that the export tax falls heavily on factor incomes in sectors producing exported goods.

Examination of the changes in producer prices by sector (see appendix B) reveals that the tax on all petroleum products penalizes energy-intensive sectors which produce traded goods—for example, mining, iron and steel, transport equipment, and industrial chemicals.[5] The prices of other energy-intensive nontraded activities, such as cement, rise substantially, but their profits are protected because they are assumed to be cost-plus sectors. For the import tax, the main losers are nonferrous metals and milling of maize and grain—both exporting sectors with significant imported intermediate inputs—while the principal beneficiaries are import-competing manufacturing sectors—especially transport equipment, machinery, and chemicals—and domestic producers of vegetable oil. The major price reductions associated with the export tax affect exportable primary products—rice and paddy, tapioca, sugar, fish, and nonferrous metals. Producers in all these sectors would be hard hit by the tax, while sectors which use exportables as intermediate inputs in producing import-competing goods—for example, vegetable oils and some chemicals—would benefit from the tax.

Among the price increases associated with the specific fuel taxes, it is the impact of the kerosene excise on consumer prices which stands out. This is twice

5. Tables showing the impact of fuel taxes on profits and self-employment income are available from the author.

as large as would be generated by a value-added tax on private consumption yielding similar revenue. This is because the kerosene tax results in a large increase in the producer price of charcoal and firewood via the market-clearing pricing rule discussed in the previous section. As might be expected, the taxes on gasoline and especially on diesel oil are primarily reflected in the prices of energy- and transport-intensive sectors. Note also that both these taxes reduce the producer prices of exportable primary products—for example, paddy, cassava, and sugar. This is because the taxes increase the cost of processing these products and of transporting them from the farm gate to processors and then to the port. Since both transport and processing activities are assumed to be cost-plus and export prices are fixed, any increase in these costs must reduce the price paid to farmers. The same effect, of course, results from the general tax on all petroleum products.

The general implication of these results is that if the Thai government wishes to raise fuel prices on efficiency grounds, it could fully offset the overall impact on the price level while still gaining additional public revenue by lowering the general level of import tariffs. Alternatively, if the government needs to raise additional revenue, then a general tax on petroleum products may be less inflationary than some plausible alternative sources of revenue such as an import tax, a value-added tax, or an industrial sales tax.

The other conclusion is that in developing countries similar to Thailand, fuel taxes have a very modest effect on the general level of prices and on relative prices. In part, this results from the low energy intensity of the Thai economy, though the fuel tax rates required to collect 1 percent of GDP in tax revenue are simply the reciprocal of the degree of energy intensity. The main reason is the extent to which fuel taxes can be passed on rather than being absorbed by factor incomes. Thailand has a relatively open economy with a high proportion of domestic production competing with traded goods. This competition limits the impact of fuel taxes on the general price level; these taxes tend to reduce factor incomes and only slightly increase consumer prices. Conversely, the taxes which alter trade prices (R2 and R3) have a much stronger effect under the general price model. The import sales tax has an effect similar to an import tariff. All sectors which compete with the traded goods are able to raise their prices in response to increased costs, and this rise will feed through the prices of all substitute and complementary goods—both inputs and outputs. An export tax would lower prices for exportables sold domestically, for nontraded substitutes, and for factor incomes in export production. It is this much more complex interaction between traded, nontraded, and factor market pricing which is captured in the general pricing model.

IV. Fuel Taxes and the Distribution of Real Income

The changes in consumer prices associated with various tax reforms will affect the distribution of real income between households. If the consumption vector of household h is x^h and consumer prices are r, as above, then total household expenditure is $e^h = rx^h$, and tax changes will be reflected in e^h through induced changes in prices. In cash terms, the proportional change in real income, which I will refer to as the expenditure transfer, is:

$$\frac{\Delta e^h}{e^h} = \sum_i s_i^h \frac{\Delta r_i}{r_i} \tag{13}$$

where s_i^h is the budget share of good i for household h at the initial point. I will concentrate on this measure of the effect of the tax reforms, since it is directly relevant to individuals and can also be used to compute indexes of the effects of the reforms on aggregate inequality.

The expenditure transfers were calculated for households included in the 1976 and 1981 Socio-Economic Surveys using price changes computed from the pricing models for 1975 and 1982 respectively. Each of the expenditure items in the surveys was reclassified to match the sectors distinguished in the pricing models.[6] The surveys recorded, separately, items purchased in the market, items received as pay in kind, and items consumed out of the household's own production.

The estimates of the expenditure transfers are based only on items purchased in the market for consumption. Price changes for goods which are received as pay in kind or consumed out of domestic production will have an effect on the cost of a given consumption basket which is exactly offset by the corresponding change in inputed income. The expenditure transfers associated with each tax reform were calculated for all the households for which complete data on expenditure patterns were available—a sample of 11,300 households for 1975–76 and one of 11,897 households for 1981–82.

Before examining the magnitude of the expenditure transfers associated with the tax reforms, it is worth comparing the patterns of direct household expenditure on petroleum products as recorded in the Socio-Economic Surveys. The average percentages of total household expenditure spent on various petroleum products by urban and rural[7] households are shown in table 5 together with their standard deviations. The figures show large differences between expenditure patterns for urban and rural households. Liquified petroleum gas is purchased by urban households but hardly at all by rural households, whereas this pattern is reversed for kerosene. Gasoline is much more important to urban households than to rural ones, though the relative share of gasoline in total expenditures on petroleum products increased between 1976 and 1981 for both

6. The mapping of expenditure categories to sectors in the pricing model proceeded by linking the items identified in the budget survey with the detailed list of products compiled in preparing the 180-sector input-output table. These were then associated with the final sectors by applying the sectoral conversion used to obtain the sectors in the pricing model from the full input-output table.

7. In this study, "rural" covers households living in villages and sanitary districts, while "urban" refers to households living in municipal areas. The assignment of sanitary districts to the rural category is questionable, but the definition has been adopted for consistency with previous studies.

Table 5. *Shares of Household Expenditures Allocated to Petroleum Products, Thailand*
(percent)

Expenditures	1976 *Mean*	1976 *Standard deviation*	1981 *Mean*	1981 *Standard deviation*
Urban households				
Gasoline	1.26	3.53	1.66	4.00
Kerosene	0.11	0.49	0.06	0.36
Diesel oil	0.01	0.10	0.01	0.12
Liquified petroleum gas	0.41	1.25	0.44	1.23
All petroleum products	1.94	4.13	2.24	2.52
Rural households				
Gasoline	0.46	2.42	0.77	2.59
Kerosene	1.08	1.13	0.80	1.17
Diesel oil	0.10	1.02	0.11	1.05
Liquified petroleum gas	0.05	0.30	0.08	0.58
All petroleum products	1.64	2.80	1.71	2.94

Source: National Statistical Organization, Socio-Economic Surveys, 1976, 1981.

groups. The coefficients of variation for expenditures on gasoline as a share of total expenditures are high, and more detailed analysis shows that gasoline consumption is concentrated among households with high shares of expenditures on petroleum products relative to total expenditures.

The medians of the household expenditure transfers—that is, $\Delta e^h/e^h$ expressed as a percentage of original expenditure—for the three general tax reforms and the three specific fuel excises are shown in table 6. As discussed earlier, because the three general tax reforms all generate equal revenue, this provides a scaling which helps in interpreting the expenditure transfers, both in comparing these taxes, and in comparison with the rates of a strictly proportional tax on private consumption which would raise the same amount of revenue. In addition to the median expenditure transfers, the table also gives the range between the tenth and the ninetieth percentiles of the distribution of expenditure transfers across households as a simple measure of the dispersion of the effects of the tax reforms on different households.

All the general tax reforms generate median expenditure transfers much lower than would be associated with a general tax on consumption. The export sales tax stands out because it generates a negative expenditure transfer for almost all households, which, as indicated by the changes in the consumer price index, implies that on the expenditure side households experience a real income *gain* as a result of the export sales tax. (The impact on factor income, however, is to create a positive [that is, adverse] average net transfer; see section V below.) The absolute magnitudes of the median transfers for different groups associated with the export tax are large, as are the ranges between the tenth and ninetieth percentiles. These observations mean that the export tax may lead to a redistrib-

Table 6. *Distribution of Expenditure Transfers, Thailand*
(percentage of original expenditures)

		Median expenditure transfer			*Range between tenth and ninetieth percentiles of expenditure transfers*		
Taxes	*Year*	*All*	*Urban*[a]	*Rural*	*All*	*Urban*	*Rural*
General							
R1. All petroleum products	1975–76	0.74	1.02	1.70	1.09	1.51	0.99
	1981–82	0.46	0.64	0.43	0.95	1.13	0.90
R2. Import sales tax	1975–76	0.66	0.69	0.65	0.84	0.72	0.86
	1981–82	0.63	0.65	0.62	0.94	0.83	0.96
R3. Export sales tax	1975–76	−1.28	−1.77	−1.15	3.00	2.07	3.11
	1981–82	−1.07	−1.13	−1.06	2.13	1.85	2.18
Equal revenue	1975	1.67					
Uniform consumption tax (rate)	1982	1.89					
Fuel excise							
R4. Gasoline	1975–76	0.08	0.15	0.08	0.29	0.64	0.25
	1981–82	0.06	0.08	0.05	0.35	0.55	0.30
R5. Kerosene	1975–76	1.82	1.18	1.95	4.89	3.18	5.17
	1981–82	0.59	0.25	0.66	1.82	1.23	1.92
R6. Diesel oil	1975–76	0.14	0.17	0.13	0.20	0.19	0.20
	1981–82	0.05	0.07	0.05	0.16	0.17	0.16
Equal revenue	1975	0.42					
Uniform consumption tax (rate)	1982	0.47					

a. Approximately 14 percent of Thailand's population is urban.

Note: Expenditure transfers are defined here as the percentage change in household expenditures that results from the specified tax change.

Source: Author's calculations.

ution of real income between households with different characteristics or expenditure patterns.

The median expenditure transfers for the tax on all petroleum products fell between 1975–76 and 1981–82, despite the increase in the average share of household expenditures devoted to petroleum products. In part, this may reflect a change in the distribution of consumption of petroleum products, but more importantly it indicates a reduction in the proportion of petroleum products consumed, directly or indirectly, by households. While the sizes of the median expenditure transfers have declined, the ranges between the tenth and ninetieth percentiles have not fallen commensurately, so that the dispersion of the expenditure transfers is larger for 1981–82 than for 1975–76. As one would expect, because of higher incomes and easier access to supplies of all fuels, urban households have significantly higher median expenditure transfers for the tax on petroleum products than do rural households. The import sales tax does not discriminate between urban and rural households as do the other two general taxes, but by 1981–82 it caused the largest median expenditure transfer for the whole population.

Among the specific fuel excises, it is the tax on kerosene which stands out as generating a median transfer for all households which is higher than that for an equal revenue consumption tax. As the figures in the previous table would lead one to expect, the kerosene tax also affects rural households much more severely than urban households. Conversely, the tax on gasoline falls more heavily on urban than on rural households. The median expenditure transfers for the kerosene tax in 1975–76 are several times the figure of 0.42 percent that would be associated with a uniform consumption tax raising equivalent revenue. This, combined with the large ranges between the tenth and ninetieth percentiles, suggests that the tax falls particularly heavily on poor households, since otherwise it would collect much more revenue than a uniform consumption tax. The median expenditure transfers for the kerosene excise are much lower for 1981–82 than for 1975–76, as are the ranges; therefore, one might expect it to have a smaller impact upon rural and poor households in the later period.

It is, however, inadvisable to attempt to draw too many conclusions concerning the distributional impact of the taxes from these figures since it has been shown that there is large variation within income groups and sectors as well as between them. It is possible to calculate a measure reflecting the desirability of either imposing taxes or providing subsidies on different commodities by using data on the consumption of different products by households at various points in the income distribution. This measure is called the distributional characteristic of a commodity (see Atkinson and Stiglitz 1980, p. 431). In a separate study (Hughes 1986a), distributional characteristics for a wide range of commodities in Thailand have been calculated. The results of that analysis show that electricity, liquified petroleum gas, and gasoline would be prime candidates for progressive consumption taxes. Indeed, with the exception of motor vehicles and spare parts, these fuels have worse distributional characteristics than other classic luxury goods such as electrical goods, drink, and tobacco. Kerosene, charcoal, and firewood all have high distributional characteristics, which indicate that they are consumed by the relatively poor and may be candidates for subsidies. These conclusions are essentially independent of the value placed on the alleviation of inequity.

As a first step in the analysis of the distributional implications of the alternative tax reforms, table 7 gives the average expenditure transfer for all households and an index of progressivity which will be discussed below. The average expenditure transfers in the table were calculated by averaging the expenditure transfers for each household without weights; they are not the same as the expenditure-weighted average transfers, which are derived by dividing the total tax cost for each reform by total expenditures.[8] As one might expect, the fuel

8. In this context, the average expenditure transfer is defined as $(1/H)\sum_h(\Delta e^h/e^h)$, while the expenditure-weighted average transfer would be $\sum_h(\Delta e^h)/\sum_h e^h$.

Table 7. *Indexes of Expenditure Transfer Progressivity*
(percentage of original expenditures)

Tax reform	Year	Mean expenditure transfer[a]			Progressivity index[b]		
		All	*Urban*	*Rural*	*All*	*Urban*	*Rural*
General taxes							
R1. All petroleum products	1975–76	0.89	1.23	0.83	0.22	0.24	0.18
	1981–82	0.58	0.77	0.55	0.14	0.20	0.11
R2. Import sales tax	1975–76	0.73	0.77	0.72	0.16	0.12	0.21
	1981–82	0.71	0.73	0.71	0.13	0.07	0.17
R3. Export sales tax	1975–76	−1.59	−1.84	−1.55	0.13	0.59	0.13
	1981–82	−1.23	−1.20	−1.23	0.11	0.36	0.09
Fuel excise taxes							
R4. Gasoline	1975–76	0.17	0.29	0.15	0.13	0.19	0.11
	1981–82	0.14	0.21	0.13	0.08	0.14	0.06
R5. Kerosene	1975–76	2.36	1.51	2.51	−0.60	−0.71	−0.53
	1981–82	0.83	0.54	0.88	−0.19	−0.24	−0.16
R6. Diesel oil	1975–76	0.15	0.19	0.14	0.01	−0.01	0.01
	1981–82	0.08	0.09	0.07	0.01	0.01	0.01

a. The average percentage change in household expenditure resulting from each tax.
b. Calculated by regressing the expenditure transfer for each household on total original household expenditure and household size and then multiplying the coefficient for total expenditures by the average value of total expenditures in the sample. It is measured as a percentage of original expenditures. Negative index values indicate regressive taxes.
Source: Author's calculations.

taxes have a rather skewed impact, so the means of the distributions exceed the medians by substantial amounts (comparing values for tables 6 and 7). The skewness is particularly marked for the gasoline tax, which implies that this tax affects small numbers of households rather heavily though its impact on most households is small. The differences between the means and medians for the import sales tax are slight, which indicates that the distributions of its expenditure transfers are much more symmetrical than are those of the fuel taxes.

Skewness of the distribution of expenditure transfers across households is not per se a disadvantage since, for example, both highly progressive and highly regressive taxes may display substantial degrees of positive skewness. One problem is that a tax which is roughly proportional across households overall but which displays considerable skewness may generate considerable opposition because a small number of households gain or lose disproportionately by comparison with apparently similar households. This raises the issue of the horizontal equity or inequity of any tax reform, which will be discussed below. First, the extent to which the incidence of the taxes is progressive or regressive must be examined. This may be done in a number of ways, and the main conclusions are independent of the measure of progressivity adopted.

In table 7, I have adopted a relative approach: first, the expenditure transfer (expressed as a percentage of original expenditures) was regressed upon total household expenditure and household size; second, the regression coefficient for

Table 8. *The Impact of Tax Reforms on Social Welfare, Thailand*

Tax reform	*Index of welfare change* ($-100\,\Delta I/[1-I]$) 1975–76	1981–82
General taxes		
R1. All petroleum products	0.13	0.12
R2. Import sales tax	0.11	0.11
R3. Export sales tax	0.11	0.15
Uniform lump sum transfer[a]	1.24	1.53
Fuel excise taxes		
R1. Gasoline	0.07	0.07
R5. Kerosene	−0.48	−0.20
R6. Diesel oil	0.01	0.01
Uniform lump sum transfer[b]	0.31	0.38

a. Transfers = 1 percent of total final demand.

b. Transfers = 0.25 percent of total final demand.

Note: The index of welfare change is defined in note 9. Progressive taxes generate positive values, while adverse welfare changes are noted by negative values.

Source: Author's calculations.

household expenditures was multiplied by average household expenditures to give the index of progressivity. Formally, this index is calculated by estimating the coefficients μ_0, μ_1, and μ_2 in equation 14:

$$(\Delta e^h/e^h) = \mu_0 + \mu_1 e^h + \mu_2 N \tag{14}$$

where N is total household size. IP, the index of tax progressivity, is then defined as

$$IP = \mu_1 \bar{e} \tag{15}$$

where $\bar{e}$ is the average value of e^h. This index may be thought of as the predicted difference between the proportional expenditure transfers for households of a fixed family size with expenditures equal to 0.5 times the average household expenditures and 1.5 times such an average. In this form, any tax change that results in a large expenditure transfer from the poorest households creates a high negative total household expenditure coefficient, μ_1, while progressive taxes generate high positive coefficients. The index is expressed as a percentage of original household expenditures.

The values of the progressivity indexes in the table should be interpreted with caution. Perhaps the most important conclusion to be drawn from the regressions estimated in order to compute the indexes is that the R^2 values are exceedingly low (less than 0.15), even by comparison with other cross-section studies. The regression coefficient μ_1 had substantial t values (more than 10 in most equations) because of the very large sample sizes, but the relationships between the expenditure transfers and total households expenditure are very noisy. Bearing this warning in mind, one sees that the tax on gasoline is consistently among the most progressive of the specific fuel taxes while the tax on kerosene is consistently regressive. The reduction in the absolute values of the progressivity indexes between 1975–76 and 1981–82 mirrors the fall in the average expenditure transfer in most cases (as discussed above), so that the relative difference between the tax burdens on households with 0.5 and 1.5 times average households is similar in the two periods. Despite the highly regressive impact of the kerosene excise, the general tax on petroleum products is more progressive than either the import or the export sales taxes when all households are considered. Among urban households, the export sales tax has the most progressive impact; among rural households, the import sales tax is the most progressive.

While indexes of progressivity indicate the nature of the correlations between the expenditure transfers and total expenditure, they do not show how important these correlations may be in affecting overall inequality and social welfare. For this purpose, table 8 shows estimates of the welfare impact of the tax reforms.[9] Regardless of the degree of inequality aversion, the change in social welfare in this measure depends upon the proportional change in average household expenditure, that is, the amount of tax collected from households, and the resulting proportional change in inequality. The index of welfare change in table 8 focuses specifically on the impact of the tax reforms on vertical inequality, with negative values indicating regressive taxation and positive values generated by progressive taxes. The table also shows the effect on inequality of a uniform lump sum subsidy per household member to all households. This subsidy distributes the same amount of revenue as is raised by the two sets of taxes—that is, amounting in total to 1 and 0.25 percent of total final demand.

There are considerable price differences between urban and rural areas in Thailand and also between the various provinces (see Meesook 1974). In evaluating the effect of various tax changes on inequality, I was primarily interested in the distribution of real income, so that the household expenditure figures used in

9. The measure is based upon Atkinson's index of inequality (Atkinson 1970). This is associated with the following social welfare function:

$$W(\epsilon) = \sum_h \frac{1}{1-\epsilon} (e^h)^{1-\epsilon},$$

and the inequality index is defined by:

$$I(\epsilon) = 1 - \frac{1}{\bar{e}} \left[\frac{1}{H} \sum_h (e^h)^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}}$$

where ϵ indicates the degree of inequality-aversion and H is the total number of households sampled. Thus the impact of a tax reform on social welfare can be expressed as:

$$\Delta W(\epsilon) = (1-\epsilon)\, W \left[\frac{\Delta \bar{e}}{\bar{e}} - \frac{I(\epsilon)}{1 - I(\epsilon)} \right]$$

The formulas for $\epsilon = 1$ differ slightly because $W(1) = \sum_h \log e^h$ but for all ϵ values, an increase in $I(\epsilon)$ denotes an increase in inequality.

computing the inequality indexes were deflated by Meesook's regional price indexes. The values of the price indexes were normalized so that the overall weighted average for Thailand was equal to 1.0. In the remainder of this article, the deflated value of total household expenditures will be referred to as real household expenditures.

The inequality indexes were calculated using expenditure per member of the household, so they allow for variations in household size, but the values of the indexes remain as measures of the inequality of the distribution across households. The results in table 8 show that by 1981–82 among the general taxes, the export sales tax has the strongest welfare benefit, presumably because the real income gains resulting from the decline in the prices of rice and other foodstuffs are of particular benefit to poor households; but the differences between the impact of the three general taxes are slight. By comparison with the effect of a lump sum transfer disposing of the same revenue, the distributional impacts of all three taxes are small, though all of them marginally reduce the degree of inequality of the distribution of real expenditures across households. Overall, one could not put a convincing case either for or against the use of any of these general taxes on distributional grounds.

The analysis of the welfare effect of the specific fuel taxes reinforces previous conclusions about the adverse distributional impact of taxing kerosene. However, it is important to keep this effect in perspective; the beneficial impact of the lump sum transfer in 1981–82 is nearly twice the size of the adverse impact of the kerosene tax. In other words, it would only be necessary to distribute approximately half the revenue of the kerosene tax in the form of a uniform lump sum transfer to households to offset the overall impact of the kerosene tax. This would, of course, not amount to full compensation for many households; but equally, I have not attempted to allow for substitution in consumption as a result of the effect of the taxes on relative prices.

The striking difference between the welfare changes for the kerosene excise for 1975–76 and 1981–82 reflects the effects of the government policy of limiting domestic kerosene price increases in the face of rising world oil prices. As has been shown, kerosene consumption rose rapidly between 1975 and 1982, so that a much lower tax rate is required in the later period to collect equivalent revenue. If the increase in the consumption of kerosene had come from households, this would not explain the decline in the absolute value of the welfare change resulting from the kerosene tax. It follows that the major part of the extra demand for kerosene must have come from agricultural, commercial, and industrial users, who may or may not have been able to pass on the kerosene tax in the form of higher prices for their goods or services. On the expenditure side, the figures show that the expansion in the nonhousehold demand for kerosene has substantially reduced the regressive impact of a kerosene tax and there is no reason to believe that this conclusion would be modified by taking account of the associated income changes. Hence, the provision of a subsidy for kerosene seems to have induced changes in fuel consumption patterns which largely undermine the original basis for the subsidy.

In contrast to the tax on kerosene, the gasoline excise tax generates a positive, though small, improvement in the distribution of income. Taking account of the different amounts of revenue raised by the general taxes and the fuel excises, the gasoline tax is clearly the best of the tax reforms examined in terms of its impact on vertical inequality. Nonetheless, the analysis shows that fuel taxes and other indirect taxes—including some which have not been discussed in this article—are unlikely to be suitable policy tools when a reduction in vertical inequality is an important objective.

While the effect of fuel taxes on aggregate inequality may be small in most cases, they do generate substantial horizontal inequity because of their differential impact on households with similar levels of expenditures per capita but different expenditure patterns. Economists disagree over whether the horizontal effects of a tax reform should be taken into account when assessing its merits. In political terms, however, large differences between the expenditure transfers experienced by apparently similar households may undermine support for a reform and provide the leverage sought by pressure groups who wish to subvert the objectives of the reform. Hence, policymakers must be concerned about the horizontal inequity associated with alternative tax proposals. There are a variety of ways of measuring the effects of a tax reform on horizontal equity. One approach, discussed by King (1983), is to compute indexes of horizontal inequality (similar to the Atkinson indexes of vertical inequality used in table 8). In effect, these measure the extent to which the ranking of households in the overall distribution has been shuffled by the tax reform. King shows that the indexes of vertical and horizontal inequality can be combined to give an overall index reflecting the net effect of a reform, whose value for a rank-preserving reform will simply be equal to the Atkinson index. I have computed this overall inequality index for each of the reforms using various values of the horizontal and vertical inequality-aversion parameters. The general conclusion is that an improvement in the overall index of inequality requires either a low degree of sensitivity to horizontal inequality or a high degree of sensitivity to vertical inequality, or both, and even in these cases the gain is very small. For most plausible combinations of the two parameters, the horizontal inequity outweighs any improvement in vertical inequality.

Another more concrete method of measuring horizontal inequity relies on examining the residuals of a regression equation with the expenditure transfer as the dependent variable and total household expenditures as the independent variable. Suppose that one estimates the simple linear equation:

$$\Delta e^h / e^h = \mu_0 + \mu_1 e^h \tag{16}$$

and calculates the residuals:

$$z^h = (\Delta e^h / e^h) - (\mu_0 + \mu_1 e^h) \tag{17}$$

One can then analyze the distribution of the z^h across households. This generates a measure of the extent to which individual households at a given level of expenditure differ in the change in expenditure induced by the various taxes. In table 9, the index of horizontal inequity is computed as the difference between the tenth and the ninetieth percentiles of this distribution. This means that equation 16 has been shifted upward so that 10 percent of households lie above the line, and similarly, that it has been shifted downward so that 10 percent of households lie beneath it; see figure 1. The index is thus equal to the vertical distance between these two lines and is measured as a percentage of original household expenditures.

The figures in the table show that the horizontal inequity associated with the tax on kerosene is high by comparison with the other specific fuel taxes. In general, the degree of horizontal inequity associated with all the fuel taxes is higher for urban households than for rural households, though—as so often—kerosene is the exception. Among the general taxes, it is the export sales tax which generates the most horizontal inequity. After scaling for the difference in the amount of revenue collected, the tax on all petroleum products generates slightly less horizontal inequity than the specific tax on gasoline. This suggests that broadly based fuel taxes are likely to encounter less opposition than taxes on particular fuels, unless, like diesel oil, they are used almost entirely as intermediate inputs into the production of other goods and services.

V. Generalizations of the Model

All models designed for the analysis of policy choices rest upon a number of more or less drastic simplifying assumptions, so before discussing the implica-

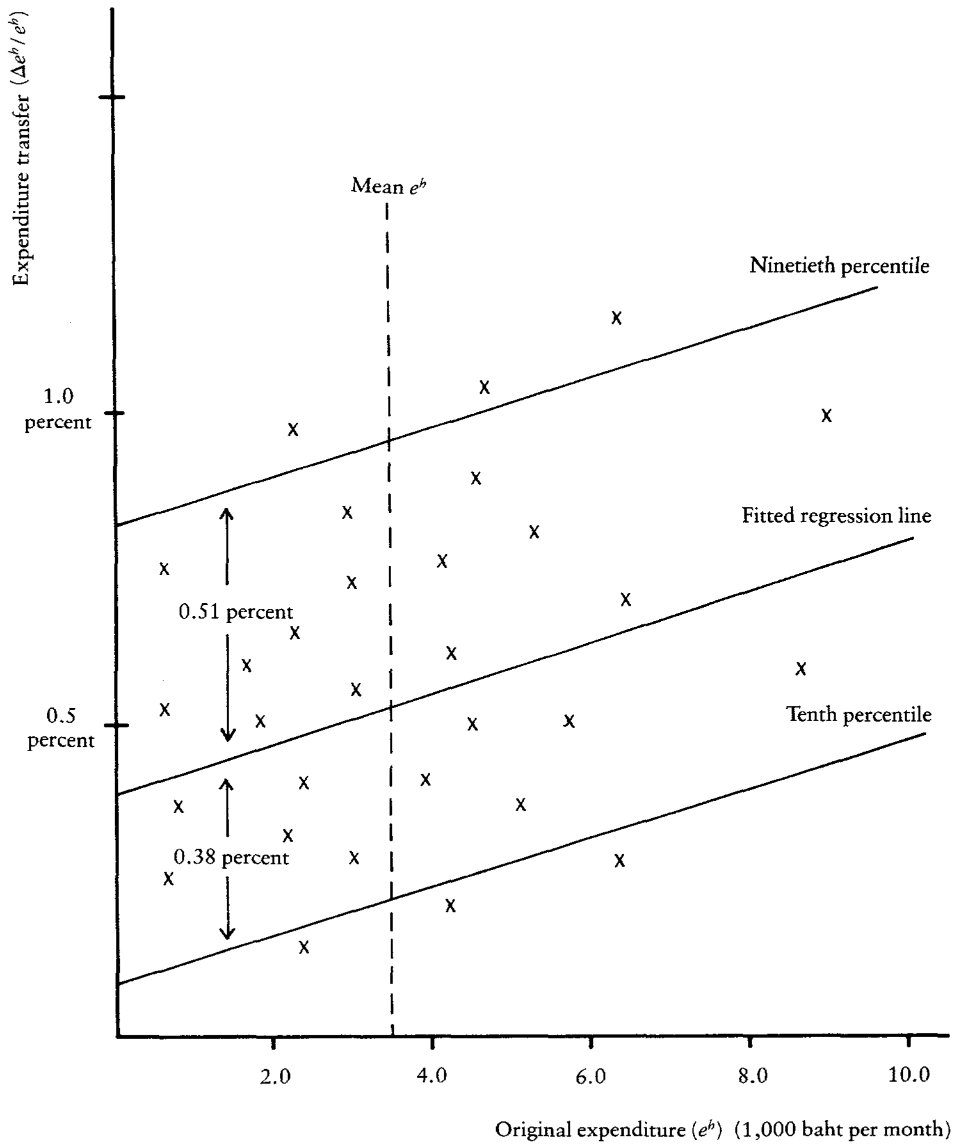
Table 9. *Indexes of Horizontal Inequity Caused by the Tax Reforms, Thailand*
(percentage of original expenditures)

Tax reform	*Year*	*All*	*Urban*	*Rural*
General taxes				
R1. All petroleum products	1975–76	1.04	1.48	0.97
	1981–82	0.89	1.07	0.86
R2. Import sales tax	1975–76	0.78	0.69	0.77
	1981–82	0.89	0.82	0.88
R3. Export sales tax	1975–76	3.00	1.84	3.11
	1981–82	2.12	1.82	2.18
Fuel excise taxes				
R4. Gasoline	1975–76	0.27	0.58	0.24
	1981–82	0.31	0.53	0.27
R5. Kerosene	1975–76	4.64	3.14	4.87
	1981–82	1.84	1.24	1.92
R6. Diesel oil	1975–76	0.20	0.19	0.17
	1981–82	0.16	0.17	0.15

Note: The index of horizontal inequity used in this table is defined in the text. For comparison, average values of the expenditure transfer are given in table 7.

Source: Author's calculations.

Figure 1. *Illustrative Plot for the Calculation of the Index of Horizontal Inequity: Tax on All Petroleum Products, All Households, Thailand, 1981–82*



tions of the findings reported above it will be useful to consider the robustness of the results to changes in some of these assumptions. Details of the more elaborate models which underpin this discussion are given in Hughes (1986c). Here I focus upon two important aspects of the models, substitution effects and income effects.

Substitution Effects

In estimating both the price and welfare effects of the taxes, the model does not allow for substitution between inputs in production or between goods and services in consumption. This is appropriate for a short-run analysis of small tax changes, but, as I have emphasized above, it leads to an overestimation of the longer-term impact of the taxes, especially when a substantial shift in the relative prices of competing goods is involved—for example, the specific fuel taxes. For the import and export sales taxes, the substitution effects are quite small and need not be of concern. Taxes on fuels involve two types of substitution: between some kind of composite energy input and other composite inputs such as materials and labor; and between fuels within the energy composite. It seems that the first type of substitution is more important in determining the overall effect of fuel taxes on producer and consumer price indexes. Allowing for both kinds of substitution reduces the predicted increases in the consumer price index that result from the tax on all petroleum products and the excises on gasoline and diesel oil by between 20 and 30 percent of their values without substitution. For the kerosene tax, the proportionate reduction is less than 10 percent. It should be remembered, however, that with substitution, the tax rates calculated above will no longer generate equal net revenue because the tax-induced substitution effects imply substantial shifts in total demand for different fuels, which are subject to varying taxes or subsidies.

It is more difficult to estimate the implications of substitution in household consumption because it has proved difficult to derive plausible price elasticities for consumer demand. The impact of substitution in production alone reduces the median expenditure transfers and their dispersion by between 30 and 50 percent for the taxes on all petroleum products, gasoline, and diesel oil but does not alter conclusions about their impact on inequality. Substitution in consumption might be expected to reduce the median expenditure transfers even further and to lower the progressivity of the taxes on all petroleum products and on gasoline. Production substitution has only a limited effect in reducing the expenditure transfers caused by the kerosene excise, but substitution in consumption should substantially reduce both the median expenditure transfer and the regressivity of this tax.

Income Effects

In sections II and IV, it was emphasized that the difference between the cost-plus pricing model and the general pricing model adopted in this study lies in the assumption that the incidence of taxes on intermediate goods is fully shifted forward under cost-plus pricing, whereas the general pricing model allows for the possibility of backward shifting onto incomes as a result of competition from traded goods. Thus, income effects may be important in assessing the impact of particular taxes when there are significant differences between the price increases predicted by the two models. Unfortunately, it is usually quite difficult to trace changes in sector profit rates through to income changes for households in a household budget survey. The Thai Socio-Economic Surveys provide an exceptionally rich set of data on sources of household income, so an attempt was made to estimate the impact of the tax changes on entrepreneurial and self-employment incomes.

It was assumed that profits and earnings from self-employment are a residual after the cost of material inputs, hired labor, and taxes have been met—as implied by equation 10. On this basis, the proportional change in such income for each sector was calculated from the pricing model and this was applied, to the extent allowed by the detail on sources of income in the surveys, to estimate the income change experienced by each household. This estimation of what I shall call the "income transfer" was reasonably satisfactory for agricultural income but less so for profits and similar income from industrial and service activities. The "net transfer" generated by a particular tax is then simply the sum of the expenditure and income transfers. These were analyzed in the same way as the expenditure transfers. Both median and average net transfers for each tax were larger than the equivalent values for the expenditure transfer, but the changes were small for the fuel taxes and the import sales tax. For the export sales tax, the distribution of net transfers is completely different from the distribution of expenditure transfers, as one would expect, since it is known that the tax is more than fully shifted back onto producers' incomes. The median net transfer is still negative, but the average net transfer is positive, and the dispersion of the net transfer is extremely high. The export sales tax is seen to be quite regressive on the basis of the net transfers according to the progressivity index, though it has little effect on vertical inequality as measured by the welfare index. Use of the net transfers enhances the distributional benefits associated with the fuel taxes and reduces the regressive impact of the kerosene excise. Overall, the income transfers tend to reinforce conclusions based on the expenditure transfers for the fuel taxes, whereas for the export tax they offset the expenditure transfers so that the net impact of the tax is both difficult to assess and very variable according to the circumstances of each household.

One other type of income effect is the feedback from aggregate demand to wage levels referred to in equation 12. In the spirit of investigating structural adjustment, I have examined the implications of assuming that nominal wage rates decline by 1 percent when various of the general taxes are imposed. Naturally, this reduces the impact of the taxes on the general price level and thus the size of the typical expenditure transfer. It has little effect on the distributional impact of the taxes, even when the decline in nominal wages is taken into account when calculating the income transfers experienced by households.

These investigations suggest that the general character of the conclusions in sections III and IV concerning the fuel taxes are not affected by relaxing some of the major assumptions of the model. Inevitably, the magnitude of price changes and the distribution of real income transfers are altered, but most of the variations are readily understood and they do not affect the basic picture. For the export sales tax, the income effects are substantial and would cause one to revise one's views concerning the desirability of the tax quite radically. This is not surprising given the pattern of price and profit changes discussed in section III, but it is a useful reminder of the need for care in choosing taxes to be analyzed with the aid of the main model.

VI. Conclusion

In this article, I have outlined an approach which enables one to analyze the incidence of indirect taxes imposed upon intermediate as well as final goods. Because of the difficulties involved in collecting the requisite information on tax rates and price elasticities, I have not tried to calculate welfare measures indicating whether particular taxes should be increased or decreased. Instead, the discussion of the incidence of the taxes has, in effect, extended the descriptive approach adopted in standard tax analysis by examining the impact of the taxes on the distribution of real income for large samples of households. This procedure can be implemented with relatively limited resources and can be easily updated as better information becomes available. At the same time, it can be made the starting point for a more thorough welfare analysis or it can be used to answer specific questions concerning the impact of proposed reforms on particular groups of the population.

The adoption of a pricing model which is more general than the conventional cost-plus pricing rule has a substantial effect on the results of the analysis, because it leads to a lower overall increase in both producer and consumer price indexes and to a rather different pattern of relative price changes. Furthermore, the divergence from cost-plus pricing means that the incidence of the taxes is shifted backward onto factor incomes to a significant extent. A separate analysis of the incidence of the tax reforms on net real incomes suggests that the changes in factor incomes can have a significant effect on conclusions about the impact of certain tax changes on the distribution of real income. The inclusion of changes in factor incomes in the analysis did not alter any of the main conclusions about the impact of the fuel taxes examined in this article. Conversely, the income changes associated with an export sales tax were large but very erratic in their distribution across households so that the index of horizontal inequity for the tax was greatly increased.

By focusing specifically on fuel taxes, this article has shown that the effect of such taxes on price indexes is small and that, for example, a reduction in taxes on imports offset by the imposition of an equivalent tax on all petroleum products would leave the consumer price index essentially unchanged and would tend to improve the overall distribution of income. In present circumstances, the significance of these results is that the Thai government could choose to take advantage of the fall in the world price of oil to hold domestic prices for petroleum products constant, that is, to increase taxes on petroleum products and use the revenue to reduce import duties. This would not affect the decline in the underlying rate of inflation, but it would improve the distribution of income slightly and would confer long-term efficiency benefits by reducing effective rates of protection and discrimination against export-oriented sectors. Going one step further, the government could use the revenue from higher fuel taxes to reduce both import duties and export taxes. The fall in inflation would be less, since lower export taxes tend to push up domestic prices, but the benefits resulting from a less distorted set of incentives for producers and exporters would be greater. Of course, those employed in import-substituting sectors would find such changes unpalatable, but a period of falling world oil prices provides an especially favorable environment for moving away from a policy of increasing protectionism.

On distributional grounds, the major objection to fuel taxes arises from the adverse impact of a tax on kerosene. Unfortunately, there are very powerful efficiency arguments for not discriminating between kerosene and diesel oil in setting taxes and, in the longer run, a large discrepancy between taxes on gasoline and diesel oil leads to substitution away from gasoline in transport. Hence, distributional considerations apart, there are good a priori reasons for preferring a tax system which imposes similar tax rates on all petroleum products or on all fuels. Such taxes would improve the overall vertical inequality of the distribution of real income. The broader the tax base, the less would be the horizontal inequity arising because of its differential impact on households with similar total expenditure levels. An alternative approach might be to find a tax or subsidy which could be used to offset the effects of kerosene taxation on poorer (especially rural) households, but in practice it is very difficult to identify a suitable commodity or group of commodities. Any combination of commodity subsidies designed to offset the overall distributional impact of taxing kerosene would generate substantial horizontal effects—that is, there would be a redistribution of real income between households at similar initial levels of income per person.

Between 1975 and 1982, the Thai government substantially reduced the price of kerosene relative to diesel oil and other petroleum products. As a result, consumption rose rapidly among nonhousehold users, so that by 1981–82 the kerosene excise was much less regressive than in 1975–76. This implies that the distributional benefits of a kerosene subsidy on its own are likely to be rapidly eroded because of substitution away from other fuels in favor of kerosene. Since this substitution would primarily be away from diesel oil, it might then be argued that both fuels should be subsidized equally. In that case, more than 90 percent of the subsidy would be devoted to diesel oil, so that the net distributional and inflationary benefits of the subsidy would be very small. It is this combination of easy substitution between kerosene and diesel oil in industrial and other uses and the dominance of diesel oil—for which taxes or subsidies are effectively neutral in distributional terms—over kerosene in total consumption which ensures that a policy of redistribution via fuel subsidies would almost certainly prove to be an expensive failure.

Overall, the analysis of fuel taxes may be interpreted in two contrasting ways:

- It can be argued that there is no real basis for using fuel taxes as a method of achieving other social or economic objectives, so that they should be set to achieve efficiency in the use of different sources of energy in the major energy-consuming sectors, such as transport.
- The second interpretation concentrates on the finding that a general tax on petroleum products has a very limited impact on the economy as a whole. It may thus be seen as a desirable method of raising government revenue.

The choice between these two interpretations depends on the weight given to government revenue relative to the efficiency losses associated with higher fuel prices and taxes.

Appendix A. *Sectors Covered by the Traded and Market-Clearing Nontraded Pricing-Rules, Thailand*

Traded sectors

1. Paddy: linked to rice exports
2. Maize and cereals: exports
3. Cassava: linked to tapioca exports
7. Sugarcane and raw sugar: linked to sugar exports
9. Raw fibers: kenaf exports, cotton imports
10. Tobacco: imports
11. Coffee, tea, and miscellaneous crops: imports
12. Rubber and processing: exports
16. Logging and forest products: exports
19. Coal, oil, and gas: imports
20. Mining: linked to tin exports
26. Rice milling: exports
27. Tapioca milling: exports
30. Sugar refining: exports
40. Wood products: exports
42. Industrial and miscellaneous chemicals: imports
43. Fertilizers: imports
49. Iron and steel: imports
50. Nonferrous metals: tin exports, other imports
51. Prefabricated metal products: imports
52. Industrial and other machinery: imports
53. Electrical equipment and goods: imports
54. Miscellaneous transport equipment (aircraft, ships): imports

Market-clearing nontraded sectors

4. Other root crops, beans, and nuts: fixed by traded agricultural goods
5. Vegetables: fixed by traded agricultural goods
6. Fruit: fixed by traded agricultural goods
17. Charcoal and firewood: fixed by logging and kerosene

Sources: Derived from Thai input-output tables (NESDB 1980; Chulalongkorn University Social Research Institute 1985).

Appendix B. *Changes in Producer Prices Caused by Tax Reforms, Thailand*
(percent)

Sector	*Tax reform*: *All petrol products* 1975	*All petrol products* 1982	*Import sales* 1975	*Import sales* 1982	*Export sales* 1975	*Export sales* 1982	*Gasoline* 1975	*Gasoline* 1982	*Kerosene* 1975	*Kerosene* 1982	*Diesel oil* 1975	*Diesel oil* 1982
1. Paddy	−0.4	−0.8	−0.1	−0.2	−14.6	−11.0	−0.1	−0.2	−0.0[a]	−0.1	−0.1	−0.3
2. Maize and cereals	−0.4	−0.3	−0.2	−0.1	−14.9	−9.2	−0.1	−0.1	−0.0	−0.1	−0.1	−0.1
3. Cassava	−1.0	−0.7	−0.1	−0.1	−15.5	−9.9	−0.3	−0.1	−0.0	−0.0	−0.3	−0.3
4. Other roots, beans, and nuts	−0.2	−0.5	0.1	−0.1	−7.2	−9.1	−0.1	−0.1	−0.0	−0.1	−0.1	−0.2
5. Vegetables	−0.2	−0.3	0.1	0.1	−7.2	−5.1	−0.1	−0.1	−0.0	−0.0	−0.1	−0.1
6. Fruit	−0.2	−0.3	0.1	0.1	−7.2	−5.1	−0.1	−0.1	−0.0	−0.0	−0.1	−0.1
7. Sugarcane and raw sugar	−0.7	−0.5	−0.3	−0.2	−19.9	−13.1	−0.2	−0.1	−0.0	−0.1	−0.2	−0.2
8. Coconut and palm oil	0.2	−0.9	0.3	16.6	−0.0	0.0	0.0	−0.1	0.0	−0.0	0.1	−0.1
9. Raw fibers	−0.2	−0.1	9.9	9.1	0.0	0.0	−0.1	−0.0	−0.0	−0.0	−0.1	−0.0
10. Tobacco	−0.1	−0.0	−0.0	−0.0	−10.9	−7.3	−0.0	−0.0	−0.0	−0.0	−0.0	−0.0
11. Coffee, tea, and miscellaneous crops	−0.3	−0.2	−0.1	−0.1	−14.3	−8.9	−0.1	−0.1	−0.0	−0.1	−0.1	−0.0
12. Rubber, including processing	−0.7	−0.4	−0.2	−0.1	−17.1	−9.9	−0.2	−0.1	−0.1	−0.1	−0.2	−0.1
13. Livestock	0.3	0.1	0.2	0.3	−2.7	−1.9	0.0	0.0	0.1	0.3	0.1	0.0
14. Poultry products	0.4	0.4	0.3	0.4	−2.8	−3.0	0.0	0.2	0.1	0.4	0.2	0.0
15. Agricultural services	2.5	1.9	0.6	1.0	−0.0	−0.0	0.4	0.0	1.3	0.0	0.7	1.2
16. Logging and forestry	−0.2	1.6	10.2	0.6	0.0	−0.0	−0.1	0.7	−0.0	2.4	−0.1	0.1
17. Charcoal and firewood	9.9	8.0	0.0	0.0	−0.0	−0.0	0.0	0.0	87.1	43.0	0.0	0.0
18. Fishing	2.0	−0.9	0.2	−0.8	−0.2	−18.1	0.1	−0.1	0.0	−0.1	1.2	−0.2
19. Coal, oil, and gas	0.0	0.0	8.7	8.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20. Mining	−1.1	−2.6	−0.3	−0.2	−17.9	−11.7	−0.1	−0.6	−0.0	−0.1	−0.1	−0.4
21. Quarrying	1.4	1.5	0.6	0.7	−0.1	−0.1	0.7	0.6	0.0	0.3	0.2	0.2
22. Slaughtering	0.4	0.4	0.2	0.4	−2.0	−1.4	0.1	0.1	0.1	0.5	0.2	0.1
23. Canning of food	0.8	−0.1	0.5	−0.0	−0.5	−7.4	0.1	−0.0	0.0	−0.0	0.4	−0.0
24. Dairy products	0.3	0.3	1.5	2.3	−1.1	−1.2	0.0	0.1	0.0	0.1	0.0	0.0
25. Vegetable and animal oils	0.4	0.0	0.6	8.8	−2.4	0.0	0.1	0.0	0.0	0.0	0.1	0.0
26. Rice milling	−0.2	−0.4	−0.0	−0.1	−10.9	−8.1	−0.1	−0.1	−0.0	−0.0	−0.1	−0.2
27. Tapioca milling	−0.6	−0.0	−0.1	−0.0	−11.8	−7.4	−0.2	−0.0	−0.0	−0.0	−0.2	−0.0
28. Maize and grain milling	0.4	0.3	0.2	0.3	−7.3	−4.7	0.0	0.0	0.3	0.4	0.0	0.0

29. Noodles and bakery products	0.4	0.5	0.3	0.4	−3.9	−3.0	0.1	0.0	0.1	0.2	0.1	0.0
30. Sugar refining	−0.2	−0.2	−0.0	−0.0	−11.0	−7.7	−0.1	−0.0	−0.0	−0.0	−0.1	−0.1
31. Miscellaneous food industries	0.5	0.6	0.5	1.1	−2.6	−1.8	0.0	0.0	0.1	0.1	0.1	0.1
32. Animal feed	0.4	0.1	0.4	1.0	−4.3	−4.6	0.0	0.0	0.1	0.0	0.1	0.0
33. Beverages	0.4	0.4	0.9	0.8	−1.1	−1.0	0.0	0.1	0.0	0.0	0.1	0.0
34. Tobacco products	0.1	0.4	0.2	0.3	−3.6	−1.5	0.0	0.0	0.0	0.0	0.0	0.0
35. Spinning, weaving, and finishing	1.0	0.9	3.4	3.3	−0.0	−0.0	0.0	0.1	0.1	0.1	0.1	0.1
36. Knitting	0.8	0.6	2.1	1.9	−0.0	−0.1	0.0	0.1	0.1	0.1	0.1	0.1
37. Miscellaneous textiles	0.8	0.6	3.0	2.8	−0.0	−0.1	0.1	0.1	0.0	0.1	0.2	0.1
38. Wearing apparel	0.8	0.5	2.3	2.3	−0.0	−0.0	0.1	0.1	0.0	0.1	0.2	0.0
39. Leather industries	0.6	0.4	1.6	1.6	−0.4	−0.3	0.1	0.1	0.1	0.2	0.1	0.0
40. Wood products	−0.3	0.7	10.5	1.0	0.0	−0.0	−0.1	0.2	−0.0	0.7	−0.1	0.1
41. Paper, printing, and publishing	0.9	0.7	3.0	3.4	−0.3	−0.1	0.1	0.1	0.1	0.1	0.1	0.1
42. Industrial and miscellaneous chemicals	0.0	0.0	8.7	8.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43. Fertilizers	0.0	0.0	8.7	8.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44. Drugs and medicines	0.6	0.5	2.9	2.0	−0.8	−0.9	0.1	0.2	0.3	0.2	0.1	0.1
45. Soap, cosmetics, and cleaning preparations	0.6	0.5	2.8	3.0	−0.3	−0.1	0.1	0.1	0.0	0.1	0.1	0.1
46. Rubber products	0.4	0.3	1.8	1.5	−2.1	−2.0	0.0	0.0	0.0	0.0	0.1	0.0
47. Nonmetallic mineral products	1.9	2.3	2.1	1.6	−0.6	−0.5	0.1	0.6	1.2	0.8	0.2	0.2
48. Cement and concrete products	4.0	3.6	1.1	0.9	−0.5	−0.2	0.2	0.2	0.0	0.1	0.2	0.2
49. Basic iron and steel industries	0.0	0.0	8.7	8.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50. Nonferrous metal industries	−0.1	−0.1	−0.0	−0.0	−11.4	−8.0	−0.0	−0.0	−0.0	−0.0	−0.0	−0.0
51. Prefabricated metal products	0.0	0.0	8.7	8.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
52. Industrial and miscellaneous machinery	0.0	0.0	8.7	8.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
53. Electrical goods and machinery	0.0	0.0	8.7	8.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
54. Miscellaneous transport equipment	0.0	0.0	8.7	8.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
55. Motor vehicles and cycles	0.6	0.4	3.9	3.1	−0.5	−0.5	0.1	0.1	0.1	0.1	0.1	0.1
56. Miscellaneous manufactured goods	0.3	0.2	1.2	1.7	−1.3	−0.8	0.0	0.1	0.1	0.1	0.0	0.0
57. Electricity	8.7	4.3	0.8	1.4	−0.0	−0.0	0.8	0.1	0.0	0.0	0.6	0.2
58. Gas and water	2.0	0.6	1.5	4.9	−0.1	−0.0	0.2	0.2	0.8	0.0	0.1	0.1
59. Construction	0.9	1.4	3.0	2.0	−0.3	−0.1	0.2	0.3	0.1	0.1	0.2	0.2
60. Transport services	1.8	1.6	0.8	0.6	−0.1	−0.1	0.4	0.9	1.2	0.1	0.7	0.1
61. Posts and communications	1.8	2.2	0.4	0.7	−0.0	−0.1	0.7	0.4	0.0	0.0	0.4	0.9

(Table continues on the following page.)

Appendix B. *Changes in Producer Prices Caused by Tax Reforms, Thailand*
(percent)

Sector	Tax reform: All petrol products 1975	All petrol products 1982	Import sales 1975	Import sales 1982	Export sales 1975	Export sales 1982	Gasoline 1975	Gasoline 1982	Kerosene 1975	Kerosene 1982	Diesel oil 1975	Diesel oil 1982
62. Hotels and restaurants	0.5	0.7	0.5	0.4	−0.9	−1.3	0.1	0.1	0.8	1.0	0.1	0.0
63. Business services	0.2	0.5	0.4	0.3	−0.1	−0.0	0.1	0.2	0.0	0.0	0.0	0.1
64. Entertainment	0.5	0.8	0.5	0.6	−0.1	−0.1	0.1	0.2	0.1	0.0	0.1	0.1
65. Personal and miscellaneous services	0.6	0.5	1.5	0.5	−0.1	−0.0	0.1	0.3	0.3	0.0	0.2	0.0
66. Government and public services	0.2	0.1	0.2	0.2	−0.1	−0.1	0.0	0.0	0.0	0.0	0.0	0.0
67. Miscellaneous	0.8	1.0	1.6	3.0	−3.6	−2.8	0.2	0.5	0.4	0.2	0.2	0.0
68. Wholesale and retail trade	0.2	0.4	0.3	0.2	−0.1	−0.1	0.1	0.2	0.1	0.3	0.0	0.0
69. Road passenger transport	5.9	4.8	0.8	0.8	−0.1	−0.1	1.9	0.6	0.0	0.0	2.1	2.3
70. Rail and air transport	4.6	5.7	0.9	0.5	−0.1	−0.2	2.7	3.4	0.2	0.2	0.3	0.5
71. Water transport	3.5	3.9	0.3	0.6	−0.0	−0.1	0.0	0.2	0.1	0.1	1.7	2.2
72. Road freight transport	6.2	5.3	0.6	0.8	−0.1	−0.1	2.0	1.2	0.0	0.0	2.1	2.2
73. Gasoline	22.2	15.7	0.0	0.0	0.0	0.0	14.5	11.4	0.0	0.0	0.0	0.0
74. Kerosene	22.2	15.7	0.0	0.0	0.0	0.0	0.0	0.0	196.2	85.2	0.0	0.0
75. Diesel oil	22.2	15.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.6	9.7
76. Residual fuel oil	22.2	15.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
77. LPG and miscellaneous petroleum products	22.2	15.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

a. The expression "−0.0" indicates a negative number between 0 and −0.0499.

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Modeling the Impact of Agricultural Growth and Government Policy on Income Distribution in India

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This article uses a limited general equilibrium model to investigate the growth and equity effects of a variety of economic and technical changes and selected agricultural policies in India. It explores how changes in food prices, rural wages, and farm profits associated with the Green Revolution period affected income distribution between net buyers and sellers of food. The model shows that income gains from the Green Revolution initially accrued to the wealthier rural groups but that after 1972–73 they were transferred to urban consumers and that by 1980–81 the per capita incomes of poor and wealthier rural groups alike were barely above their respective 1960–61 levels. The model is also used in counterfactual analysis of the impact of changes in technological, demographic, investment, taxation, and income redistribution variables. Its findings indicate the importance of trade policies for the nature of the equity outcomes from agricultural growth and suggest that a reduction in population growth and an increase in nonagricultural employment and income are required to convert agricultural growth into reduced rural poverty.

As a result of the Green Revolution, agricultural productivity in India has risen sharply over the last two decades and India has become a self-sufficient producer of basic food grains. While there is no dispute about the rapid increase in production, economists have not had available a similarly compelling analysis of who has benefited from this growth.

Debates about the effects of the Green Revolution and Indian agricultural policies on the distribution of income have, almost without exception, been limited to the question of how income is distributed across small and large farms and between landowners and workers, rather than between producers and consumers of food. Typical subjects of study have been the differences in adoption behavior of small and large farms, the distributional impact of their differential access to credit, and the direct labor-use effects of high-yielding varieties or of irrigation.

The determination of these direct first effects of changes in agricultural tech-

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niques and policies is, of course, necessary and important. Meanwhile, however, the longer-term macroeconomic effects of changes in agricultural technology and agriculture-related policies have not received sufficient attention. This paper presents a limited general equilibrium model which incorporates most of the relevant macroeconomic factors needed to determine the distributional impact of the Green Revolution. The model also allows assessments of other trends and policies that may be determinants of income distribution. This analysis is directed to the following objectives:

- To trace changes in income distribution between rural and urban groups and between different income groups
- To determine the equity effects of the Green Revolution
- To suggest how changes in economic, demographic, and technical trends would be likely to influence income distribution
- To indicate the effects of alternative government policies on equity and poverty.

In order to address these objectives, we developed a limited general equilibrium model that is capable of accounting for changes in rural and urban income induced by changes in agricultural commodity supply and demand. This model is described in section I of this paper and is presented in mathematical terms in appendix A. The major elements of the model are:

- The demand and supply of four agricultural outputs
- The demand and supply of three agricultural inputs
- Real incomes of rural and urban inhabitants at different income levels.

The key feature of the model is that prices and quantities of agricultural output and variable inputs are endogenous. The model differs from an economy-wide model, however, in that nonagricultural income and production are treated as exogenous.

Succeeding sections of the paper discuss several of the applications of the model.

Section II briefly describes a standard exercise which we carried out to compare the model's endogenous ex post predictions of the quantities and prices of agricultural inputs and outputs with the actual paths of such quantities and prices as shown by macroeconomic data. Section III discusses the use of selected equations from the model to account for changes in rural and urban income in India during the period from 1961 to 1981. In section IV, the model is used in counterfactual analysis to determine how income and agricultural variables would have changed under various hypothetical scenarios.

The model's findings are summarized in section V. Among other things, our investigations show that India's progress in agriculture during the twenty-year period in question apparently had little net positive effect on the incomes of either the rural well-to-do (the landowners) or the rural poor. The chief beneficiaries of increased agricultural output (which was accompanied by government policies that caused a relative decline in food prices as compared with manufactured goods prices) were urban residents. Our findings suggest that the incomes of the rural poor in India would be more likely to improve as a result of demographic changes and increases in nonagricultural employment than as a result of technological improvements in agriculture.

These conclusions, it should be understood, were arrived at through an ambitious attempt to try to understand an exceedingly complex reality. Our efforts to do so are subject to various limitations, many of which stem from a lack of complete data. In order to construct and utilize our model, many assumptions had to be made, and readers will find many caveats scattered throughout this article. The strength of the model, however, arises from our econometric estimation of parameter values which are based on the very large amounts of data compiled and incorporated into it. Despite its limitations, we hope that this paper can further the evolution of analysis of important issues in economic development.

I. A Summary of the Model

The limited general equilibrium model for our investigation determines quantities and prices in seven markets: three input markets, labor, draft power, and fertilizers; and four agricultural output markets, rice, wheat, coarse cereals, and other crops. It also determines residual farm profits. Given these prices and quantities, it then determines the real incomes of four rural and four urban income quartiles (R1, R2, R3, and R4 and U1, U2, U3, and U4, respectively, in the appendixes).

The supply of the four agricultural commodities and the demand for the three factors of production are modeled as a jointly estimated system of output supply and factor demand equations.[1] Output supply and factor demand shift in response to changes in exogenous endowment and technology variables: land (cultivable area), annual rainfall, irrigation, high-yielding varieties, roads, farm capital (animals and implements), regulated markets, and technological change.

The *supply of labor* is responsive to the real rural wage. Agricultural labor is supplied by rural groups and also by some urban emigration, which is responsive to the rural wage.

The *supply of draft power* is responsive to the real rental rate for draft animals and is supplied by each of the rural groups.

The *fertilizer supply* is treated as an aggregate of nutrient tons, which is responsive to the price of fertilizer relative to nonagricultural goods prices.

1. Separate systems were estimated for each of four agroclimate zones. These systems were then aggregated to the national level. A flexible functional form was used to allow for cross-price effects among all seven outputs and factors.

The *supply of land* is exogenously given as the cultivated area. This is appropriate, because area expansion in Indian agriculture has virtually stopped since the mid-1960s. However, this treatment still allows cropped area to vary endogenously via changes in the extent of double and triple cropping. And, of course, the area allocated to different crops can vary.[2] While the supply of land is exogenous, net returns to land (the residual farm profits after variable factors have been paid) are determined endogenously.

Consumer demand is responsive to the prices of commodities and the real income of each of the eight income groups. Poorer groups have higher income elasticities than richer groups. Each income group's demand must therefore be modeled separately. Demand was estimated econometrically; a flexible functional form was used, so that all (compensated) cross-price elasticities were directly estimated. Aggregate demand is the sum of the demands of all the income groups.

Nominal income is computed as each group's supply of agricultural production factors multiplied by the factor prices, plus an exogenously given component for nonagricultural income. *Real income* is calculated for each of the eight groups as their nominal income deflated by an endogenous consumer price index that is specific to that group's consumption patterns and reflects all endogenous changes in food prices.

Prices and quantities of commodities and factors of production are determined as those which equate aggregate supply and demand in each of the seven markets. The government can influence agricultural prices through the use of tariffs, food imports and exports, food grain storage, forced procurement at fixed prices, and consumer ration shop sales at nonequilibrium prices.[3] The model solves simultaneously for changes in endogenous prices and quantities and thus determines for each income group the change in its nominal income, price deflator, real income, labor supply, draft power supply, and level of consumption.

Nonagricultural prices are given exogenously and are used as the numeraire of the model. Because nonagricultural income is also given, nonagricultural production is exogenous and consumption of this output must adjust via trade.

The base year used in constructing the model is 1973–74. Initial values are computed largely from an extensive rural household survey by the National Council for Applied Economic Research.[4] The entire model is written in logarithmically linear equation form.

There are several important characteristics of the model which must be kept in mind while interpreting our findings.

First, it is well known that the distributional outcomes from general equilib-

2. Neither the total cropped area nor the area under different crops is explicitly traced in the model because the supply equations do not distinguish between area and yield supply.

3. Although we deal mainly with food trade in this paper, forced procurement and food subsidies are discussed in Binswanger and Quizón (1986).

4. For a fuller discussion of data sources and estimation of parameter values, see appendix B and Pal and Quizón (1983).

rium models depend crucially on labor market assumptions (Taylor 1979). We model the real rural wage by equating supply and demand for labor; that is, it is a full employment model. This treatment is consistent with the empirical evidence that there is little year-round unemployment in rural areas and that most unemployment is seasonal (Krishna 1976). Moreover, real wages are variable both within and across years; that is, no model of constant nominal or real wages is consistent with the data. Econometric studies of labor demand (Evenson and Binswanger 1984) and supply (Bardhan 1984; Rosenzweig 1984) are also consistent with our neoclassical treatment of the rural labor market.

In spite of this evidence in favor of a neoclassical approach, we are keenly aware that there is considerable friction in rural labor markets. For example, there are substantial and persistent interregional wage differentials, and seasonal unemployment is clearly present. But our model is not regional and does not deal with intrayear wage determination.

Similarly, because the model aggregates across different regions, it is not able to account for regional concentration of the Green Revolution. Because, in the longer term, increased production led to a decline in agricultural prices, farmers who had not adopted the Green Revolution technology—and whose yields had not increased—were harmed. Thus our simulation obscures both the more radical income gains in beneficiary areas and the declines in the nonadopting regions.

The model treats nonagricultural incomes (and implicitly urban wages and nonagricultural output) as exogenously determined. The purchasing power of the nonagricultural incomes, however, depends on agricultural prices. When these prices rise, urban agricultural demand will fall because of both price and income effects. But other feedbacks from agricultural activity to the nonagricultural sector are not allowed for in the model. One consequence of our treatment of the nonagricultural sector is that changes in food prices have no effect on the nominal urban wage; that is, reductions in food prices benefit urban wage earners and are not passed along to employers in the form of lower wages.

Although the model determines what happens to real farm profits and the incomes of the rural income groups, it does not treat endogenously what subsequently happens to private savings and private agricultural investments brought about by the changing fortunes of farmers. Thus our model is not a very long-run model. The reason for this treatment is that no econometric studies exist which quantify the link between farm profits and farm investment.

Because there is no adequate empirical evidence for the actual changes in factor or asset endowments, we have not attempted to track these changes in our analysis of income distribution trends and we do not have endogenous endowment changes in our simulations. For such an analysis, one would need either to get comprehensive and accurate data or to be able to model investment processes in land and other factors of production for each of the four rural income groups. At the present time, the absence of such empirical knowledge makes the modeling of endowment changes a distant goal.

Finally, the model leaves out the effects of the market for foreign exchange on agricultural performance, and vice versa. India is modeled as a state-trading economy in which decisions to export or to import agricultural commodities rest solely with the government. These decisions are exogenous to the model.

II. Comparing Model Predictions with Actual Changes

A set of experiments was performed to compare the model's predictions of agricultural prices and quantities with the actual prices and quantities reported. Ideally, one would want to compare the model's predictions of income distribution with actual patterns. Unfortunately, the data needed for such a comparison do not exist. Changes in exogenous variables (such as population, agricultural technology, capital and inputs, and nonagricultural prices and income) were introduced into the model for the five-year periods between 1960–61 and 1980–81, and the model's calculated production and prices were compared with the actual quantity and price data reported for those periods (see part B of appendix table 11). Difficulties encountered in compiling actual data for the comparison are discussed in appendix B.

In table 1, we compare indexes of actual and predicted values for six years and give the ratios of predicted to actual levels for each variable (with 1973 as the base). As can be seen, the fit between predicted and actual values is generally close despite the substantial changes that occurred in many actual values during the period. Of 65 predictions, 28 differ from the actual figure by 10 percent or more and only 10 by 20 percent or more. The poorest predictions are for the extreme years 1960–61 and 1980–81.

Although during the period as a whole we overpredicted the growth rate in agricultural output by only about 0.5 percent per year, our quantity predictions are better than our price predictions. On the price side, the most serious problem is the overprediction of the rate of growth in agricultural prices from 1975–76 to 1980–81. Figure 1 shows that actual terms of trade moved rapidly against agriculture during that period, but our model does not fully capture this downward trend, apparently because our model exaggerates the growth of demand. Notwithstanding these difficulties, the results show that our model is able to replicate reasonably actual agricultural conditions for the period.

Among the individual variables, fertilizer consumption in the pre-Green Revolution period is the one tracked least accurately. We overpredict fertilizer consumption in those early years by a factor of 200 percent. This error is partly due to an extremely low base-year value. We also underestimate the rapid growth in fertilizer demand in the 1975–76 to 1980–81 period. This may be partly because we are not able to account for the rapid growth in the fertilizer subsidy in our simulations.

Table 1. *Comparative Indexes of Production, Employment, Wages, and Prices*

Variable	*Agricultural year* 1960–61	1965–66	1970–71	1975–76	1980–81
All crop production					
Actual value	78.46	79.95	101.02	108.23	122.16
Predicted value	74.83	78.28	98.62	108.49	130.28
Ratio of predicted to actual value	0.95	0.98	0.98	1.00	1.07
Rice production					
Actual value	82.82	81.49	101.91	106.01	121.37
Predicted value	82.65	83.81	100.05	107.68	125.95
Ratio of predicted to actual value	1.00	1.03	0.98	1.02	1.04
Wheat production					
Actual value	47.32	48.24	99.69	116.10	149.54
Predicted value	41.39	52.83	95.59	117.51	162.49
Ratio of predicted to actual value	0.87	1.10	0.96	1.01	1.09
Coarse cereal production					
Actual value	89.19	90.96	106.45	108.52	110.81
Predicted value	82.12	80.96	99.35	108.52	119.59
Ratio of predicted to actual value	0.92	0.89	0.93	1.00	1.08
Other crop production					
Actual value	83.05	86.86	99.07	107.05	116.10
Predicted value	75.57	80.79	97.62	105.26	127.27
Ratio of predicted to actual value	0.91	0.93	0.99	0.98	1.10
Fertilizer consumption					
Actual value	11.45	32.50	84.30	108.53	205.85
Predicted value	35.21	58.75	74.44	114.46	182.02
Ratio of predicted to actual value	3.08	1.81	0.88	1.05	0.88
Employment					
Actual value	85.17	90.62	96.07	102.62	109.17
Predicted value	81.54	86.60	95.49	103.36	111.74
Ratio of predicted to actual value	0.96	0.96	0.99	1.01	1.02
Rice prices					
Actual value	92.89	93.68	97.15	101.78	89.97
Predicted value	92.98	116.50	81.19	107.88	120.87
Ratio of predicted to actual value	1.00	1.24	0.84	1.06	1.34
Wheat prices					
Actual value	100.57	109.06	108.30	106.36	85.35
Predicted value	120.20	134.52	86.33	108.54	103.66
Ratio of predicted to actual value	1.20	1.23	0.80	1.02	1.21
Coarse cereal prices					
Actual value	93.13	106.49	86.09	90.70	74.70
Predicted value	102.38	116.84	85.77	95.20	101.38
Ratio of predicted to actual value	1.10	1.10	1.00	1.05	1.36
Other crop prices					
Actual value	100.74	99.20	103.56	95.59	101.66
Predicted value	93.22	114.29	87.44	105.41	126.31
Ratio of predicted to actual value	0.93	1.15	0.84	1.10	1.24
Labor wages					
Actual value	102.57	104.85	109.57	97.69	98.40
Predicted value	116.22	121.74	93.05	102.00	105.57
Ratio of predicted to actual value	1.13	1.16	0.85	1.04	1.07
Prices of all commodities					
Actual value	100.00	100.00	100.00	100.00	100.00
Predicted value	100.11	113.49	88.80	105.30	119.08
Ratio of predicted to actual value	1.00	1.13	0.89	1.05	1.19

Source: World Bank data; see appendix table 11.

Figure 1. *Agricultural/Nonagricultural Terms of Trade for India, 1960–61 to 1980–81 (Actual Data; 1973–74 = 100)*

Source: Appendix table 11, part A.

III. Accounting for Changes in Income Distribution

In this section we compute a reference path of the real incomes of each of the rural and urban income groups during the period from 1960–61 to 1980–81. We generate the implied distribution of income among the eight groups by using actual estimates of agricultural output, agricultural prices, wages, and fertilizer consumption, as well as the exogenous variables that affect the income and factor market equations in the model. The numbers in table 2 are indexes of the predicted levels and are calibrated so that the predicted level of each variable is equal to 100 for 1970–71, the end of the first phase of the Green Revolution.

We assumed that during the twenty-year period, the across-quartile shares in ownership of factor inputs and within-quartile shares of nonagricultural and factor incomes in total income remained equal to their respective base-year (1973–74) values (see discussion in section I). We also assumed that the rates of growth in the population, in the agricultural capital stock, and in the nonagricultural income of each quartile were the same across the groups. But there may have been other causes of change in actual incomes that we were unable to account for, such as changes in taxation, in investment behavior, in people's occupations, and in food subsidies. Table 2 shows what would have happened to real income as a result of changes in agricultural production and technology, agricultural output and input prices, nonagricultural incomes and prices, and population. Although the total endowments of the various groups change over

Table 2. *Simulated Indexes of Income Distribution and Income Sources, India, 1960–61 to 1980–81*
(1970–71 = 100)

	Agricultural year					
Endogenous variables	*1960–61*	*1965–66*	*1970–71*	*1973–74*	*1975–76*	*1980–81*
Real per capita income (actual)						
National	92.0	95.0	100	95.1	95.4	105.9
Rural, by quartile						
First (poorest)	101.0	99.0	100	95.9	97.4	107.0
Second	96.9	95.8	100	94.6	94.8	99.9
Third	93.8	93.5	100	93.8	93.3	96.3
Fourth (richest)	88.5	88.6	100	92.4	90.7	88.8
Aggregate[a]	92.9	92.4	100	93.6	92.9	94.9
Urban, by quartile						
First (poorest)	91.9	100.4	100	98.1	100.7	136.0
Second	90.9	102.8	100	99.3	102.6	141.9
Third	90.2	102.7	100	99.7	102.5	139.3
Fourth (richest)	87.6	102.3	100	99.8	102.2	133.5
Aggregate[a]	89.4	102.3	100	99.4	102.2	136.7
Agricultural employment	98.2	100.1	100	112.3	118.8	118.5
Real agricultural wage bill	91.2	95.3	100	101.4	104.9	105.4
Real residual farm profits	64.2	67.9	100	86.0	85.1	76.4
Nonagricultural income	71.9	93.6	100	111.3	121.8	182.7
Real per capita disposable income	92.4	94.5	100	96.7	97.8	113.6
Total actual agricultural output	79.3	81.2	100	99.4	107.1	119.6
Actual prices = agricultural/nonagricultural goods	89.8	97.2	100	97.7	91.6	76.3

a. These estimates of per capita income are computed as in equation 16 of appendix A, in which the subscript k now refers to either the rural quartiles (R1 to R4) or the urban quartiles (U1 to U4) only.

time, the relative endowment position of each group was assumed to remain the same.

The last two rows of table 2 show the actual growth of total agricultural output and the change in agricultural terms of trade. Agricultural production grew rapidly during the early Green Revolution period (1965–66 to 1970–71) and again from 1973–74 onward, while agricultural terms of trade rose prior to the Green Revolution, stayed fairly constant until 1973–74, and then dropped substantially by 1980–81.

These changes in quantity and price explain the changes in farm profits. Farm profits were seriously depressed in 1960–61 and in 1965–66 but then moved dramatically upward by 1970–71. By 1973–74 they had declined to 85 percent of their 1970–71 level, and by 1980–81 to 76 percent of the 1970–71 level. In these years, declines in output prices outweighed rapid growth in agricultural output.

Employment in agriculture (estimated in our model) grew by about 20 percent during the twenty-year period. Because real wages declined by about 5 percent, the total real wage bill for the period rose by about 15 percent.

Nonagricultural real income more than doubled during the period, with the most rapid increases occurring just prior to the Green Revolution and between 1975–76 and 1980–81. This latter gain occurred partly because the numeraire by which nonagricultural income is deflated gives a large weight to agricultural commodities, the prices of which had declined.

The trends in output and factor prices, and in agricultural and nonagricultural income, suggest that real aggregate per capita income among rural people grew by only about 8 percent during the early Green Revolution, after which it declined and stagnated. Despite a drastic shift in the distribution of rural income from wages to profits in the early period, rural income distribution was remarkably stable for the period as a whole. The effect of adverse wage trends on the rural poor was partially alleviated because agricultural employment increased somewhat and because the poor participated to a small extent in the growth of farm profits. About 11 percent of their income was derived from such profits. They also had substantial gains in nonagricultural incomes,[5] and as consumers they benefited from the decline in agricultural prices during the last five years of the twenty-year period.

The first period of the Green Revolution was one of substantial gains in farm profits. But the rapid gains in production during the late 1970s did not translate into further advances in income because the prices of agricultural products fell. The production gains from the early Green Revolution period were associated with rising prices because the government used the gains largely to replace imports. But once self-sufficiency in food grain production was more or less assured, the surplus grain production had to be absorbed domestically. This was a classic example of the process in which productivity gains in agriculture were transmitted to consumers (both rural and urban) by way of declining prices.

It is therefore not surprising to find that urban groups showed the largest gains in income, although their gains were largely a phenomenon of the last five years of the twenty-year period. They appear to have gained during the first quinquennium as well, but that gain was made despite rises in agricultural prices. In the late 1970s the combination of rapid nonagricultural growth and declining agricultural terms of trade greatly benefited the urban groups, with the biggest beneficiaries being the urban poor, since they spend a larger share of their incomes on food.

IV. Simulations of Alternative Policies and Trends

The previous section offers only partial explanations of why wages, farm profits, and income distribution evolved the way they did. An assessment of how

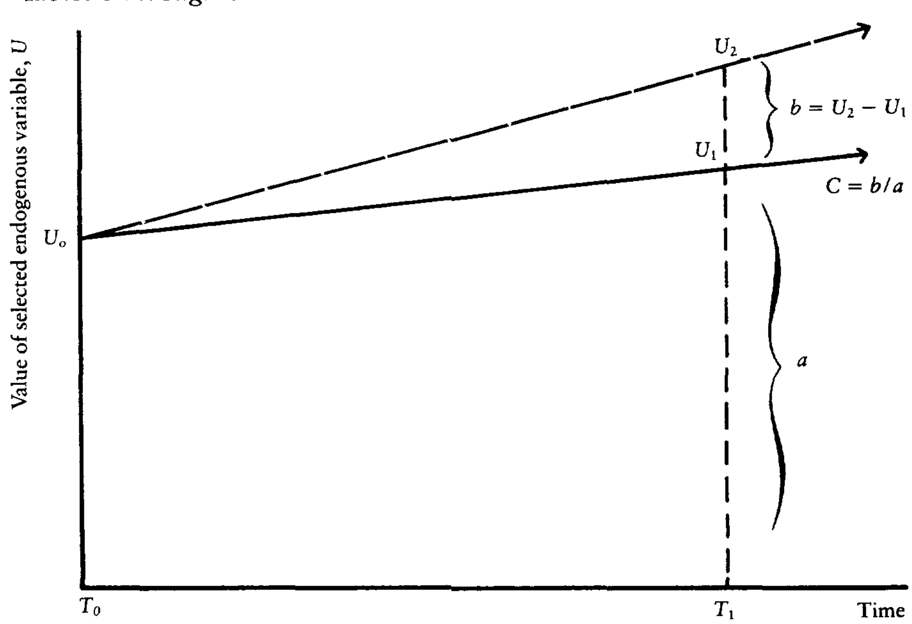
5. Nonagricultural sources provided 21 to 26 percent of the nominal per capita incomes of rural groups.

each individual change in a policy or a trend affects the model's outcomes is required to separate out the influence of different factors.

We do that in this section by comparing the results of a simulated change in selected trends or policies with the "base case," which reflects what actually occurred in India during this period. Thus we simulate a change in a specific exogenous demographic variable, for instance, and trace the effect of the change on production, prices, employment, and farm profits and through them see how income distribution would have been affected. Figure 2 illustrates this process. U_0U_1 is the path of the specific endogenous variable given actual policy trends and events, and a is the value of U at U_1. The variable U could be any of the twenty-eight shown in the left-hand column of tables 3 through 6. U_0U_2 is the simulation path of U if an exogenous change or intervention occurred, such as any of those shown in the column headings of tables 3 through 6. The value b is the difference between U_2 and U_1, the induced change in U at T_1; and C is the percentage change in U, or b/a. These percentage changes are the values reported in tables 3 through 6. In table 3, T_0 to T_1 is a ten-year period, while in tables 4, 5, and 6, T_1 is perhaps three to five years, sufficient time for farmers to respond to changes in technology, policies, and prices by adjusting their production patterns.

In order to explicitly track the changes in the terms of trade between agricul-

Figure 2. *Simulated Changes in Trends and Policies: Derivation of Values, Tables 3 through 6*



Note: C = percentage change in simulated value of U from its "base" trend value, as the result of a simulated change in one or more exogenous variables. C values are those shown in tables 3 through 6.

ture and nonagriculture, we use nonagriculture commodities as the numeraire. The change in the gross national product (GNP) deflator shown below is therefore a direct function of the change in terms of trade, not of inflation.

Demographic and Urban Growth Scenarios

In demographic scenarios 1.1a and 1.1b (see table 3), the assumption is made that population growth in India (both rural and urban) is reduced by 10 percent during a decade. Total nominal nonagricultural income is reduced by 10 percent as well and is therefore unaffected on a per capita basis. In scenario 1.1a the labor force continues to grow at the same rate as before—that is, this scenario is a stylized representation of a reduction in fertility alone, which would not affect the size of the labor force. In scenario 1.1b we assume that the reduction in fertility has caused a (long-run) decline in labor force growth and shows, in a stylized way, the effects of these reductions in fertility and labor force growth during a ten-year period.

In the first row of table 3 we see that the postulated fertility decline leads to a substantial gain in national income of about 5.6 percent and 5.2 percent in the two cases. In the second row we see that output declines somewhat more sharply (−1.2 percent) when labor force growth is also reduced than it does initially when the labor force still continues to grow (−0.6 percent). Aggregate prices, reflected in the GNP deflator, decline sharply (−19.4 percent and −18.1 percent respectively). The main difference between the two scenarios is in wages. Real wages decline by about 3 percent during the first decade because of reduced demand for agricultural output, whereas they increase by about 10 percent in our (stylized) long term. This is because long-run agricultural labor employment declines by about 5.5 percent in the latter case, so wages must rise.

In scenarios 1.1a and 1.1b there is a progressive impact on rural and urban income. The rich rural group (landowners) loses only a little in real income in the first decade (−3 percent), but in the long run this group loses more (−7.4 percent) as its members must begin to pay higher real wages. The increase in wages, coupled with declining demand, leads to a sharp reduction of 45 percent in residual farm profits. Under both scenarios, the poor in both rural and urban areas gain from the substantial decline in food prices. They gain a little more so in the long run because they also benefit from increased scarcity of labor (+15.5 percent and +19.7 percent for the rural and urban poor, respectively). The urban group gains the most since it benefits not only from lower food prices but also encounters less erosion of income as rural-to-urban migration is reduced.

Nutrition, measured here as cereal consumption, improved in all groups except in the rich urban and rural groups. For the lowest income groups the improvement is somewhat smaller than the change in real income, whereas for the richest groups the change in nutrition is much smaller than the change in income. This reflects the fact that richer groups have lower income elasticities.

Simulated scenario 1.2 in table 3 is one of urbanization. Rural population is assumed to decline by 10 percent, while urban population increases by 40.2 percent, enough to absorb the rural population. (Nominal urban income is increased by 40.2 percent in order to hold nominal per capita income constant.) In the absence of a continued rural-urban income differential, no migration would occur and the scenario would be unrealistic.

The main feature of scenario 1.2 is the assumed reduction in the number of agricultural producers while the number of consumers remains constant. Therefore, agricultural terms of trade rise sharply, which drives the GNP deflator up by 32 percent.

The reduction in agricultural population leads to a real wage increase of 9.4 percent, while the sharp increase in agricultural prices allows residual farm profits to rise by 58 percent. These effects drive the income distribution effects. Large farmers gain by nearly 30 percent, while the rural poor benefit both from increased wage income and increased farm profits, which account for 11.32 percent of their real income (appendix table 8). These gains more than offset their losses as consumers, and their incomes rise by a modest 3 percent. For the urban poor, however, the outcome is a fall of 21 percent in income as food prices rise. The losses of the second urban quartile are somewhat higher than the losses of the first (poorest) quartile. This occurs because the poorest urban quartile supplies some labor to the agricultural sector, whereas the second quartile does not. The urban rich lose less (−15 percent) than other urban groups because they spend a smaller part of their income on food.

Simulated scenario 1.3 combines scenarios 1.1b and 1.2. Overall population and labor force growth rates both decline by 10 percent, but the decline is accompanied by a rural-to-urban migration. The net effects are a decrease of 20 percent in the rural population and an increase of 30.2 percent in the urban population. The result is a large gain (14.3 percent) in real national per capita income. Meanwhile, agricultural prices increase, which leads to a modest increase in residual farm profits (13 percent). Therefore, all rural income groups experience real income gains of about 20 percent. Urban groups, however, lose.

We should note here that this scenario would not last indefinitely. People would not continue to move to urban areas in the face of a substantial decline in real wage incomes. Nominal incomes must rise if urbanization is to continue. We investigate the effect of such a rise alone in scenario 2.1 and then combine it with the demographic cum urbanization scenarios in scenario 2.2.

Scenario 2.1 lets the exogenous component of urban income increase by about 19 percent. Aggregate agricultural output increases only slightly (0.7 percent) in response to the increased demand for food because output is quite inelastic. Instead, the increased demand for food resulting from the rise in urban income translates into a substantial increase in the aggregate price level of food (16.6 percent). Thus, much of the increase in urban consumption of food must come from reduced consumption among the poorer two rural groups.

Table 3. *Simulated Effects of Demographic Changes*
(percentage change)

Endogenous variables	*Scenarios for changes in exogenous variables*					
	Reduced population growth		*Urbanization*			
	Labor force growth rate		*Population and labor growth*			
	Steady (s1.1a)	*Reduced (s1.1b)*	*Steady (s1.2)*	*Reduced (s1.3)*	*Rise in urban income (s2.1)*	*Combined scenarios: 1.1b + 1.2 + 2.1 (s2.2)*
National income per capita	5.63	5.20	9.08	14.29	6.49	20.78
Output						
Total	−0.64	−1.23	0.91	−0.32	0.74	0.42
Rice	−0.39	−1.97	2.32	0.35	1.25	1.60
Wheat	−4.58	−5.70	10.95	5.25	5.66	10.92
Coarse cereals	−2.43	−3.37	−17.12	−20.48	−5.61	−26.10
Other crops	0.44	0.56	2.04	2.60	0.84	3.43
GNP deflator	−19.44	−18.12	31.76	13.64	16.64	30.28
Prices						
Rice	−27.40	−25.51	45.02	19.51	23.04	42.55
Wheat	−34.83	−32.68	58.14	25.47	30.09	55.56
Coarse cereals	−32.83	−25.81	28.38	2.57	16.58	19.14
Other crops	−21.41	−21.00	40.12	19.12	21.08	40.20
Wage rate	−2.88	10.14	9.42	19.56	−0.35	19.22
Employment	−0.71	−5.46	−5.92	−11.38	−0.47	−11.85
Wage Bill	−3.59	4.68	3.50	8.18	−0.82	7.37
Profits	−36.01	−45.37	58.46	13.09	35.14	48.23

Income per capita (by quartile)						
Rural						
Poorest	14.91	15.53	3.13	18.56	−3.89	14.67
Second	8.61	7.72	11.62	19.33	1.51	20.84
Third	4.64	2.46	17.31	19.77	5.13	24.90
Richest	−3.34	−7.44	29.86	22.43	12.59	35.02
Urban						
Poorest	14.99	19.67	−20.95	−1.28	4.10	2.82
Second	16.55	21.02	−26.86	−5.84	2.73	−3.11
Third	14.22	19.02	−23.29	−4.27	4.47	0.20
Richest	8.44	13.62	−14.67	−1.05	9.12	8.07
Per capita cereal consumption						
Rural						
Poorest quartile	13.78	12.61	1.24	13.85	−2.95	10.91
Richest quartile	−0.54	−2.24	10.34	8.09	4.60	12.70
Urban						
Poorest quartile	14.64	16.93	−17.04	−0.11	1.96	1.85
Richest quartile	−0.58	0.55	3.15	3.70	6.54	10.25
Aggregate per capita cereal consumption	8.03	6.80	0.53	7.33	0.95	8.28

Note: The values shown are the percentage changes in the endogenous variables from their base case level, as the result of the induced change in the exogenous variables shown in the column headings.

All income, output, price, wage, profit, and consumption variables are real values.

The income groups shown are expenditure quartiles for rural and urban populations separately. The four rural expenditure quartiles together constitute 0.8009 of the total population, while the four urban quartiles include 0.1991 of the total population.

Since agricultural output rises only slightly, real wages are largely unaffected, but residual farm profits rise by 35 percent because of higher food prices. The rural poor lose 3.9 percent of their real income, but large farmers gain by more than 12 percent. Since urban groups must share their initial income gain of 19 percent with large farmers, the urban gain is reduced to about 9 percent for the urban rich and only 3 percent to 4 percent for the urban poor.

Scenario 2.2 groups the combined effects of the slowdown in population growth and labor force growth (1.1b), faster urbanization (1.2), and urban income growth (2.1). The effects on the endogenous variables are largely additive. Real urban incomes stay about constant, except for those of the urban rich, which rise by 8 percent. The incomes of the rural poor rise by about 14.7 percent, while those of the rural rich increase 35 percent. As long as the reduction in the number of agricultural producers and the rise in nominal urban income are not accommodated by more imports, the rural groups are the main beneficiaries. It is important, however, to realize that if increases in food prices were precluded by additional imports, the distributional outcome would be more favorable to the urban groups and less favorable to the rural rich.

Technical Change Scenarios

In simulated scenarios 4.1 and 4.4 (see table 4), yields of each individual crop or crop group are assumed to rise by 20 percent, a change corresponding to a major varietal shift like the Green Revolution. In scenario 4.5, the yield gain is smaller (10 percent) but is distributed evenly across all crops.

We present two versions of each of these scenarios. In the first versions (scenarios 4.1a, 4.2a, 4.3a, and 4.4a), the economy is considered closed and additional production is consumed in India. But in the second versions (scenarios 4.1b, 4.2b, 4.3b, and 4.4b), the extra yield is either exported or used to reduce imports of the commodity in question. The exported quantities (or the reduction in imports) were considered to be base-year domestic production multiplied by 20 percent. It is only after this initial increased quantity of output is exported that our simulation allows for farmer adjustment of crop mix into the more profitable crops as yields and prices change.[6]

Note that the b scenarios correspond to an assumption of state trading; it is not an open economy model with trade in many commodities. The exports (or reduced imports) of the b scenarios are an extreme assumption which the government is unlikely to carry out. It would probably alter exports (or imports) by a magnitude ranging from full domestic absorption of the surplus, as in the a scenarios, to full export of the increase in the b scenarios. Any desired intermediate point can be obtained by computing the appropriate linear combination of the impacts of the a and b scenarios.

When an increase of 20 percent in rice yields has to be absorbed domestically,

6. For a detailed discussion of how technical change is introduced in the model, see appendix III of Quizón and Binswanger (1984).

the result is a sharp decline in the price of rice (−31 percent) and in the price of its closest substitute, wheat (−15 percent). Rice production increases by about 20 percent, while wheat production declines by about 6 percent. Prices of the other agricultural commodities also decline by about 6 to 8 percent. The GNP deflator therefore declines by about 12 percent, while total agricultural output increases by about 5 percent. The price decline and the increase in agricultural output imply a real national income gain of about 4 percent.

The increased agricultural output requires only moderately larger labor inputs (1.1 percent), and the increased demand for labor results in modestly higher (1.5 percent) real agricultural wages.

The declines in agricultural prices, combined with the rise in wages, lead to a reduction in residual farm profits despite the increase in agricultural productivity. The price, farm profit, and wage effects largely explain the distributional outcome. Net buyers of food gain, and the more so the larger is their share of income spent on food. The urban poor gain the most (12 percent and 13.6 percent). The rural poor also benefit, since they too spend most of their income on food. Moreover, they benefit from the slight rise in wage levels. Since reduction in farm profits affects them only slightly, they end up with a net gain in real income of 7.5 percent. The rural rich, however, derive much income from farm profits, and their gain as consumers is not sufficient to offset their loss in profits. Their real income therefore falls by 1.4 percent.

A decision to export all the initial increase in rice production would sharply alter the distributional outcome. Since national income would rise by 5.7 percent, domestic demand would increase, which would lead to a rise of 10 percent in the domestic price level. Meanwhile, aggregate agricultural output would also rise because of the additional incentive to export. Rice production alone increases by 28 percent, which is 8 percent more than the increase caused by the technical change. Increased profitability, in other words, leads to extra resources being allocated to rice.

In this scenario, employment and real wages increase modestly. But price increases, combined with improved efficiency in production, lead to a rise in residual farm profits of 36 percent. These price, wage, and profit changes combine to produce a regressive distributional impact. All urban consumer groups lose, with the poor being hardest hit, and cereal consumption declines.[7] Meanwhile, the losses of the rural poor on the consumption side reduce their income gain to a mere 1.3 percent, while the rural rich experience a major gain in income of 14.8 percent.

The sharp effects of trade on income distribution are also evident in the other technical change scenarios, although magnitudes and other details differ significantly by commodity. Except in the case of coarse cereals, the gains of the urban groups are larger than those of any rural group when the extra output caused by

7. The losses of the poorest urban group are slightly less than those of the second quartile because of the greater direct participation of the poorest in the agricultural labor market.

Table 4. *Simulated Effects of Technical Change and Increased Exports*
(percentage change)

	Scenarios for changes in exogenous variables									
	20 percent increase in yield								*10 percent increase in all crop yields*	
	Rice		*Wheat*		*Coarse cereal*		*Other crops*			
Endogenous variables	*Closed (s4.1a)*	*Exports (s4.1b)*	*Closed (s4.2a)*	*Exports (s4.2b)*	*Closed (s4.3a)*	*Exports (s4.3b)*	*Closed (s4.4a)*	*Exports (s4.4b)*	*Closed (s4.5a)*	*Exports (s4.5b)*
National income per capita	4.10	5.65	1.98	0.02	1.01	2.08	7.31	10.58	7.20	10.20
Output										
Total	5.35	6.19	2.11	2.13	2.26	2.48	10.34	12.18	10.03	11.49
Rice	20.09	27.90	−1.67	−1.35	2.82	0.51	−0.55	0.64	10.35	13.85
Wheat	−5.94	1.78	18.33	29.27	1.46	1.82	1.14	9.35	7.49	21.11
Coarse cereals	4.86	−5.42	1.49	−3.57	12.75	22.21	−4.55	−14.02	7.28	−0.40
Other crops	0.16	−1.62	0.81	−0.49	−0.16	−0.69	21.20	24.52	11.00	10.86
GNP deflator	−11.96	10.13	−6.59	6.14	−4.91	5.59	−12.78	22.24	−18.13	22.05
Prices										
Rice	−30.87	9.10	−8.86	9.60	−1.81	10.85	−10.36	35.29	−25.95	32.42
Wheat	−21.13	19.62	−29.26	8.04	−4.05	13.55	−8.04	47.72	−31.24	44.46
Coarse cereals	−6.74	13.92	−6.07	7.24	−35.50	−6.24	−17.89	18.84	−33.10	16.88
Other crops	−8.12	14.45	−3.47	7.79	−3.73	6.89	−23.78	24.05	−19.55	26.59
Wage rate	1.54	2.39	0.14	0.82	−2.08	2.10	0.21	−0.87	−0.10	2.22
Employment	1.14	0.81	0.23	0.17	−0.37	0.83	0.18	−0.88	0.59	0.46
Wage bill	2.68	3.20	0.37	0.99	−2.45	2.93	0.39	−1.75	0.50	2.69
Profits	−7.54	36.07	−4.11	17.63	−1.08	15.03	4.11	80.75	−4.31	74.74

Income per capita (by quartile)										
Rural										
Poorest	7.52	1.33	2.65	−0.62	3.98	1.48	5.74	−2.05	9.95	0.07
Second	5.06	6.06	1.89	2.02	1.84	2.69	5.72	9.64	7.26	10.20
Third	3.55	9.22	1.23	3.71	0.75	3.54	5.82	17.56	5.67	17.02
Richest	−1.37	14.85	−0.04	7.21	−0.12	6.15	5.20	32.86	1.84	30.53
Urban										
Poorest	12.02	−6.90	7.47	−4.45	3.28	−3.92	12.79	−18.02	17.78	−16.65
Second	13.61	−7.69	6.15	−5.43	1.78	−5.22	13.47	−20.66	17.51	−19.50
Third	11.09	−7.07	5.46	−4.69	1.24	−4.53	12.60	−18.12	15.19	−17.20
Richest	5.74	−4.77	2.79	−2.91	0.09	−2.63	11.04	−10.69	9.83	−10.50
Per capita cereal consumption										
Rural										
Poorest quartile	11.21	2.03	2.62	−1.27	7.83	2.06	0.63	−3.88	11.14	−0.53
Richest quartile	4.27	6.46	3.03	2.59	−0.68	1.20	−4.27	8.24	1.18	9.25
Urban										
Poorest quartile	13.07	−5.01	9.48	−3.49	5.63	−2.78	5.27	−16.96	16.72	−14.12
Richest quartile	6.75	3.50	0.81	0.20	−1.36	−0.35	−5.43	−0.81	0.39	1.27
Aggregate per capita cereal consumption	10.14	3.70	3.57	.00	4.16	1.02	−0.93	−0.12	8.47	2.29

Note: The values shown are the percentage changes in the endogenous variables from their base case level, as the result of the induced change in the exogenous variables shown in the column headings.

All income, output, price, wage, profit, and consumption variables are real values.

The income groups shown are expenditure quartiles for rural and urban populations separately. The four rural expenditure quartiles together constitute 0.8009 of the total population, while the four urban quartiles include 0.1991 of the total population.

technical change is absorbed domestically. (In the case of coarse cereals, the gains of the rural poor exceed those of the urban group because urban consumers buy very little coarse cereals.) It is clear that the export of the initial gain caused by the technical change always leads to losses for urban consumers and is associated with a sharply regressive distribution of its benefits in rural areas.

Differences in the magnitude of the effects associated with technical change are partly a reflection of each commodity classification's share of agricultural output. Rice and other commodities have the largest shares, 26.7 percent and 51.3 percent respectively (see appendix table 9). Technical changes that affect the production of these commodities therefore contribute more to national income. The shares of coarse cereals and wheat are roughly 10.7 percent and 11.3 percent respectively, so their national income contributions are more modest.

However, final demand elasticities matter as well. Other commodities have the highest income elasticity (see appendix table 4). In the no-trade scenario, therefore, the decline in the own price of other commodities (−23.8 percent) is smaller than the decline in the own price of any other crop following an equal technical change. Coarse cereals are at the other extreme. A 20 percent increase in yield leads to a 35.5 percent decline in prices.

The income distribution impacts of the trade and no-trade scenarios differ accordingly. Technical change that affects other commodities benefits urban groups fairly evenly, and the disparities among rural groups are also modest. But technical change that affects coarse cereals clearly benefits the poor urban and poor rural groups, while neither the urban nor the rural rich gain.

As the all-crop scenarios (4.5a and b) illustrate, trade policy is the major determinant of the distributional outcome of technical change. The gains for the urban poor can vary from a high of 17.8 without trade to a low of −16.6 percent in the open economy scenario, depending on how much of the gain in yield is exported or used to reduce imports. For the rural rich, gains can vary from 1.8 percent to 30.5 percent while the impact on the urban rich can range from a gain of 9.8 percent to a loss of 10.5 percent.

When technical change affects all crops positively and there is no expansion of trade, the poorest rural group gains 9 percent from drops in prices but virtually nothing from wage rises. When, however, the full gains from technical change are exported, the poorest rural group sees no fall in prices. But its wages rise, and to a small extent this group also benefits from the massive rise in farm profits. On balance, both of the poorest rural quartiles would still be much better off without an increase in trade. The situation is reversed for the second income quartile. The positive farm profit effects outweigh the negative food price effects. When exports increase as a consequence of technical change, the income gain of the second rural quartile is 10.2 percent; without exports the gain drops to 7.3 percent.

A remarkable feature of technical change scenarios is the modest impact they have on real rural wages, regardless of what happens in trade. The largest absolute change in the real wage bill is an increase of 3.2 percent in scenario

4.1b. This very small wage response is not caused by the elasticity of labor supply, which is instead very inelastic. The total supply elasticity of rural labor, including the migration response, is less than 0.5. Demand for labor is also inelastic (−0.48) and thus cannot account for the limited wage response. Indeed, when labor is withdrawn from rural areas, either because of reduced fertility (scenario 1.1b) or rural-to-urban migration (scenario 1.2), real rural wages increase sharply.

Real wages remain stable despite technical change because technical change has contradictory effects on the demand for labor. As yields increase, less labor is needed to produce any given level of output, and thus labor demand is depressed. At the same time, however, the technical change has increased real incomes and reduced the relative prices of agricultural commodities, so that demand for the products increases. Thus, while the *per unit* labor requirement has declined, the impact on total labor demand is offset by the induced *rise* in demand for and production of agricultural commodities. It is the balance between these offsetting forces which determines the final effect on the demand for labor.

The findings shown in tables 3 and 4 should dispel the notion that technical change is responsible for the slight wage decline observed in section II. This decline must instead be the result of inadequate growth in labor demand in the nonagricultural sector.

Investment Scenarios and Fertilizer Subsidies

In this subsection we present only closed economy scenarios.

Under scenario 5.1 (see table 5), the assumption is that investment in irrigation is accelerated enough to increase the percentage of area irrigated by 10 percent. This leads to an increase in aggregate output of 2.7 percent and a drop in the aggregate price level of 5.8 percent. Because irrigation requires labor, labor employment and real wages rise slightly. Residual farm profits, however, decline by 4.8 percent as a consequence of slightly higher labor costs and lower output prices. The income distributional outcomes follow from these price and profit changes. The landless gain modestly (2.9 percent), while large farmers lose (−0.7 percent). All urban households gain substantially, with the poorest showing the largest gain (6 percent).

In the aggregate, real per capita income rises modestly (1.7 percent). Changes in the yield and price of individual commodities thus reflect shifts in income distribution rather than aggregate income growth. Wheat shows the biggest production increase and the largest price drop.

Scenario 5.2 focuses on expanding such capital inputs as tractors, other implements or machines, and livestock, and on improving the marketing infrastructure. Both of these are accelerated by 10 percent. Real per capita income then decreases slightly (0.2 percent) as a consequence of producer losses. Aggregate agricultural output increases by about 0.8 percent, and the price index drops by 3 percent. The effects on income distribution are similar to those of increased

Table 5. *Simulated effects of increased agricultural investment and inputs*
(percentage change)

	Scenarios for change in exogenous variables			
Endogenous variables	*10 percent increase in irrigated area (s5.1)*	*10 percent rise in capital inputs and marketing infrastructure (s5.2)*	*Irrigated land up 10 percent plus 5 percent rise in inputs and marketing (s5.3)*	*20 percent fertilizer subsidy (s5.4)*
National income per capita	1.71	−0.20	1.61	1.30
Output				
Total	2.72	0.81	3.12	1.26
Rice	0.64	−1.24	0.02	0.34
Wheat	5.14	1.34	5.81	1.29
Coarse cereals	1.88	2.12	2.94	−2.13
Other crops	3.48	1.47	4.22	2.47
GNP deflator	−5.76	−2.95	−7.23	−1.13
Prices				
Rice	−6.93	−2.11	−7.98	−1.76
Wheat	−12.77	−5.34	−15.44	−1.78
Coarse cereals	−9.39	−7.19	−12.98	1.25
Other crops	−6.38	−3.93	−8.34	−1.94
Wage rate	0.71	0.42	0.92	−1.90
Employment	0.44	0.25	0.56	−0.77
Wage bill	1.14	0.67	1.48	−2.67
Profits	−4.79	−8.20	−8.89	5.58
Income per capita (by quartile)				
Rural				
Poorest	2.92	1.64	3.74	−0.35
Second	1.71	0.03	1.73	0.75
Third	0.90	−1.02	0.39	1.54
Richest	−0.67	−2.39	−1.87	2.54
Urban				
Poorest	6.04	2.66	7.37	0.60
Second	5.73	2.56	7.01	0.74
Third	5.15	2.38	6.35	0.60
Richest	3.50	1.73	4.37	0.40
Per capita cereal consumption				
Rural				
Poorest quartile	2.57	1.21	3.18	−0.74
Richest quartile	−0.07	−1.30	−0.72	0.60
Urban				
Poorest quartile	5.59	2.25	6.72	0.06
Richest quartile	−0.38	−0.95	−0.86	−0.33
Aggregate per capita cereal consumption	1.84	0.04	1.86	0.07

Note: The values shown are the percentage changes in the endogenous variables from their base case level, as the result of the induced change in the exogenous variables shown in the column headings.

All income, output, price, wage, profit, and consumption variables are real values.

The income groups shown are expenditure quartiles for rural and urban populations separately. The four rural expenditure quartiles together constitute 0.8009 of the total population, while the four urban quartiles include 0.1991 of the total population.

irrigation, but the disparities among the income groups are substantially less because the effect on output is smaller.

Scenario 5.3 combines the two previous scenarios, except that investment in irrigation is accelerated twice as much (10 percent) as investment in capital and marketing (5 percent). Since the distributional effects of scenarios 5.1 and 5.2 are so similar, their combined effects are largely a matter of increased magnitudes.

Scenario 5.4 portrays a simple fertilizer subsidy scheme in which government pays 20 percent of the actual cost of fertilizers.[8] Since we assume that the supply elasticity of fertilizers is high (4.0), this scheme results in a considerable shift of the supply curve. We also assume that fertilizer is not rationed or is sold in the black market at higher prices. In other words, the subsidy actually reaches the farmers and alters their fertilizer use.

Under this scenario, aggregate agricultural output increases by about 1.3 percent with the output gains concentrated in wheat and in other commodities. Output of coarse cereals, which are not fertilizer-responsive, declines by 2.1 percent. The GNP deflator declines by 1.1 percent, which leads to gains for urban consumers. Fertilizer is substituted in part for labor, and the real wage bill declines by 2.7 percent. Thus the rural poor lose, since their losses in wages outweigh their gains as consumers. The rural rich, however, obtain a gain in income because of higher farm profits. For them, the fertilizer subsidy and lower wages more than offset the negative effect of smaller output prices.

Note, too, that the rural poor's cereal consumption declines by more than their real income loss because the prices of coarse cereals rise.

Taxation and Redistribution Scenarios

Scenarios 6.1 and 6.3 (see table 6) postulate various forms of taxation each of which raises Rs12 billion (billion is 1,000 million). It is assumed that the money is used for purposes which do not affect agricultural demand or supply.

In scenario 6.1 a land tax of 10 percent of residual farm profits is levied. Residual farm profits are considered a proxy for land rents.

In scenario 6.2 the assumption is that a progressive income tax is levied on rural residents alone. In order to raise Rs12 billion at 1973–74 prices, rates of 3.1 and 6.2 percent on the nominal incomes of the upper two rural quartiles are required. The two poorer quartiles are untaxed.

Scenario 6.3 involves imposing an excise tax on nonagricultural goods. This is achieved by means of an exogenous increase of 9.7 percent in the price index for nonagricultural goods. Unlike the land tax or the income tax, the excise tax would also fall on the urban income groups.

Scenarios 7.1 to 7.3 are income redistribution schemes that assume an increase of 30 percent in the nominal per capita income of the poorest rural

8. Indian fertilizer subsidy policy is complex, and a more detailed analysis is required to assess its exact impact.

Table 6. *Simulated effects of changes in taxation and income redistribution policies*
(percentage change)

	Scenarios for change in exogenous variables						
				30 percent income redistribution			
Endogenous variables	*10 percent land tax (s6.1)*	*Rural income tax (s6.2)*	*Nonagricultural excise tax (s6.3)*	*From 10 percent land tax (s7.1)*	*From rural income tax (s7.2)*	*From nonagricultural excise tax (s7.3)*	*From land transfer (s8.1)*
National income per capita	−3.14	−2.91	−2.67	0.32	0.55	0.79	0.57
Output							
Total	−0.29	−0.25	−0.02	0.12	0.17	0.39	0.18
Rice	−1.00	−0.81	−0.27	0.68	0.87	1.41	1.01
Wheat	−3.17	−2.84	−2.06	0.86	1.20	1.97	1.35
Coarse cereals	3.59	3.27	2.24	−0.12	−0.44	−1.47	−0.60
Other crops	−0.16	−0.18	0.03	−0.26	−0.28	−0.07	−0.32
GNP deflator	−7.11	−6.05	2.19	3.68	4.74	12.98	5.19
Prices							
Rice	−10.47	−8.80	−0.39	6.01	7.67	16.09	8.45
Wheat	−14.07	−12.15	−3.51	6.46	8.38	17.03	9.21
Coarse cereals	−5.61	−4.44	3.25	5.61	6.78	14.46	7.25
Other crops	−8.60	−7.41	−0.32	3.75	4.95	12.03	5.41
Wage rate	0.36	0.40	−0.54	0.57	0.61	−0.34	0.63
Employment	0.28	0.27	−0.09	0.10	0.09	−0.28	0.08
Wage bill	0.64	0.67	−0.63	0.66	0.69	−0.61	0.72
Profits	−25.10	−12.84	−5.03	−3.37	8.89	16.70	9.76

Income per capita (by quartile)							
Rural							
Poorest	0.58	1.46	−1.00	27.87	28.74	26.28	28.62
Second	−2.99	−0.46	−2.56	−2.25	0.28	−0.82	0.31
Third	−5.41	−4.88	−2.12	−2.39	−1.86	0.90	1.37
Richest	−10.10	−10.76	−3.51	−2.24	−2.89	4.35	−4.31
Urban							
Poorest	5.82	5.59	−1.19	−3.62	−3.85	−10.63	−4.23
Second	6.72	6.09	−1.81	−3.57	−4.20	−12.10	−4.63
Third	5.98	5.44	−2.57	−3.03	−3.57	−11.58	−3.93
Richest	3.82	3.66	−4.54	−1.88	−2.03	−10.24	−2.24
Per capita cereal consumption							
Rural							
Poorest quartile	0.59	0.98	−0.37	16.52	16.91	15.57	16.73
Richest quartile	−3.10	−3.36	0.62	−1.06	−1.32	2.66	−1.82
Urban							
Poorest quartile	4.86	4.54	−0.52	−3.47	−3.78	−8.84	−4.15
Richest quartile	−0.29	−0.21	−0.04	−0.38	−0.31	−0.13	−0.36
Aggregate per capita cereal consumption	−0.59	−0.46	−0.20	0.58	0.71	0.97	0.78

Note: The values shown are the percentage changes in the endogenous variables from their base case level, as the result of the induced change in the exogenous variables shown in the column heading.

All income, output, price, wage, profit, and consumption variables are real values.

The income groups shown are expenditure quartiles for rural and urban populations separately. The four rural expenditure quartiles together constitute 0.8009 of the total population, while the four urban quartiles include 0.1991 of the total population.

quartile. In scenario 7.1 the source of the added 30 percent is the land tax discussed above, which is just sufficient to finance the increase. In scenario 7.2 the progressive income tax is used to finance the increase. In scenario 7.3 the source is the excise tax at the rate of 9.7 percent.

The land tax translates into substantial price drops (the GNP deflator is −7 percent) but only a minimal decline in aggregate agricultural output (−0.3 percent). The decline in residual farm profits is 25 percent. Urban groups gain from the price decline, while rural groups (except for the poorest) suffer a real income loss, the more so the richer they are. This income redistribution leads to a redirection of production toward coarse cereals (3.6 percent) and away from rice and wheat (−1 and −3.2 percent respectively).

Qualitatively, the effects of the income tax are very similar to those of the land tax. The only exception is the much smaller effect of the income tax on farm profits, an effect that is the result of reduced final demand rather than a direct tax effect. Because the rural poor escape direct taxation and the rural rich carry the entire tax burden, the income distribution effect of the income tax is more progressive than that of the land tax.

The excise tax has a more even incidence than the other taxes, since it also falls on the urban groups. The urban rich and the rural rich are the groups whose incomes are reduced the most, −3.5 and −4.5 percent respectively.

Depending on how taxes are levied, the planned gain of 30 percent in income for the rural poor is somewhat eroded. The gain from the excise tax falls to 26.3 percent, the gain from the land tax falls to 27.8 percent, and the gain from the income tax falls to 28.7 percent. This happens because the rural poor have a higher propensity to consume food than the rich, and their increased demand for food causes food prices to rise. In the land tax and income tax scenarios, the richer rural groups lose very little because rising food prices increase farm profits. In fact, the rich rural group loses only about as much as the untaxed rich urban groups, whose loss stems from rising food prices. These higher prices mean, in effect, that the urban groups end up paying part of the income transfer to the rural poor. In the excise tax scenario, the price level rises particularly fast (13 percent) because increases in food prices and the excise tax both affect the price level. Therefore, almost the entire burden of an excise tax would be placed on the urban groups. Large farmers would show a net gain as a consequence of the increased food demand of the rural poor.

In scenario 8.1, sufficient land is transferred from the fourth rural quartile (the richest) to the first quartile to give the rural poor an initial income boost of nearly 30 percent. The effects are very similar to the land tax and income tax scenarios, although the rural rich lose a bit more, since they are the only taxed group.

The taxation and income redistribution scenarios show that a substantial increase in the income of the rural poor could be achieved that would cause only small losses—or, in some cases, even a net gain—for the rural rich. This is an important, and initially counterintuitive, result that is again critically dependent on letting food prices rise. If, for example, the government decided to accommodate the increased food demand via imports, large farmers would inevitably lose as their profits would not increase.[9]

V. Conclusion

During the past two decades, Indian agricultural output has grown at an annual rate of 2.7 percent, which is extremely high by international standards. Production is now at a level that would be sufficient to feed India's population, which has increased by 2.2 percent annually. The technical changes associated with the Green Revolution have been an important part of this increased output, and there is no question that, had they not occurred, India would be far worse off today than it is. During the early Green Revolution period, the real per capita income of the rural population of India rose by about 8 percent. However, these gains were rapidly eroded. The sobering point is that in 1980–81 real rural per capita income appears to have been only about 2 percent higher than in 1960–61.

The early productivity gains of the Green Revolution were retained by the agricultural sector because Indian policymakers used these gains to reduce imports of foods. Food prices therefore continued to rise slightly. But when near self-sufficiency was reached, all the extra output had to be absorbed domestically, food grain prices declined, and terms of trade moved substantially against agriculture. The benefits of the productivity gains were thereby transferred to consumers, a classic case of the agricultural treadmill.

The early Green Revolution period was associated with a sharp rise in residual farm profits, while the real wage bill rose much more modestly. The real income gain of that period was distributed regressively; large farmers gained the most while the rural poor gained very little. However, the subsequent rapid drop of about 25 percent in residual farm profits reduced the per capita incomes of the rural rich to their 1960–61 levels. By 1980–81, both the absolute level of real rural per capita income and its distribution appear to have returned to about what they were in 1960–61.

Real rural wages (as measured by actual data) appear to have risen somewhat during the early Green Revolution but then dropped back so that by 1980–81 they were barely above the 1960–61 level. Agricultural employment (as measured by the model) rose substantially but at a rate slower than rural labor force growth. The simulations show clearly that the main reasons for these trends are the adverse demographic trends and the insufficient growth in nonagricultural employment. The rural poor did not lose too much only because they shared

9. Note that the government can also alter the income distribution by direct food distribution at subsidized prices to rural or urban groups. These issues are discussed in a separate paper (Binswanger and Quizón 1986).

somewhat in farm profit growth, in nonagricultural income growth, and in the consumer benefits from declining agricultural terms of trade.

There were probably subgroups of the rural poor, including the totally landless agricultural workers, who suffered more severely than indicated. In addition, several areas of the country did not participate in the adoption of Green Revolution technology and their farmers must have been hurt by the decline in agricultural prices. We are currently investigating interregional issues, but it is evident that the simulations presented here have obscured the sharper declines in income experienced by these subgroups and regions.

A further sobering point is that some intuitive notions of how agricultural development trends or policies affect income distribution are likely to be wrong. Much of the debate on the distributional impact of technical change has concentrated excessively on the nature of the technical changes. Our analysis suggests that trade policy is a far more important determinant of income distribution. All growth-oriented policies or technical changes tend to benefit net buyers of food if the additional agricultural output is absorbed domestically rather than used to reduce imports or increase exports. Forcing domestic absorption has been the policy customarily pursued by India except during the early part of the Green Revolution, when agriculture production gains were used largely to reduce imports. Since the gains that occurred later were not used to expand exports, net food buyers in both rural and urban areas benefited.

This evidence, however, does not imply the general superiority of policies prohibiting external food trade for equity objectives. Given a shortfall in food production, rather than the sharp increases examined here, use of food imports to avert shortages and a marked rise in prices will *serve* equity goals.

There are, of course, differences in the impact of different technical changes or investment policies. As intuition would suggest, technical changes resulting in greater production of coarse cereals benefit poor rural consumers more than technical change directed toward improving production of other types of food. And investment in irrigation has a greater effect on the demand for labor than a fertilizer subsidy, which tends to encourage the substitution of fertilizers for labor.

But none of the agricultural development measures can affect rural labor demand or wages nearly as much as changes in population growth or growth in the demand for nonagricultural labor. This does not mean, of course, that we should not pay attention to the selection of agricultural techniques or other employment determinants. It simply suggests that major improvements in the incomes of the rural poor must eventually come mainly from demographic changes and growth in nonagricultural employment.

The only other avenue for substantially affecting incomes of the poorest group, the rural poor, are direct income transfers or land redistribution. Such transfers increase food demand and under closed economy conditions lead to rising food prices, which thereby erode the gains to the rural poor to roughly 90 percent of the initial nominal transfer. More important than this erosion of benefits, however, is the effect these price changes have on shifting the burden of the tax required to finance the income or asset transfers. If the rural rich are the source of taxes (or land) to finance the income (or land) transfer, the rise in food prices and therefore in farm profits drastically reduces the real incidence of the tax on them and shifts it to the urban groups. In the case of more broad-based taxes such as an excise tax, the rural rich can even become net beneficiaries from the income distribution because the increase in farm profits exceeds their tax burden. Note that these conclusions would not hold in a free trade situation in which food prices remained at a constant level. Again, the crucial nature of the trade decision on the real outcome of government policies must be emphasized.

Appendix A. The Model in Mathematical Terms

The model is an extension of the theoretical model described in Quizón and Binswanger (1983). Producer behavior is represented by a system of output supply and factor demand equations called the *producer core.* Analytically, the producer core is derived from a variable profit function $\Pi^* = \Pi^*(V, Z, \tau)$, where Π^* is maximized variable profits, $V = (P, W)$ is the vector of prices of outputs (P) and variable inputs (W), Z is a vector of fixed inputs, and τ is a technology index (appendix table 1 lists definitions of the symbols used in the model). The output supply and factor demand curves are derived from Π^* via Shepard's lemma; that is, the vector of outputs (Y) and (negative) variable inputs ($-X$) is written as

$$Q = [Y, -X] = \frac{\partial \Pi^*}{\partial V}.$$

In terms of rates of changes, they are written as

$$(1) \qquad Q_i' = \sum_j \beta_{ij} V_j' + \sum_g \beta_{ig} Z_g^* + E_i' \qquad i \epsilon O,\ VI$$

O is the set of outputs and VI the set of variable inputs. The prime notation X' of a variable X indicates the total rate of change over time of variable X. The star notation X^* refers to the rate of change of an exogenous variable or to the exogenous component of an endogenous variable. β_{ij} are the elasticities of supply (or demand) of an output i (or factor i) with respect to a price j. The Zs are exogenous variables and fixed inputs affecting producer behavior, and the β_{ig} are supply or demand elasticities with respect to those fixed inputs. Some of the Z variables are subject to government policy. $E_i' = \partial Q_i / \partial \tau \; 1/Q_i \; \partial \tau / \partial \tau$ are the technology shifters of the supply and factor demand equations if fixed inputs are held constant. (For a detailed discussion of these technology concepts used, see Quizón and Binswanger 1984.)

Output demand is treated in a more disaggregated fashion. Let $k = 1, \ldots, K$ refer to income groups. Then total final demand is defined as

$$(2) \qquad Y_i = \sum_k Y_{ik} \qquad i \epsilon O$$

Appendix Table 1. *Symbols Used in the Model*

E_i^t	=	$\frac{\partial Q_i}{\partial \tau}\frac{1}{Q_i}\frac{\partial \tau}{\partial t}$ = technology shifters, that is, shifts in output supplies and factor demands for given fixed input levels. These are profit function definitions.
G	=	square matrix of elasticities and shares
K^*	=	column vector of exogenous shifter variables
L	=	labor services
M	=	total nominal income
m	=	real per capita income
MN	=	nonagricultural income
N	=	population
NA	=	nonagricultural commodities
P	=	output prices
$\bar{P}$	=	output price indexes
Q	=	$[Y, -X]$ = vector of outputs and (negative) variable inputs
S	=	rent to fixed factor
s_i	=	share of output i in total revenue or share of factor i in input prices
t	=	time
U'	=	column vector of endogenous variables
V	=	$[P, W]$ = vector of output and variable input prices
W	=	wage rate or variable input prices
w	=	real wage rate
X	=	variable inputs
Y	=	outputs
y	=	per capita output
Z	=	fixed factors; Z_1 refers to land
τ	=	technology index
β	=	price elasticity of supply or demand in production (outputs and inputs respectively)
π	=	variable profit function
λ_{ik}	=	proportion of i from (by) group k
ϵ	=	price elasticity of factor supply
ℓ	=	labor supply per person
ϕ	=	variable profit shares
μ_{ik}	=	share of group k's consumer expenditures spent on commodity i
ν_k	=	share of real income accruing to group k

Modifiers of variables unless already defined above:

X	=	level
X, X^T	=	a column and a row vector of the X variables, respectively
X'	=	$\frac{dX}{dt}\frac{1}{X}$ = total rate of change (n growth rate) of variable X with respect to time
X^*	=	exogenous component of the rate of change of a variable (except that π^* stands for maximized variable profits)

Indexes and sets of inputs and outputs

g	=	shifter variables
i	=	commodities (outputs, inputs)
j	=	commodities (outputs, inputs)
k	=	income groups
K	=	set of income groups or their total number
O	=	set of outputs or total number of outputs
I	=	set of inputs or total number of inputs
VI	=	set of variable inputs or their total number

where Y_{ik} is the total demand of consumer group k. Rewriting equation 2 in terms of changes,

$$(3) \qquad Y_i' = \sum_k \lambda_{ik} Y_{ik}' \qquad i \epsilon O$$

where $\lambda_{ik} = Y_{ik}/Y_i$ is the proportion of commodity i consumed by income group k. The consumption of each income group is described by an income-group-specific consumer demand system:

$$(4) \qquad \underline{Y}_k = N_k \underline{y}_k(\underline{P}, m_k)$$

where the underbars denote a column vector of the variable; for example, $\underline{Y}_k = (Y_1, Y_2, \ldots, Y_O)$, N_k is the population in income group k, and y_{ik} is the per capita demand which depends on output prices and the per capita income of the income group. Transforming each equation into rates of changes leads to

$$(5) \qquad Y_{ik}' = y_{ik}' + N_k' = \sum_j \alpha_{ijk} P_j' + \alpha_{imk} m_k' + y_{ik}^* + N_k' \qquad i,j \epsilon O$$

Here, y_{ik}^* is an exogenous change in per capita demand of income group k, and α_{ij} and α_{im} are the price and income elasticities of final demand.

We assume that the population in each income group grows at an exogenous rate N_k^*. But the rural population grows via immigration or via diminished emigration and vice versa for the urban population. We assume this migration to be responsive to the real rural wage rate. Differentiating N_k with respect to time and the real wage and converting to rates of changes leads to

$$(6) \qquad N_k' = \epsilon_{mk} w' + N_k^* = \epsilon_{mk} (W_L' - \bar{P}_k') + N_k^*$$

where ϵ_{mk} is the migration elasticity into (or for the urban group, out of) the specific income group with respect to the real rural wage and $\bar{P}_k$ is an income-group-specific price deflator defined below. Let the rural income groups be indexed $k = 1, \ldots 4$ and the urban group by $k = 5, \ldots 8$. Total labor supply to agriculture is

$$L = \sum_{k=1}^{8} L_k,$$

or in rates of changes

$$(7) \qquad L' = \sum_{k=1}^{8} \lambda_{Lk} L_k'$$

where $\lambda_{Lk} = L_k/L$ is the proportion of labor supplied to agriculture by income group k. Labor supply of income group k is $L_k = \ell_k N_k$ where ℓ_k is total labor supply per person. Differentiating with respect to the real wage and time and converting to rates of change, we find

$$(8) \qquad L_k' = \epsilon_{\ell k} w' + \ell_k^* + N_k' = \epsilon_{\ell k} (W_L' - \bar{P}_k') + \ell_k^* + N_k'$$

where $\epsilon_{\ell k}$ is the total labor supply elasticities of income group k and ℓ^* is an exogenous shifter in the labor supply to agriculture of income group k.

The supply of bullocks is similarly aggregated as

$$X_i = \sum_{k=1}^{8} X_{ik}$$

Rates of change are aggregated as usual; that is,

(9) $$X_i' = \sum_{k=1}^{8} \lambda_{ik} X_{ik}' \qquad i = \text{bullocks}$$

The supply of each input is only dependent on its own price, W_i; therefore,

(10) $$X_{ik}' = \epsilon_{ik}(W_i' - \bar{P}_k') + X_i^* \qquad i = \text{bullocks}$$

While the model contains many fixed input (Z) variables, such as irrigation and rainfall (see appendix table 10), we treat land (indexed as Z_1) as the only fixed factor which is a recipient of residual farm profits. The change in residual farm profits per unit of land (rental rate of land) S' is derived residually from the profit function, a derivation given in detail in Quizón and Binswanger (1986).

(11) $$S' = \sum_i \phi_i V_i' + \sum \phi_i Q_i' - Z_i^* \qquad i \epsilon O,\ VI$$

where

$$\phi_i = \frac{Q_i V_i}{\Pi^*}$$

are variable profit shares, which are positive for outputs and negative for inputs.

Changes in income-group-specific consumer price levels $\bar{P}_k'$ can be related to the endogenous changes in agricultural output prices as follows:

(12) $$\bar{P}_k' = \sum_{i \epsilon O} \mu_{ik} P_i' + \sum_{i \epsilon O} \mu_{NAk} P_{NA}^*$$

where μ_{ik} is the share of total consumer expenditures spent on commodity i by income group k. The subscript NA refers to nonagricultural commodities. The GNP deflator $\bar{P}$ is derived in the same way by dropping the k subscripts.

The nominal income of income group k is M_k and is defined as the sum of all net factor incomes accruing to the group plus nonagricultural incomes MN.[10]

(13) $$M_k = \sum_{i \epsilon VI} X_{ik} W_i + Z_{lk} S + MN_k$$

where Z_{1k} is land supplied by group k.

10. Note that we treat all rural labor supply as "agricultural" labor because we assume wage equalization between the agricultural and nonagricultural *rural* labor markets.

Real per capita income is derived by dividing by the number of people and the consumer price index: that is,

$$m_k = M_k / \bar{P}_k N_k \tag{14}$$

Differentiating 13 and 14 totally and converting to rates of changes leads to

$$m'_k = \sum_{i \epsilon VI} \delta_{ik}(W'_i + X'_{ik}) + \delta_{Sk}(S' + Z^*_{1k}) - \bar{P}'_k - N'_k + \delta_{MNk} MN^*_k \tag{15}$$

where the δ_i are the shares of net income arising from the respective source.

The real per capita income of India's rural and urban population is defined as

$$m = \sum_k \lambda_{Nk} m_k \tag{16}$$

where $\lambda_{Nk} = N_k / \sum_k N_k$ are the initial shares of group k in the total population. Differentiating and converting into rates of changes leads to

$$m' = \sum_k \lambda_{Nk} \frac{m_k}{m} m'_k = \sum_k \nu_k m'_k \tag{17}$$

where ν_k is the proportion of real income accruing to group k.

Note that m' is not equal to the conventional definition of a change in real per capita income, which would be

$$m' = M' - N' - \bar{P}' \tag{18}$$

where $\bar{P}'$ is computed from the equivalent of equation 12 but the k subscript is dropped, and M is defined as in equation 13 but again the k subscript is dropped. The difference between equations 17 and 18 is that 17 utilizes real income weights, for which each group's real income is deflated by a group-specific price deflator. Thus 17 is closer to a measure of a change in real per capita welfare than is 18.

The model treats India as a closed economy with respect to agricultural commodities except that trade by the government is allowed and is easily treated as a fixed addition to and reduction from domestic supply. The full model consists of equations 1, 3, 5, 6, 7, 8, 9, 10, 11, 12, 15, and 17.

The equation system can be exhibited in matrix form:

$$GU' = K^* \tag{19}$$

where G is a square matrix of elasticities and shares, U' is the column vector of endogenous variables, and K^* is a column vector of exogenous shifter variables. (For simpler examples of such full systems, see Quizón and Binswanger 1983, 1986.) The effect of a shift in an exogenous variable on the endogenous variables in the system can be solved as

$$U' = G^{-1} K^* \tag{20}$$

which exists so long as the matrix G is nonsingular.

Appendix B. Data and Parameter Values

The data used to compile our core (or G) matrix come from a variety of sources.[11] The agricultural commodities, rice, wheat, inferior cereals, and other crops, are exhaustive in that they account for all *crop* production in the agricultural sector. Livestock products are aggregated into "other agricultural commodities."

The commodity-specific output supply and the fertilizer and labor demand elasticities for the semiarid tropics (SAT) are from Bapna, Binswanger, and Quizón (1984); for North India and the eastern rice region (ER) from Evenson (1981); and for the coastal rice region (CR) of South India from unpublished estimates. Estimation equations were derived from a normalized quadratic profit function on which all regularity conditions were imposed, except for the condition of convexity of the resultant Hessian matrices. The estimates were therefore adjusted in an *ex post* manner in order to satisfy this convexity constraint, following trial and error procedures described in Quizón and Binswanger (1984).

The bullock power demand elasticities have been estimated in Evenson and Binswanger (1984). Only the own-price elasticity and the cross-price elasticity with respect to labor are available for bullock power demand.

The output demand elasticities are from Binswanger, Quizón, and Swamy (BQS, 1984) and are averages for all India. Original price coefficient estimates in the reported demand equations were first adjusted following trial and error procedures to satisfy convexity restrictions. Then, from the twenty-eighth round of the National Sample Survey (28 NSS) *Tables on Consumer Expenditures,* the average commodity prices, the per capita quantities consumed, and the real per capita expenditures and incomes of each of our defined expenditure quartiles were computed. These were used with the adjusted convex price coefficient estimates and the income coefficient estimates from BQS to obtain all expenditure-quartile-specific output price and income elasticities of demand.[12] Total consumption by commodity and by group, computed straightforwardly from the 28 NSS, was used to obtain the λ_{ik} output consumption weights in equation 3 and the μ_{ik} weights in equation 12.

The 1970–71 National Council for Applied Economic Research (NCAER) Additional Rural Income Survey (ARIS) is a national rural household survey that contains a wealth of data, including information on household ownership of different agricultural factors of production, household incomes by income source, and costs of agricultural production by factor of production. The survey does contain data on hired labor but not, however, on family labor input. We therefore used data on family labor input by farm size group from the Farm

11. All notations used in this appendix are defined in appendix A.

12. For the highest income group, urban 4, the estimated elasticities for coarse cereals had high negative values. These values were reduced to a minimum of -1.

Management (FM) studies and matched each household in the NCAER survey with the corresponding farm size group in the FM study which most closely resembled the agroclimatic features of the district in which the NCAER household resided. For a number of semi-arid districts, we used family labor data from the more recent village studies of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). With this addition, the NCAER survey enables computation of the λ_{ik} input supply weights in equations 7 and 9, the π_i profit shares in equation 11, and the δ_{ik} income weights in equation 15. Pal and Quizón (1983) describe in detail how all these shares are computed from the NCAER-ARIS survey.

The only unaccounted parameters in our G matrix thus far are the input supply elasticities, that is, ϵ_{ik} in equations 6, 8, and 10. On the basis of Rosenzweig's (1980) econometric estimates, we assume ϵ_{lk} to be equal to 0.3. The migration elasticities, ϵ_{mk}, are computed from Dhar (1980) and are equal to 0.1083 for the rural groups and −0.4356 for the urban groups.[13] For bullock labor, the own-price elasticity is assumed to be equal to 0.4993, that is, the average of the value weighted sums of the own-price elasticities of supply for agricultural outputs in each agroclimatic region. This follows from the notion that bullocks are reproducible out of agricultural output. Finally, the fertilizer supply elasticity is set at 4.0, a high value which reflects opportunities for international trade.

The most important elements of our G matrix are given in appendix tables 3 through 9. All parameters pertaining to cost, income, and factor supply shares are listed in Pal and Quizón (1983). The β_{ig} matrix (equation 1) of shifter variables is listed in appendix table 10. These elasticity estimates are from the same estimation equations used to construct the matrix of output supply and variable input demand elasticities. The complex K^* vector of exogenous shifter variables (equation 19) can be reconstructed from the appendix tables and other data sources that already have been mentioned.

13. Quizón and Binswanger (1984) explain how these migration elasticities were computed from Dhar's study.

Appendix Table 2. *Agroclimatological Regions of India Showing the States, Union Territories, and Districts that Comprise Them*

Agroclimatological region	*State or union territory*	*Districts*[a]
Semiarid tropics (SAT)	Andhra Pradesh	Adilabad, Nizamabad, Karimnagar, Medak, Warangal, Mahbubnagar, Hyderabad, Nalgonda, Khammam, Kurnool, Guntur, Vishakapatnam, Anantapur, Cuddapah, Ongole, Nellore, Chitoor
	Gujarat	All
	Karnataka	Bidar, Gulbarga, Bijapur, Belgaum, Dharwar, Raichur, Shimoga, Bellary, Chikmagalur, Chitradurga, Hassan, Tumkur, Mandya, Mysore, Bangalore, Kolar
	Madhya Pradesh	All
	Maharashtra	All
	Rajasthan	All
	Tamil Nadu	Dharmapuri, The Nilgiris, Coimbatore, Salem, Tiruchirapalli, Pudukkottai, Madurai, Ramanathapuram, Tirunelveli
	Dadra and Nagar Haveli	—
Eastern rice (ER)	Arunachal Pradesh	All
	Assam	All
	Bihar	All
	Manipur	All
	Meghalaya	All
	Mizoram	All
	Nagaland	All
	Orissa	All
	Tripura	All
	Uttar Pradesh	Jalaun, Jhansi, Hamirpur, Banda, Fatehpur, Rae Bareli, Sultanpur, Faizabad, Basti, Allahabad, Pratapgarh, Jaunpur, Azamgarh, Gorakhpur, Mirzapur, Varanasi, Ghazipur, Ballia, Deoria
	West Bengal	All
Coastal Rice (CR)	Andhra Pradesh	Srikakulam, East Godavari, West Godavari, Krishna
	Goa	—
	Karnataka	North Kanara, South Kanara, Coorg
	Kerala	All
	Pondicherry	—
	Tamil Nadu	Chingliput, North Arcot, South Arcot, Thanjavur, Kanyakumari
Northern wheat (NW)	Chandigarh	—
	Delhi	—
	Haryana	All
	Himachal Pradesh	All
	Jammu and Kashmir	All
	Punjab	All
	Uttar Pradesh	Dehradun, Saharanpur, Bijnor, Nainital, Muzaffarnagar, Meerut, Moradabad, Rampur, Bulandshahr, Budaun, Bareilly, Pilibhit, Mathura, Aligarh, Agra, Etah, Mainpuri, Farukhabad, Shahjahanpu, Kheri, Etawah, Hardoi, Sitapur, Kanpur, Unnao, Lucknow, Barabanki, Bahraich, Gonda

— Not applicable.

a. For those states that fall into two agroclimatological regions, districts are allocated and identified individually.

Appendix Table 3. *Price Elasticities of the Producer Core for All India*

	Prices						
Quantities	*Rice*	*Wheat*	*Coarse cereals*	*Other crops*	*Fertilizer*	*Labor*	*Bullocks*
Rice	0.5531	−0.1280	−0.1271	−0.1834	−0.0206	−0.0940	0.0000
Wheat	−0.0900	0.4454	−0.1583	−0.0879	−0.0614	−0.0479	0.0000
Coarse cereals	−0.2280	−0.1088	0.7554	−0.2039	0.1791	−0.3986	0.0000
Other crops	−0.1632	−0.0320	−0.0652	0.2955	−0.1011	0.0663	0.0000
Fertilizer	0.0026	0.1203	−0.4635	0.7525	−0.8355	0.4278	0.0000
Labor	0.1019	0.0228	0.2045	−0.0489	0.0753	−0.4782	0.1225
Bullocks	0.0000	0.0000	0.0000	0.0000	0.0000	0.1335	−0.4041

Note: Elasticities are computed at base year 1973–74 prices and quantities. Estimates are aggregated from Evenson (1981), Evenson and Binswanger (1984), and Bapna, Binswanger, and Quizón (1986).

Appendix Table 4. *Own-Price and Expenditure Elasticities of Demand for All India, by Commodity and by Expenditure Quartile*

	Own-price elasticities of demand					*Income elasticities of demand*				
Expenditure quartile	*For rice*	*For wheat*	*For coarse cereals*	*For other food*	*For Nonfood*	*For rice*	*For wheat*	*For coarse cereals*	*For other food*	*For nonfood*
Rural 1	−0.7752	−0.7172	−0.6153	−0.8857	−0.5431	0.8196	1.1325	0.0653	1.2734	1.4408
Rural 2	−0.8311	−0.7247	−0.5507	−0.8077	−0.5529	0.7436	1.039	−0.3328	1.1540	1.5724
Rural 3	−0.8735	−0.7217	−0.4544	−0.7878	−0.5530	0.6825	1.0011	−0.5889	1.1158	1.5760
Rural 4	−1.0363	−0.7218	−0.0000	−0.7255	−0.5258	0.3768	0.8966	−1.0000	1.02154	1.5504
Urban 1	−0.8088	−0.7233	−0.5883	−0.8426	−0.5484	0.7771	1.0760	−0.1302	1.2040	1.5211
Urban 2	−0.8425	−0.7241	−0.5255	−0.8009	−0.5532	0.7271	1.0279	−0.4055	1.1420	1.5761
Urban 3	−0.9420	−0.7195	−0.2758	−0.7604	−0.5463	0.5672	0.9505	−0.9449	1.0682	1.5698
Urban 4	−1.1286	−0.6786	−0.0000	−0.7123	−0.4943	0.0844	0.7698	−1.0000	0.9827	1.5350

Note: Elasticities are computed at base year 1973–74 prices and quantities. Estimates are from Binswanger, Quizón, and Swamy (1984).

Appendix Table 5. *Shares of Commodities in Consumption of Each Expenditure Quartile*

Expenditure quartile	Commodity					
	Rice	*Wheat*	*Course cereals*	*Other food*	*Nonfood*	*Total*
Rural 1	0.3152	0.0847	0.1792	0.2643	0.1565	1.0000
Rural 2	0.2789	0.1021	0.1215	0.3128	0.1848	1.0000
Rural 3	0.2611	0.1029	0.0870	0.3364	0.2126	1.0000
Rural 4	0.1389	0.1254	0.0613	0.3661	0.3082	1.0000
Urban 1	0.2004	0.1525	0.0744	0.3875	0.1851	1.0000
Urban 2	0.2503	0.0935	0.0346	0.4004	0.2212	1.0000
Urban 3	0.1923	0.0955	0.0265	0.4073	0.2784	1.0000
Urban 4	0.0926	0.0634	0.0101	0.4261	0.4077	1.0000

Source: 28 NSS, *Tables on Consumer Expenditures,* 1973–74.

Appendix Table 6. *Share of Each Expenditure Quartile for All India, Total Consumption by Commodity*

Expenditure quartile	Commodity				
	Rice	*Wheat*	*Coarse cereals*	*Other food*	*Nonfood*
Rural 1	0.1405	0.0672	0.2125	0.0530	0.0505
Rural 2	0.2027	0.1293	0.2432	0.0998	0.0935
Rural 3	0.1938	0.1606	0.1877	0.1146	0.1152
Rural 4	0.1857	0.3131	0.2262	0.2186	0.2946
Urban 1	0.0476	0.0812	0.0507	0.0766	0.0394
Urban 2	0.0806	0.0616	0.0310	0.0910	0.0530
Urban 3	0.0837	0.0885	0.0308	0.1361	0.1097
Urban 4	0.0655	0.0985	0.0179	0.2103	0.2441
Total	1.0000	1.0000	1.0000	1.0000	1.0000

Source: 28 NSS, *Tables on Consumer Expenditures,* 1973–74.

Appendix Table 7. *Share of Each Expenditure Quartile in the Total Supply of Agricultural Inputs for All India*

Expenditure quartile	Agricultural input		
	Agricultural labor	*Bullocks*	*Agricultural land owned*
Rural 1	0.2380	0.0973	0.1137
Rural 2	0.2651	0.1514	0.1625
Rural 3	0.2466	0.2327	0.2553
Rural 4	0.2315	0.4402	0.4685
Urban 1	0.0118	0.0063	0.0669
Urban 2	0.0014	0.0097	0.0359
Urban 3	0.0051	0.0260	0.0320
Urban 4	0.0005	0.0358	0.0377
Total	1.0000	1.0000	1.0000

Sources: 1970–71 NCAER-ARIS survey; 26 NSS, *Tables on Landholdings, All India, 1981–82.*

Appendix Table 8. *Share in Total Income from Agricultural Inputs for All India by Expenditure Quartile*

	Agricultural input				
Expenditure quartile	*Agricultural labor*	*Bullocks*	*Residual farm profits*[a]	*Agricultural implements and machinery*	*Total agricultural income*
Rural 1	0.5283	0.0256	0.1132	0.0737	0.7408
Rural 2	0.4278	0.0254	0.2422	0.0567	0.7521
Rural 3	0.3383	0.0258	0.3298	0.0498	0.7437
Rural 4	0.2215	0.0241	0.4726	0.0646	0.7828
Urban 1	0.0713	0.0201	0.0069	0.0000	0.0983
Urban 2	0.0028	0.0099	0.0359	0.0000	0.0486
Urban 3	0.0061	0.0169	0.0320	0.0000	0.0550
Urban 4	0.0002	0.0093	0.0377	0.0000	0.0472
All Groups	0.2042	0.0157	0.2213	0.0380	0.4792

a. Defined as net returns to land.

Source: 1970–71 NCAER-ARIS survey.

Appendix Table 9. *Summaries of Agricultural and Demographic Data Used in the Model*

Share in total real income by expenditure quartile for all India

Rural 1	0.0898	Urban 1	0.0345
Rural 2	0.1425	Urban 2	0.0456
Rural 3	0.1752	Urban 3	0.0696
Rural 4	0.3185	Urban 4	0.1244
Total rural	0.7260	Total urban	0.2740

Share in the population by expenditure quartile for all India

Rural 1	0.2002	Urban 1	0.0498
Rural 2	0.2002	Urban 2	0.0498
Rural 3	0.2002	Urban 3	0.0498
Rural 4	0.2002	Urban 4	0.0498
Total rural	0.8009	Total urban	0.1991

Share of agricultural commodities in the value of total agricultural output for all India[a]

Rice	0.2666
Wheat	0.1073
Coarse cereals	0.1128
Other crops	0.5133

Share of agricultural inputs in the total cost of agricultural production for all India[b]

Agricultural labor	0.3258
Bullocks	0.1086
Residual farm profits	0.3088
Fertilizer	0.0331
Agricultural implements and machinery	0.0979

a. Data are from the national accounts.

b. Data are from the 1970–71 NCAER-ARIS survey.

Appendix Table 10. *Output Supply Elasticities with Respect to Exogenous Shifter Variables*

	Variable					
Commodity	*Rain*	*High-yield varieties*	*Irrigated area*	*Roads*	*Land*	*Capital*
Rice	0.3563	0.2755	0.0011	−0.2116	0.4801	−0.0458
Wheat	0.2178	0.3764	0.7965	−0.0488	0.2871	0.2566
Coarse cereals	−0.0575	−0.1931	0.2547	0.3207	0.2000	0.1025
Other crops	0.0750	0.0340	0.3629	0.0911	0.3056	0.1155
Fertilizer	0.1558	0.5606	0.6370	0.5422	0.0000	0.0000
Labor	0.0557	0.0526	0.0917	−0.0027	0.61291	0.0761
Bullocks	0.0578	0.0441	0.1022	0.0018	0.8882	−0.0183

Note: Elasticities are computed at base year 1973–74 quantities. Estimates are aggregated from Evenson (1981), Bapna, Binswanger, and Quizón (1984), and Evenson and Binswanger (1984).

Appendix Table 11. *Data Description and Data Sources for Counterfactual Analysis*

Variable or exogenous shock	*Additional Description*[a]	*Data source*[b]
	A. For actual price and quantity levels	
1. Rice production	Production index for rice	*Index Numbers of Area, Production, and Yield of Principal Crops in India—Cropwise,* Directorate of Economics and Statistics, Ministry of Agriculture
2. Wheat production	Production index for wheat	Same as 1 above
3. Coarse cereal production	Production index for coarse cereals	Same as 1 above
4. Other crop production	Production index for pulses and nonfood grains	Same as 1 above
5. All crop production	Production index for all crops	Same as 1 above
6. Fertilizer consumption	Computed as the sum of fertilizer production, net fertilizer imports, and net withdrawals from fertilizer stock	*Production, Imports, Distribution and Consumption of Fertilizers,* Fertilizer Association of India
7. Employment	Index of employed male rural workers	*Union Primary Census Abstract,* Census of India
8. Rice prices[c]	Wholesale price index for rice	*Index Numbers of Wholesale Prices in India,* Economic and Scientific Research Foundation
9. Wheat prices[c]	Wholesale price index for wheat	Same as 8 above
10. Coarse cereal prices[c]	Wholesale price index for coarse cereals	Same as 8 above
11. Other crop prices[c]	Production-weighted wholesale price index for other crops	Same as 8 above
12. Labor wages[c]	Index of money wage rate of agricultural laborers as defined in Jose (1974)	Jose (1974) and *Agricultural Wages in India,* Directorate of Economics and Statistics, Ministry of Agriculture
13. Prices of all commodities[c]	Consumption-weighted price index for all commodities (food and nonfood articles)	Same as 8 above
14. Real per capita income	Personal disposable income at constant prices divided by the population; this was used as an exogenous shock in section II	*Macroeconomic Aggregate and Population,* Central Statistical Office, Department of Statistics, Ministry of Planning
	B. For the Exogenous Shifters	
1. Rate of change in net cropped area		*Area under Principal Crops in India,* Directorate of Economics and Statistics, Ministry of Agriculture
2. Rate of change in population	Assumed to be equal across expenditure groups for given period of time	*Population by Sex, Sex Ratio, Percentage Decadal Variation of Population and Urban Population as a Percentage of Total Population,* 1901–1981, Census of India

3. Rate of change in capital used in agricultural production	Assumed to be equal across expenditure groups for given period of time. "Capital" refers to the value of household-owned livestock and machinery and implements used in agricultural production. How this variable was constructed is explained in the text.	*Gross Domestic Capital Formation by Industry of Use,* Central Statistical Office, Department of Statistics, Ministry of Planning *Proportion of Households Reporting and Average Value per Household of Individual Items of Assets and Liabilities as of 30th June 1971 according to Asset Groups,* Reserve Bank of India
4. Rate of change in the supply of draft animals in agricultural production	Assumed equal to the rate of growth in the total number of buffalo and cattle used for work only and assumed to be equal across expenditure groups for given period of time	*Total Buffalos and Cattle Used for Work,* Directorate of Economics and Statistics, Ministry of Agriculture
5. Rate of change in the supply of other inputs in agricultural production	Other inputs are taken to be all inputs other than land, labor, draft power, capital (as defined above), and fertilizer. Its rate of change is assumed to be equal to the rate of growth in the value of total agricultural production (at constant prices)	*Value of Output from Agriculture,* Central Statistical Office, Department of Statistics, Ministry of Planning
6. Rate of change in nonagricultural prices[c]	Nonagricultural prices are weighted averages of wholesale prices of nonfood articles	*Index of Wholesale Prices,* Economic and Scientific Research Foundation
7. Rate of change in the price of capital services and other inputs used in agricultural production[c]	Assumed equal to 6 above	Same as 6 above
8. Rate of change in nonagricultural income[c]	Assumed to be equal across expenditure groups for given period of time. Initial estimates of this exogenous shock were obtained from two independently computed indexes of nonagricultural incomes. However, this variable was treated as endogenous in section II (see text and appendix A)	*Net Domestic Production at Factor Cost by Industry of Origin,* Central Statistical Office, Department of Statistics, Ministry of Planning *Macroeconomic Aggregates and Population,* Central Statistical Office, Department of Statistics, Ministry of Planning
9. Rate of change in the domestic availability of rice caused by trade and buffer stock operations	Defined as the rate of change in the net available rice supply, that is, net imports of rice plus net releases from government-held stocks of rice	*Availability of Food Grains in India,* Directorate of Economics and Statistics, Ministry of Agriculture
10. Rate of change in the domestic availability of wheat caused by trade and buffer stock operations	Same as 9 above, but for wheat	Same as 9 above

(Table continues on the following page.)

Appendix Table 11. *Continued*

Variable or exogenous shock	*Additional Description*[a]	*Data source*[b]
11. Rate of change in the domestic availability of coarse cereals caused by trade and buffer stock operations	Same as 9 above, but for coarse cereals	Same as 9 above
12. Rate of change in the domestic availability of fertilizer caused by trade and buffer stock operations	Same as 9 above, but for fertilizer	*Production, Imports, Distribution, and Consumption of Fertilizers,* Fertilizer Association of India
13. Technical change in rice production	For 1960–61 to 1980–81 assumed to be equal to 75 percent of the rate of change in rice yield per hectare	*Index Numbers of Area, Production, and Yield of Principal Crops in India—Cropwise,* Directorate of Economics and Statistics, Ministry of Agriculture
14. Technical change in wheat production	Same as 13 above, but for wheat	Same as 13 above
15. Technical change in coarse cereal production	Same as 13 above, but for coarse cereals	Same as 13 above
16. Technical change in other crops production	Same as 13 above, but for other crops	Same as 13 above
17. Rate of change in the percentage of irrigated area	Percentage irrigated area: the ratio of gross area under irrigation to gross cropped area	*Gross Area under Irrigation by Crops,* Directorate of Economics and Statistics, Ministry of Agriculture *Area under Principal Crops in India,* Directorate of Economics and Statistics, Ministry of Agriculture
18. Rate of change in road density	Road density is defined as the ratio of road length (in kilometers) to total geographic area (in kilometers^2). "Roads" refers to all surfaced and motorable unsurfaced roads	*Extra-Municipal Roads (Classified According to Surface) Including National Highways Maintained by P. W.D. and Local Bodies and Roads Constructed in C.D. and N.E.S. Blocks,* Ministry of Shipping and Transport

a. Data values are three-year averages. They are indexed such that the average for the three years 1972–73 to 1974–75 is equal to 100.

b. Only table headings and the agency which reports them are listed here.

c. These variables are deflated by $\bar{P}$. See text of appendix A for further explanation.

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A Survey of Agricultural Household Models: Recent Findings and Policy Implications

Inderjit Singh, Lyn Squire, and John Strauss

Semicommercial farms that produce multiple crops make up a large part of the agricultural sector in developing economies. These farms or agricultural households combine two fundamental units of microeconomic analysis: the household and the firm. Traditional economic theory has dealt with these units separately. But in developing economies in which peasant farms dominate, their interdependence is of crucial importance. Researchers at the Food Research Institute, Stanford University, and at the World Bank have developed models of agricultural households that combine producer and consumer behavior in a theoretically consistent fashion. Recent empirical applications of these models have extended them and expanded the range of policy issues which can be investigated using this general framework.

This article reports the results of empirical applications of this model in India, Indonesia, Japan, the Republic of Korea, Malaysia, Nigeria, Senegal, Sierra Leone, Taiwan, and Thailand. It provides a comparative analysis of the policy implications of the approach for such matters as the welfare of farm households, the size of marketed surplus, the demand for nonagricultural goods and services, and for hired labor, and the availability of budget revenues and foreign exchange.

In most developing countries, agriculture remains a major source of income for the majority of the population, an important earner of foreign exchange, and a focal point for government policy. Efforts to predict the consequences of agricultural policies, however, are often confounded by the complex behavioral interactions characteristic of semicommercialized, rural economies. Most households in agricultural areas produce partly for sale and partly for own-consumption. They also purchase some of their inputs—such as fertilizer and labor—and provide some inputs—such as family labor—from their own resources. Any change in the policies governing agricultural activities will therefore affect not only production but also consumption and labor supply.

Agricultural household models are designed to capture these interactions in a theoretically consistent fashion and in a manner that allows empirical applica-

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tions so that the consequences of policy interventions can be illuminated. The existence of such models would enable the analyst to examine the consequences of policy in three dimensions.

First, one could examine the effects of alternative policies on the well-being of representative agricultural households. Well-being may be interpreted here to mean household income or some other measure such as nutritional status. For example, in examining the effect of a policy designed to provide cheap food for urban consumers, an agricultural household model would allow the analyst to assess the costs to farmers of depressed producer prices. The nutritional benefits for the urban population may be more than offset by the reduced nutritional status of the rural population that results from lower farm incomes.

Second, an understanding of the behavior of agricultural households would shed light on the spillover effects of government policies on other segments of the rural population. For example, since most investment strategies are designed to increase production, their primary impact is on the incomes of agricultural households. As a result, rural investment strategies may not reach landless households or households engaged in nonagricultural activities. A model that incorporates total labor demand and family labor supply, however, would allow the analyst to explore the effects of investment policy on the demand for hired labor and hence on the rural labor market and the incomes of landless households. Similarly, a model that incorporates consumer behavior would allow the analyst to explore the consequences of increased profits for agricultural households on the demand for products and services provided by nonagricultural, rural households. Since the demand for nonagricultural commodities is often thought to be much more responsive to an increase in income than the demand for agricultural staples, this spillover effect may well be important.

Third, governments are interested in the performance of the agricultural sector from a more macroeconomic perspective. For example, agriculture is often an important source of revenue for the public budget and a major earner of foreign exchange. In assessing the effects of pricing policy on the budget or the balance of payments, the government is obliged to consider how agricultural households will alter their production and consumption in response to changes in prices. A reduction in export taxes, for example, may increase earnings of foreign exchange and budget revenues if households market enough additional production. Since agricultural household models capture both consumption and production behavior, they are an appropriate vehicle for examining the effect of pricing policy on marketed surplus and hence on foreign exchange earnings and budget revenues.

The importance of agricultural households in the total population and the significance of sector policies combine to make the behavior of agricultural households an area warranting thorough theoretical and empirical investigation. Many different approaches to the analysis of agricultural households have been followed, each with its own relevance and its own advantages and disadvantages. This article reports the results of a large body of work that has followed a similar basic approach to the analysis of agricultural household behavior.[1] This approach offers important policy insights that differ significantly from the results of more traditional approaches in which production and consumption decisions are examined separately.

Section I outlines the theoretical properties of a general model of producer, consumer, and labor supply decisionmaking. In truly subsistence households, these decisions are made simultaneously. Without access to trade, a household can consume only what it produces and must rely exclusively on its own labor. A large part of agriculture, however, comprises semicommercial farms in which some inputs are purchased and some outputs are sold. In these circumstances, producer, consumer, and labor supply decisions are no longer made simultaneously although they are obviously connected because (ignoring credit) the market value of consumption cannot exceed the market value of production less the market value of inputs. In fact, in these circumstances decisionmaking is recursive—production decisions are made with reference to market prices but are independent of other decisions, whereas consumption and labor supply decisions depend crucially on the income derived from the household's production. Section I clarifies the circumstances in which these decisions must be treated simultaneously and those in which they can be treated recursively.

Section II summarizes the major conclusions from this body of applied studies. First, it reconfirms the empirical importance of the approach for the analysis of agricultural policy. The results of comparable studies are used to demonstrate the quantitative significance of treating the main household decisions in a consistent manner for such policy-relevant magnitudes as the welfare of farm households, marketed surplus, the demand for nonagricultural goods and services, the rural labor market, budget revenues, and foreign exchange earnings. Comparative results on selected price elasticities are presented for a range of economies—Japan, Korea, Malaysia, Nigeria, Sierra Leone, Taiwan, and Thailand. The section also demonstrates the empirical significance of the approach by comparing the results of models that treat production and consumption decisions separately and those emerging from models in which the decisionmaking process is recursive.

Section III summarizes the implications for agricultural pricing policy of the results of section II. This section also draws out the policy conclusions of extensions of the basic model. It is shown that the model allows an exploration of the effects of government policy on nutritional status, health, savings, investment, and budget deficits. Studies of India, Indonesia, Korea, Senegal, and Sierra Leone are drawn upon to illustrate these extensions.

1. An in-depth analysis of this work is contained in the book *Agricultural Household Models: Extensions, Applications, and Policy* (Singh, Squire, and Strauss 1986), from which this article is derived.

I. Theoretical Framework

Modeling the Agricultural Household

In general, any analysis of the consumption or labor supply of agricultural households has to account for the interdependence of household production and consumption. Agricultural households combine the household and the firm, two fundamental units of microeconomic analysis. When the household is a price taker in all markets, for all commodities which it both consumes and produces, optimal household production can be determined independent of leisure and consumption choices. Then, given the maximum income level derived from profit-maximizing production, family labor supply and commodity consumption decisions can be made.

Given this sequential decisionmaking, the appropriate analytical framework is a recursive model with profit- and utility-maximizing components. Empirical analysis of both household consumption and production becomes considerably more tractable in a recursive model, which as a result has been used by most (but not all) empirical analyses.

In this section, a prototype static model is developed. (A more detailed treatment with derivations is found in Strauss 1986b.) For any production cycle, the household is assumed to maximize a utility function:

$$U = U(X_a, X_m, X_l) \tag{1}$$

where the commodities are an agricultural staple (X_a), a market-purchased good (X_m), and leisure (X_l). Utility is maximized subject to a cash income constraint:

$$p_m X_m = p_a(Q_a - X_a) - p_l(L - F) - p_v V + E$$

where p_m and p_a are the prices of the market-purchased commodity and the staple, respectively; Q_a is the household's production of the staple (so that $Q_a - X_a$ is its marketed surplus); p_l is the market wage; L is total labor input; F is family labor input (so that $L - F$, if positive, is hired labor and, if negative, is off-farm labor); V is a variable input (for example, fertilizer); p_v is the variable input's market price; and E is any nonlabor, nonfarm income.

The household also faces a time constraint; it cannot allocate more time to leisure, on-farm production, or off-farm employment than the total time available to the household:

$$X_l + F = T$$

where T is the total stock of household time. It also faces a production constraint or production technology that depicts the relationship between inputs and farm output:

$$Q_a = Q(L, V, A, K)$$

where A is the household's fixed quantity of land and K is its fixed stock of capital.

In this presentation, various complexities are omitted. For example, the possibility of more than one crop is ignored. In addition, it is assumed that family labor and hired labor are perfect substitutes and can be added directly. Production is also assumed to be riskless.[2] Finally, and perhaps most importantly, it is assumed that the four prices in the model—p_a, p_m, p_v, *and* p_l—are not affected by actions of the household. That is, the household is assumed to be a price taker in the four markets; as seen below, this will result in a recursive model.

The three constraints on household behavior can be collapsed into a single constraint. Substituting the production constraint into the cash income constraint for Q_a and substituting the time constraint into the cash income constraint for F yields a single constraint:

$$p_m X_m + p_a X_a + p_l X_l = p_l T + \pi + E \tag{2}$$

where $\pi = p_a Q_a (L, V, A, K) - p_l L - p_v V$ and is a measure of farm profits. In this equation, the left-hand side shows total household "expenditure" on three items: the market-purchased commodity, the household's "purchase" of its own output, and the household's "purchase" of its own time in the form of leisure. The right-hand side is a development of Becker's concept of full income, in which the value of the stock of time ($p_l T$) owned by the household is explicitly recorded, as is any labor income (Becker 1965). The extension for agricultural households is the inclusion of a measure of farm profits, $p_a Q_a - p_l L - p_v V$, with all labor valued at the market wage, this being a consequence of the assumption of price-taking behavior in the labor market. Equations 1 and 2 are the core of all the studies of agricultural households reported in this article.

Equations 1 and 2 reveal that the household can choose the levels of consumption for the three commodities, the total labor input, and the fertilizer input into agricultural production. Maximization of household utility subject to the single constraint yields the following first-order conditions:

$$p_a \frac{\partial Q_a}{\partial L} = p_l \tag{3a}$$

$$p_a \frac{\partial Q_a}{\partial V} = p_v \tag{3b}$$

$$\frac{\partial U}{\partial X_a} \bigg/ \frac{\partial U}{\partial X_m} = \frac{p_a}{p_m} \tag{4a}$$

$$\frac{\partial U}{\partial X_l} \bigg/ \frac{\partial U}{\partial X_m} = \frac{p_l}{p_m} \tag{4b}$$

plus the constraint. Equations 3a and 3b show that the household will equate the marginal revenue products for labor and fertilizer to their respective market prices. An important attribute of these two equations is that they contain only two endogenous variables, L and V. The other endogenous variables, X_m, X_a, and X_l, do not appear and do not, therefore, influence the household's choice of L or V (provided second-order conditions are met). Accordingly, farm labor and fertilizer demand can be determined as a function of prices (p_a, p_l and p_v), the

2. These assumptions can be relaxed and have been in the literature. For a more general treatment of the static model, see Strauss (1986b). Roe and Graham-Tomasi (1986) treat the case of production risk.

technological parameters of the production function, and the fixed area of land and quantity of capital. Since equations 3a and 3b depict the standard conditions for profit maximization, it can be concluded that the household's production decisions are consistent with profit maximization and independent of the household's utility function.

The maximized value of profits can be substituted into equation 2 to yield:

$$p_m X_m + p_a X_a + p_l X_l = Y^* \tag{5}$$

where Y^* is the value of full income associated with profit-maximizing behavior. Equations 4a, 4b, and 5 can be thought of as the first-order conditions of a second maximization. That is, having first maximized profits (see equations 3a and 3b), the household then maximizes utility subject to its (maximized) value of full income. Equations 4a, 4b, and 5 can then be solved to obtain the demand equations for X_m, X_a, and X_l as functions of prices (p_m, p_a, p_l) and full income (Y^*). This demonstrates, given the assumptions made about markets, that even though the household's production and consumption decisions may be simultaneous in time, they can be modeled recursively (Nakajima 1969; Jorgenson and Lau 1969).

The presence of farm profits in equation 5 demonstrates the principal message of the farm household literature—that farm technology, quantities of fixed inputs, and prices of variable inputs and outputs affect consumption decisions. The reverse, however, is not true provided the model is recursive. Preferences, prices of consumption commodities, and income do not affect production decisions; therefore, output supply responds positively to own price at all times because of the quasi-convexity assumption on the production function. However, for consumption commodities (X_a) which are also produced by the household (Q_a), own-price effects are

$$\frac{dX_a}{dp_a} = \left.\frac{\partial X_a}{\partial p_a}\right|_{Y^*} + \frac{\partial X_a}{\partial Y^*} \frac{\partial Y^*}{\partial p_a} \tag{6}$$

The first term on the right-hand side of this expression is the standard result of consumer demand theory and, for a normal good, is negative. The second term captures the "profit effect," which occurs when a rise in the price of the staple increases farm profits and hence full income. Applying the envelope theorem to equation 6,

$$\frac{\partial Y^*}{\partial p_a} dp_a = \frac{\partial \pi}{\partial p_a} dp_a = Q_a dp_a \tag{7}$$

that is, the profit effect equals output times the price increase and therefore is unambiguously positive. The positive effect of an increase in profits (and hence farm income), an effect totally ignored in traditional models of demand, will definitely dampen and may outweigh the negative effect of both income and substitution in standard consumer demand theory. The presence of the profit effect is a direct consequence of the joint treatment of production and consumption decisions.

The assumption that farm households are price takers may not always be appropriate. To explore the consequences of making prices endogenous to the household, it will be convenient to use duality results to express the equilibrium of the household. We can define the full income function as the maximization of full income with respect to outputs and variable inputs subject to the farm production function. As indicated in equation 2, the full income function can be written as the sum of the value of endowed time, a restricted (or short-run) profits function, and exogenous income. For the expenditure side of full income, we can define an expenditure function as the minimum expenditure (equation 5) required to meet a specified level of utility, $e(p_l, p_m, p_a, \bar{U})$.

Now we are in a position to relax our assumption that prices are fixed. The household's equilibrium is characterized by equality between the household's full income function and its expenditure function, $e(\bullet)$, where the expenditure function is evaluated at the utility level achieved at the household's optimum. This condition will hold whether or not households face given market prices. Now suppose that a household is constrained (or chooses) to equate consumption with production for some commodity(ies), for example, labor. One possible reason for this would be the nonexistence of a market. Another reason might be heterogeneous commodities—for example, family and hired labor may be imperfect substitutes, with the household choosing to sell no family labor off the farm. Alternatively, sales and purchase prices might differ for an identical commodity so that the price paid to farmers for their output is much lower than that which the farm household would have to pay to buy the goods later in the year when the household supply was depleted. Thus the family may decide to produce all of that good which it would need.

Consequently, the household's equilibrium will be characterized by a set of additional conditions—equality of household demand and household supply for each such commodity. The "virtual price" is that which would induce the household to equalize its demand and supply if a market existed (Deaton and Muellbauer 1980; Neary and Roberts 1980).

Virtual prices are not fixed for the household, as market prices are assumed to be. Rather they are determined by the household's choices. From the household's equilibrium, it can be seen that they will be a function of market prices, time endowment, fixed inputs, and utility. Consequently, these prices depend on both the household's preferences and its production technology. Changes in market prices will now affect behavior both directly, as before, and indirectly through changes in virtual prices.

The consequences of this additional effect can be shown provided one is willing to assume that commodities are substitutes or complements in consumption or production. If, for instance, the price of the farm good rises, the demand schedule for labor should shift upward. If leisure and food consumption are substitutes, substitution and income effects will cause supply to shift upward. Given that other market prices and fixed inputs are constant, the virtual wage has to rise to re-equate labor supply with demand. The rise in the virtual wage will influence household choices; for example, when the virtual wage rises, farm output will rise less than otherwise in response to a rise in its price. Indeed, it is possible for the virtual wage to rise so sharply as a response to increased food prices that farm output could actually fall as a consequence of a rise in farm output prices.[3]

If prices are endogenous for commodities which are both consumed and produced by the household, this affects the type of interdependence which exists between the household's consumption and production choices. For such commodities, the virtual prices are functions of both household preferences and production technology. Because these prices help to determine both consumption and production choices, production technology will influence household commodity demands both through the virtual price and through full income. Output supplies and input demands also will depend on preferences because preferences are partial determinants of the virtual price. If, however, the household faces only market prices, or if it faces a virtual price for a commodity which is consumed but not produced (or vice versa), then production choices will not depend on household preferences, but consumption choices will depend on production technology through full income. The model is then recursive.

Estimation Issues

Recursive models are much easier to estimate empirically because they allow all prices to be taken as exogenous to the household. From the household's equilibrium, one can then derive a set of commodity demand equations (including leisure or labor supply) and a set of output supply and variable input demand functions (or equivalently, a production function). The commodity demands are functions of commodity prices and full income.[4] Holding full income constant, these demand functions satisfy the usual constraints of demand theory; they satisfy the budget constraint, are homogeneous of degree zero with respect to prices and exogenous income, and display symmetry and negative semidefiniteness in the Slutsky-substitution matrix. The output supplies and input demands are functions of input and output prices and of farm characteristics (including land and fixed capital stock). They are derived from a profit function which obeys the usual constraints from the theory of the firm: they are homogeneous of degree one and convex with respect to prices. These results can be used as a guide when specifying the model for estimation since they imply restrictions on functional forms and on parameters, both within and between equations.[5]

In a recursive model, the output side can be modeled either by programming techniques (see Ahn, Singh, and Squire 1981; Singh and Janakiram 1986) or by

3. This point was emphasized by Sen (1966) and Nakajima (1969). Other differences in comparative statics between recursive and simultaneous models are detailed in Strauss (1986b).

4. Household characteristics, such as size and age/sex composition, might also be entered into the model as quasi-fixed factors which affect household utility. This would ignore the choice nature of these variables.

5. Issues of estimating demand equations are outside the scope of this article. The interested reader should consult a source such as Deaton and Muellbauer (1980).

econometric estimation of a multiple output profit or cost function. If estimation is to be by econometric means, errors have to be added to the model. The issues involved in sensibly specifying an error structure are outside the scope of this paper. For simplicity, suppose the errors are added to the demand and output supply equations. If, for a given household, the errors in the input demand and output supply equations are uncorrelated with the errors in the commodity demand equations, the entire system of equations is statistically block recursive. In this case, profits will be uncorrelated with the commodity demand disturbances so that the latter equations may be consistently estimated as a system independent from the output supply and input demand equations.[6] The practical advantage which results from separate estimation of the demand and production sides of the model is that far fewer parameters need to be estimated for each side separately. This is potentially important if the equations are nonlinear in parameters and have to be estimated using numerical algorithms, since expense is greatly reduced and tractability increased. Thus models with greater detail can be estimated.

Estimation does not have to be of a system of equations, since single equations can be consistently estimated as well. This may be especially advantageous when the underlying model is not recursive. In that case, virtual prices and hence farm profits are endogenous so that the commodity demand, output supply, and input demand equations are not in reduced form. To estimate the full set of "structural" equations is expensive (see Lopez 1986 for such a study). At the other extreme, one can specify the reduced-form equations. The disadvantage of that approach is that it is usually not possible to solve for the reduced form analytically. Consequently one cannot take full advantage of economic theory in imposing (or testing) parameter restrictions, though some of the restrictions may be readily apparent. Nevertheless, one can specify what variables belong in the reduced form and thus can estimate a least-squares approximation to it. Several of the studies included in this survey are of this type. As a compromise, a subset of the structural equations might be estimated, and the endogeneity of any choice variables taken into account. In this way, some economic structure can be imposed (tested) on the data.

Recursive versus Simultaneous Models

Since most of the empirical work to date has assumed that production and consumption decisions are recursive, it is of interest to investigate the significance of this assumption. This assumption has to be examined on a case-by-case basis. The relevant questions are whether markets exist and, if they do, whether an individual household is able to influence the market price. In most countries, it may be reasonable to expect that households are price takers both in their

6. However, if production and consumption side errors are correlated, then profit is correlated with the demand side errors, and its endogeneity must be accounted for to estimate the demand equations consistently, whether or not the deterministic model is recursive.

output markets and in the markets for their main nonlabor inputs such as fertilizer. Price determination may be more problematic in factor markets. Iqbal (1986), for example, argues that the interest rate paid by households in his study is a function of the amount borrowed and is thus influenced by the household. He therefore employs a reduced-form equation to capture the resulting simultaneity. Iqbal's model has two periods and is expressly concerned with borrowing and investing decisions. For single-period models, labor is the most important factor. While the labor market warrants careful attention in each case, several recent surveys have provided some support for the price-taking assumption (Binswanger and Rosenzweig 1984; Squire 1981).

Given the relative convenience of estimation in the case of recursive models, one may also wish to investigate the magnitude of any error introduced when a recursive model is used in a situation where it is not fully justified. Recall that the comparative statics of a simultaneous model contain additional terms because virtual prices respond to changes in exogenous variables. Even if the utility and production function parameters were correctly estimated, elasticities calculated on the assumption of a recursive model would be in error because the virtual prices would be incorrectly treated as constant. How important this omission is depends on the responsiveness of the virtual price to the changing exogenous variable and on the responsiveness of the dependent variable (of policy interest) to the virtual price. It seems intuitively clear that if the changing exogenous variable and the variable of policy interest are not closely linked to the market that is cleared by a virtual price, the issue of simultaneity is less important.

The above argument presumes that the underlying utility and production functions are known, which empirically, of course, they are not. In this case, a second bias enters into the elasticity calculations—the statistical bias of the estimates of these underlying parameters. The magnitude of this statistical bias is not known, and even its direction may not be known. Furthermore, the combined effects of parameter inconsistency and missing terms in the comparative statics may reinforce or offset each other.

The only evidence on this question comes from Lopez's (1986) study of country-level Canadian data, in which all the structural equations of a simultaneous model are estimated. In this model, self-employment and off-farm employment have different impacts on household well-being. That is, they are imperfect substitutes in the utility function, an assumption which is not easily testable. In addition, family and hired labor are assumed to be imperfect substitutes in the farm production function, a more easily testable assumption. These two assumptions imply a simultaneous model. Households supply on-farm and off-farm labor and demand family and hired farm labor. At the given market farm wage, it would be a coincidence for on-farm labor supply and demand, which are both nontraded, to be equated; therefore, in general a virtual farm wage will exist which does equate the two.

Lopez estimates a more standard, recursive model in addition to the simultaneous one described above. In this example, the exogenous variables are wage rates of off-farm employment and hired farm labor, the variable of interest is labor supply, and the virtual price is also a wage rate (of family farm labor). He finds that the total (on-farm plus off-farm) labor supply elasticity with respect to wage (both hired-in on-farm and hired-out off-farm) is much lower if the simultaneous model estimates (0.04) rather than the recursive model estimates (0.19) are used. In this circumstance, the difference between a recursive and a simultaneous specification is likely to be at its greatest. We conjecture that the sensitivity of other elasticities—such as the marketed surplus elasticity with respect to output price—is less.[7]

Unfortunately, it is not easy to assess the overall importance of this issue. It may be possible to assess the bias in comparative statics caused by ignoring simultaneity, but even then the potential bias depends on the hypothetical sources of the simultaneity, and these will differ from study to study. Some questions will lead naturally to a simultaneous model (for example, Iqbal's study) but, before abandoning the recursive assumption, the analyst should carefully consider both the potential sources of simultaneity and the interaction among changes in exogenous variables, changes in the virtual price, and changes in the variables of policy interest. The bulk of the existing empirical work on agricultural household models notwithstanding, the essential lesson of the approach is the importance of combining production and consumption decisions. Whether the method of combination should involve a recursive model or a simultaneous model is a secondary issue which must be decided on a case-by-case basis.

II. Summary of Recent Empirical Findings

What can be learned about the economic response of rural, mainly farming households from these empirical studies which use an integrated approach to modeling the behavior of agricultural households? Does the new agricultural household modeling approach matter empirically both in terms of predicting economic behavior as well as in terms of the policy implications that follow from it? Although the studies summarized in this paper differ in the details of the applied methods, the characteristics of the sampled households, and the focus of their policy interest, nonetheless they share the view that integrating production and consumption decisions is not only the proper approach to modelling economic behavior of agricultural households but that the empirical results and their policy implications are sufficiently different to justify the effort.

The Surveyed Studies

Table 1 lists some essential characteristics of the different partial equilibrium studies which are summarized in this paper. The first empirical studies giving estimates of agricultural household models were conducted at Stanford Univer-

7. See Singh, Squire, and Strauss (1986, chap. 2) for a more detailed treatment.

Table 1. *Selected Characteristics of Surveyed Partial Equilibrium Studies*

Study	*Economy*	*Type of data*	*Number of observations*	*Variation in prices*	*Type of analysis*[a]	*Policy problems addressed*
Lau, Lin, and Yotopoulos (1978)	Taiwan	Average by farm size and region for each of two years	80	By region and all prices.	LLES and Cobb-Douglas profit function estimated for three commodities.	Consumption of agricultural commodity, marketed surplus, and labor supply.
Barnum and Squire (1979b)	Malaysia	Cross-section household level	207	By region for wages only.	LES and LLES estimates for three commodities along with Cobb-Douglas production function.	Rice consumption, labor supply, and marketed surplus.
Kuroda and Yotopoulos (1980)	Japan	Cross-section average by farm size and region	72	By region for all prices.	LLES and Cobb-Douglas profit function for four commodities. Leisure disaggregated by farm workers and off-farm workers.	Consumption of agricultural commodity, marketed surplus, and labor supply.
Rosenzweig (1980)	India	Cross-section household level for all India	862	By region for male and female wages.	Reduced-form estimates of male and female off-farm labor supply equations.	Off-farm labor supply by sex.
Ahn, Singh, and Squire (1981)	Korea	Cross-section household level	443	By region for wages and subset of prices.	Multiple (six) commodities analyzed. Linear programming used for production side and LES estimated for demand side.	Effects of technological change on consumption of agricultural commodity.

Adulavidhaya, Kuroda, Lau, and Yotopoulos, (1984)	Thailand	Separate household cross-section data sets used for demand system and input demand system	440[b]; 480	By region for prices.	LLES and Cobb-Douglas profit function for three commodities.	Consumption of agricultural commodity, marketed surplus, and labor supply.
Strauss (1986a)	Sierra Leone	Cross-section household level	138	By region for all prices.	Multiple (seven) commodities analyzed. QES estimated on demand side with constant elasticity of transformation Cobb-Douglas output supply equations.	Price and income responsiveness of caloric availability.
Singh and Janakiram (1986)	Northern Nigeria	Cross-section household level	312	By region.	Multiple commodities analyzed (intercropping). Linear programming used for production side and LES for demand equations.	Production choice among alternative crops. Substitutability of certain crops in consumption.
Iqbal (1986)	India	Panel data, household level for all India	1,602	By region for interest rate and wages.	Reduced form estimates of borrowing and interest rate equations; nonseparable.	Determinants of borrowing and interest paid for large and smallholding farmers.
Pitt and Rosenzweig (1986)	Indonesia	Cross-section household level	2,347	By region for all prices.	Farm profits, male labor supply, reduced form illness, and health input demand equations; separability tested.	Effects of health on profits and labor supply and determinants of individual health status. Intrafamily distribution considered.

a. Demand systems abbreviated are LLES, Linear Logarithmic Expenditure System; LES, Linear Expenditure System; QES, Quadratic Expenditure System. All models are separable, except as noted.

b. Observation numbers for demand side and production side analyses respectively.

Table 2. *Selected Elasticities in Response to Changes in Agricultural Commodity Prices*

Economy	*Agricultural commodity*	*Consumption of agricultural commodity*	*Consumption of market-purchased goods*	*Marketed surplus*	*Labor supply*
Japan	Farm output	−0.35	0.61	2.97	−1.01
Korea	Rice	0.01	0.81	1.40	−0.13
Malaysia	Rice	0.38	1.94	0.66	−0.57
Nigeria[a]	Sorghum	0.19	0.57	0.20	−0.06
Sierra Leone	Rice	−0.66	0.14	0.71	−0.09
Taiwan	Farm output	0.22	1.18	1.03	−1.54
Thailand	Farm output	−0.37	0.51	8.10	−0.62

Sources: Listed for each economy in the first column of table 1.

Note: Each value shown is the ratio of the percentage change in the endogenous variable (the column heading) to the percentage change in the price of the listed agricultural commodities.

a. Northern portion only.

sity by Lau, Yotopoulos, and their collaborators (Lau, Lin, and Yotopoulos 1978; Kuroda and Yotopoulos 1980; Adulavidhaya, Kuroda, Lau, and Yotopoulos 1984), and at the World Bank by Barnum and Squire (1979, 1980). These econometric studies specify recursive models and estimate commodity demands and either output supply and input demand or a production function.

Subsequent studies have extended the basic methodology in various ways. One study has disaggregated commodities on the consumption side of the model with the objective of providing a more careful accounting of caloric intake (Strauss 1986a). Another paper looks at determinants of health within a farm household framework (Pitt and Rosenzweig 1986). A third extends the model to endogenize saving and investment decisions (Iqbal 1986). Both the latter two studies estimate reduced-form equations, the first for health and the second for borrowing, rather than estimate the full system of demand and supply equations. In addition, this article reviews several recent attempts to embed agricultural household models in a multimarket framework. This framework allows a more comprehensive analysis of agricultural policies since it accounts for important interactions that are neglected in partial equilibrium models (Braverman and Hammer 1986).

Main Results

Table 2 presents a subset of elasticities calculated from the seven studies which estimate the full system of commodity demand equations. The table reports the effect of changes in the price of the agricultural commodity on consumption of the agricultural commodity, consumption of market-purchased goods, marketed surplus, and labor supply.

For consumption of the agricultural commodity, the studies show an almost even split between those which report a positive own-price elasticity and those which report a negative one. Both positive and negative elasticities are small. The positive response indicates that the profit effect has more than offset the traditional negative effect of both income and substitution predicted by standard consumer demand theory. For consumption of market-purchased goods, the most important result is the strongly positive cross-price elasticities. This result also attests to the strength of the profit effect in increasing total expenditure. The reported elasticities suggest that the level of farm incomes and the availability of nonfarm goods are important determinants of responsiveness. For example, Sierra Leone, which has a low per capita income and relatively thin market and infrastructural development, has much lower elasticities than those of the East Asian countries.

Elasticities of marketed surplus are strongly positive, whereas those for total family labor supply are negative. The positive elasticities of marketed surplus indicate that, even where the profit effect is strong enough to make consumption response positive, the total output response is always large enough to offset increased household consumption. The negative responses for labor supply suggest a strong profit effect and reflect the fact that leisure is a normal good.

Do Agricultural Household Models Matter?

Agricultural household models integrate production and consumption decisions in rural farm households. This requires a complex theoretical structure as well as much data for empirical estimation. Is the additional effort justified? Can practitioners make do with far simpler techniques that have been traditionally used to model farm behavior—that is, with the demand and supply sides separated? The answer lies at two levels. First, at the empirical level, we must ask whether these models, which account for the interdependence of production and consumption decisions, provide estimates of elasticities that could not have been obtained otherwise. Second, at the policy level, we must ascertain whether the resulting differences in these elasticity estimates lead to policy implications that differ from those emerging from traditional methods. The remainder of this section addresses the first issue—that of the empirical significance of agricultural houshold models. The policy implications are discussed in section III.

In assessing the empirical significance of agricultural household models, it is useful to recall that their distinguishing characteristic is the inclusion of the profit effect, which results from the increase in income when crop prices are raised. Table 3, which compares two sets of elasticities—those with and those without the profit effect—clearly establishes the empirical significance of agricultural household models. The estimates of the elasticity of demand with respect to own-price not only differ significantly in the cases of Japan, Sierra Leone, and Thailand, but change sign in the cases of Korea, Malaysia, Nigeria, and Taiwan. Thus, whereas traditional models of demand, as we would expect, predict a decline in own-consumption in response to an increase in agricultural commodity prices, the agricultural household models predict an increase for three cases. This is because the profit effect offsets the negative substitution and

Table 3. *Analysis of the Profit Effect: Agricultural Price and Wage Elasticities of Commodity Demand and Labor Supply*

	Elasticity					
	Of agricultural commodity demand		*Of nonagricultural commodity demand*		*Of labor supply*	
Economy	*A*[a]	*B*[b]	*A*[a]	*B*[b]	*A*[a]	*B*[b]
Elasticity with respect to agricultural prices						
Japan	−0.87	−0.35	0.08	0.61	0.16	−1.01
Korea	−0.18	0.01	−0.19	0.81	0.03	−0.13
Malaysia	−0.04	0.38	−0.27	1.94	0.08	−0.57
Nigeria[c]	−0.05	0.19	−0.14	0.57	0.03	−0.06
Sierra Leone	−0.74	−0.66	−0.03	0.14	0.01	−0.09
Taiwan	−0.72	0.22	0.13	1.18	0.21	−1.54
Thailand	−0.82	−0.37	0.06	0.51	0.18	−0.62
Elasticity with respect to wage rates						
Japan	0.29	0.15	0.39	0.25	0.15	0.45
Korea	0.16	0.01	0.77	0.05	0.00	0.11
Malaysia	0.06	−0.08	0.29	−0.35	−0.07	0.11
Nigeria[c]	0.06	0.02	0.04	0.01	0.01	0.10
Sierra Leone	0.47	0.37	0.78	0.57	0.14	0.26
Taiwan	0.14	−0.03	0.05	−0.12	−0.12	0.17
Thailand	0.57	0.47	0.62	0.52	0.08	0.26

Sources: Listed for each economy in the first column of table 1.

Note: Each value shown is the ratio of the percentage change in the endogenous variable (the column heading) to the percentage change in agricultural price or wage.

a. Holding profits constant.

b. Allowing profits to vary.

c. Northern portion only.

income effects. In these cases, farm households increase their own-consumption as prices are raised. Whether or not this would reduce the amounts they offer on the market will depend on the elasticity of output. We know that this marketed surplus elasticity remains positive in these cases (table 2). The response, however, is dampened by the profit effect.

The differences in the elasticity of demand for nonagricultural goods with respect to the price of agricultural goods are also striking. The elasticities change sign in four cases, and in the other three cases the magnitudes are much larger when the profit effect is included. Whereas cross-price elasticities estimated using traditional demand models tend to be low or negative because of negative income effects, the agricultural household model estimates are positive and large because of the positive profit effect. The elasticities of household labor supply with respect to the price of the agricultural good also differ dramatically. In the traditional demand models, an increase in the price of the agricultural good reduces not only the consumption of that good but also that of leisure, which implies an increase in the family work effort (table 3). In contrast, agricultural household models predict a negative response of household labor supply to increased output prices because households are willing to take part of their increased incomes in increased leisure and thereby reduce their work effort.

While fewer signs change when responses to agricultural wage rates are examined, the magnitudes do. In traditional demand models, an increase in the wage rate implies an increase in real household incomes, which results in a positive demand response for agricultural and nonagricultural goods and a negative or inelastic response of household labor supply. These effects are partially offset in agricultural household models because an increase in wages also affects the production side and reduces total farm incomes. As a result, demand responses for both the agricultural and nonagricultural goods are either dampened or totally offset (Malaysia, Taiwan), while labor supply response becomes positive or more elastic.

Rosenzweig (1980) looks at the market (or off-farm) labor supply responses of landed and landless households in rural India and provides a different type of evidence that agricultural household models matter. After separately estimating market supply equations for landless and agricultural households, Rosenzweig compares coefficients between the two groups and finds that twenty-one out of twenty-two comparisons conform to the predictions of the agricultural household framework. For instance, the male off-farm labor response of landless households to increases in the market male wage is less than for agricultural households, as would be predicted because of the negative profit effect of raising male wages.

In addition to differences between elasticities estimated from traditional models and those estimated from agricultural household models, there are other elasticities provided by the latter which are not even defined for models that focus exclusively on consumption behavior. These are the elasticities of demand with respect to nonlabor input prices, stocks of fixed factors of production (including land), and farm technology. A selection of these elasticities is shown in table 4. While the absolute magnitudes are small in most cases, the point to recall is that they have no counterpart in models that do not integrate production and consumption. Thus, while traditional demand models can predict demand responses to output prices, they tell us nothing about such responses to input prices or changes in the fixed factors of production or technology. Similarly, traditional supply models can predict supply responses to changes in output and input prices and in fixed factors of production and technology but fail to tell us anything about the demand responses to these exogenous factors. Agricultural household models therefore provide a vital link between demand and supply responses to exogenous policy changes. While these links can be established informally between traditional supply and demand models, in agricultural household models they are handled directly within a consistent theory and framework of estimation.

The results of tables 3 and 4 allow us to identify when the use of a full agricultural household model is likely to be important. Since the profit effect is the distinguishing feature of these models, this amounts to identifying when the

Table 4. *Selected Elasticities with Respect to Fertilizer Prices and Land Availability*

Economy	*Agricultural commodity demand*	*Nonagricultural commodity demand*	*Marketed surplus*	*Labor supply*
Elasticity with respect to fertilizer prices[a]				
Japan	−0.03	−0.03	−0.09	0.07
Korea	−0.05	−0.23	0.34	0.04
Malaysia	−0.03	−0.18	−0.15	0.05
Taiwan	−0.11	−0.11	−0.24	0.18
Thailand	−0.03	−0.03	−0.41	0.05
Elasticity with respect to land availability				
Japan	0.19	0.19	0.96	−0.43
Korea	0.10	0.49	0.81	−0.08
Malaysia	0.26	1.37	1.15	−0.41
Nigeria[b]	0.10	0.16	0.06	−0.08
Sierra Leone	0.01	0.02	0.02	−0.01
Taiwan	0.46	0.46	1.00	−0.77
Thailand	0.11	0.11	1.48	−0.19

Sources: Listed for each economy in the first column of table 1.

Note: Each value shown is the ratio of the percentage change in the endogenous variable (the column heading) to the percentage change in fertilizer price or the area of land available.

a. Fertilizer is barely used in the Sierra Leone and Nigeria samples and therefore was not modeled.

b. Northern portion only.

profit effect is likely to be important. Three points regarding this effect are worthy of note. First, changes in some exogenous prices have a small effect on farm profits. For example, the profit effect is much more important in Malaysia than in Sierra Leone (table 3) partly because the effect of a price change on profits is much larger in Malaysia, where a 10 percent increase in output price results in a 16 percent increase in profits. In Sierra Leone, the same percentage increase in output price increases profits by only 2 percent.

Second, even if profits are affected by an exogenous price increase, profits may be only a small part of full income (equation 2) and it is full income that appears in the demand equations. For our sample economies, the share of profits in full income ranges from 0.5 in Malaysia to 0.2 in Thailand. It follows that a given percentage increase in profits will have a much bigger impact on total income in Malaysia than in Thailand.

Third, the effect of full income on demand varies among commodities. It is much more important, for example, in the case of nonagricultural commodities than agricultural ones since demand in the latter tends to be inelastic with respect to income. In Malaysia, the elasticity of demand for rice with respect to full income is only 0.5, compared with 2.7 for market-purchased goods. As a result, the profit effect is much more significant in the case of nonagricultural goods than in that of agricultural goods (table 3).

These remarks suggest that if profits are relatively insensitive to producer prices and constitute a relatively small part of full income, and if consumption of a particular item is relatively insensitive to full income, then couching the analysis in the context of an agricultural household model will not yield much of an increase in accuracy. This proves to be the case, for example, with the elasticity of demand for agricultural goods with respect to changes in producer prices in Sierra Leone (although it is not true for low-income households in that study [Strauss 1986a]). If these three conditions are reversed, however, as the example of the elasticity of demand for nonagricultural goods with respect to producer prices in Malaysia reveals, a full agricultural household model is of critical importance.

III. Policy Results

Results from the Basic Model

Agricultural household models provide policy insights in three broad areas: the welfare or real incomes of agricultural households; the spillover effects of agricultural policies on the rural, nonagricultural economy; and, at a more aggregate level, the interaction between agricultural policy and international trade or fiscal policy. To illustrate the potential role of agricultural household models, this section draws policy conclusions in each of these three dimensions for a typical agricultural policy. The policy chosen is that of taxing output (either through export taxes or marketing boards) in order to generate revenue for the national treasury and simultaneously subsidizing a major input (usually fertilizer) to restore, at least partially, producer incentives. Other policies can be examined with the use of agricultural household models, but this particular combination is a common characteristic of agriculture in developing countries and illustrates well the type of issue that can be analyzed in this framework. Care must be taken when interpreting these policy implications because the analyses are partial equilibrium in nature. A major exception are the multimarket analyses discussed below.

Consider first the effect of pricing policy on the welfare or real full income of a representative agricultural household. For some price changes—for example, a change in the price of fertilizer—the resulting change in nominal full income is an accurate measure of the change in real income since the prices of all consumer goods have remained unchanged. In other cases, however, the commodity in question may be both a consumption good and a farm output or input. For example, if the price of an agricultural staple is reduced, the household will lose as a producer but gain as a consumer. As long as the household is a net producer of the commodity, the net effect will be negative (see Strauss 1986b). Nevertheless, if one wishes to quantify the net impact on the household, allowance must be made for both the negative effect coming through farm profits and the positive effect coming through a decline in the price of a major consumption item.

Table 5 presents estimates of the elasticities of real full income with respect to changes in output price and fertilizer price for the seven studies examined earlier. For marginal changes, the decrease in real income following a reduction in the price of the agricultural output equals marketed surplus times the price decline,

Table 5. *Real Income Elasticity with Respect to Prices of Output and Fertilizer*

	Response of Income	
Economy	*To output prices*	*To fertilizer prices*
Japan	0.34	−0.03
Korea	0.40	−0.10
Malaysia	0.67	−0.07
Nigeria[a]	0.12	—
Sierra Leone	0.09	—
Taiwan	0.90	−0.11
Thailand	0.10	−0.03

Sources: Listed for each economy in the first column of table 1.

Note: Each value shown is the ratio of the percentage change in real income to the percentage change in prices of output or fertilizer.

a. Northern portion only.

— Not applicable. Fertilizer is barely used in the Sierra Leone and Nigeria samples and therefore was not modeled.

while the increase following a reduction in the price of an input equals the quantity of the input times the price reduction. Thus, knowing prices, marketed surplus, and full income, these short-run elasticities can be calculated without reference to price and income elasticities. However, for nonmarginal changes, it would be necessary to use information on the underlying structure of preferences to calculate equivalent or compensating variation.

The table reveals that the percentage change in real income is less than the percentage change in either the output price or the fertilizer price. In addition, the table suggests that the loss in real income arising from a given percentage reduction in the output price can be offset only if the price of fertilizer is reduced by a much larger percentage. In Malaysia, for example, a 10 percent reduction in output price would reduce real income by almost 7 percent, whereas a 10 percent reduction in the price of fertilizer would increase real income by less than 1 percent. This result arises from the relative magnitudes of marketed surplus and fertilizer use and indicates that, if policymakers are interested primarily in the welfare of agricultural households, intervention in output markets is likely to be much more important than intervention in the markets for variable, nonlabor inputs.

Policymakers are also concerned with the welfare of rural households that do not own or rent land for cultivation. Landless households either sell their labor to land-operating households or engage in nonfarm activities (see, for example, Anderson and Leiserson 1980). Governments, however, have very few policy instruments that affect the welfare of these households directly. Policies such as price interventions and investment programs that are directed at land-operating households nevertheless have spillover effects which may or may not be beneficial for these households. What can agricultural household models tell us about these effects?

An increase in the price of a major agricultural staple will obviously hurt households that are net consumers of that item (if other prices are held constant). The direct effect of a price increase, therefore, will be unambiguously negative for landless households and nonfarm households. If general equilibrium considerations are ignored, policymakers thus face a dilemma: if they want to improve incentives and increase the incomes of agricultural households, they do so at the expense of other rural households. There are, however, offsetting indirect effects. For example, table 6 below reveals that if the price of the agricultural commodity is increased, agricultural households increase their demand for total—hired and family—farm labor and reduce the supply of family labor (that is, increase their leisure time). As a result, the demand for hired labor can be expected to increase substantially to the benefit of landless households. In Malaysia, the reported elasticities of labor demand (1.61) and labor supply (−0.57) imply an elasticity of demand for hired labor of 10.9. While this result in part reflects the initial small percentage of hired labor in total labor (19 percent), it nevertheless implies a substantial change in labor market conditions and would undoubtedly exert upward pressure on rural wage rates. At least to some extent, it thereby offsets the negative consequences for landless households of higher prices of agricultural commodities.

The policy implications of these findings are very significant because they also shed light on the extent to which the positive gains from technological improvements trickle down via the labor market to the rural landless. It is now widely accepted that technological innovations associated with the Green Revolution (improved seeds, increased use of fertilizers and pesticides, increased irrigation and cropping intensity) have had a dramatic impact on the demand for total

Table 6. *Indirect Effects of Changes in Prices of Output and Fertilizer*

	Response		
Economy	*Of labor demand*	*Of labor supply*	*Of consumption of nonagricultural goods*
Response to changes in output prices			
Japan	1.98	−1.01	0.61
Korea	0.57	−0.13	0.81
Malaysia	1.61	−0.57	1.94
Nigeria[a]	0.12	−0.06	0.57
Sierra Leone	0.14	−0.09	0.14
Taiwan	2.25	−1.54	1.18
Thailand	1.90	−0.62	0.51
Response to changes in fertilizer prices[b]			
Japan	−0.13	0.07	−0.03
Korea	−0.12	0.04	−0.23
Malaysia	−0.12	0.05	−0.18
Taiwan	−0.23	0.18	−0.22
Thailand	−0.11	0.05	−0.03

Sources: Listed for each economy in the first column of table 1.

Note: Each value shown is the ratio of the percentage change in the endogenous variable (the column heading) to the percentage change in agricultural commodity or fertilizer price.

a. Northern portion only.

b. Fertilizer is barely used in the Sierra Leone and Nigeria samples and therefore was not modeled.

labor. But the concern has been whether this increased demand could be translated into an equal impact on hired labor, most of which comes from the smallest farms and the landless (see Quizón and Binswanger 1986). The empirical findings show that it can be. When an increase, either in the fixed factors of production or technologies, boosts incomes on the farm, they tend to reduce the amount of the family's labor effort (table 4 illustrates this using land as an example). Any increase in the demand for total labor therefore results in an even larger increase in the demand for hired labor. The labor supply and demand elasticities emerging from empirical applications of agricultural household models provide strong support for the view that trickle-down effects are both positive and significant.

Table 6 identifies a second indirect effect of increased output prices: a significant increase in the demand for nonagricultural goods. The elasticity is positive and greater than 1 in two economies—Taiwan and Malaysia—and positive and greater than 0.5 in all economies except Sierra Leone (though for low-income households in Sierra Leone it is also high: 0.9). Some of this demand will be for imports and urban-produced commodities, but a large part will be for rurally produced goods and services and therefore will increase demand for the output of nonfarm, rural households. Any increase in farm profits, whether caused by a price change or a technological improvement, can be expected to lead to a substantial increase in the demand for goods and services produced by nonagricultural households. Thus, spillover effects on output markets will at least partially offset the negative effects on nonfarm households of an increase in agricultural prices and will ensure that the benefits of technological improvements are dispensed throughout the rural community.

Table 6 also traces the effects of a change in the price of fertilizer. As noted in the discussion of the effects on the welfare of agricultural households, changes in the price of fertilizer have only a minor impact. The results suggest that small or moderate changes in fertilizer prices can be made without generating large negative or positive spillover effects.

As mentioned earlier, governments often tax agricultural output to generate revenue and simultaneously subsidize key inputs such as fertilizer to restore production incentives in the hope of achieving self-sufficiency or earning foreign exchange. Can agricultural household models shed light on these revenue and balance of trade issues? Because the models provide information on the effect of pricing policy on marketed surplus and fertilizer demand, they can be used as inputs into calculations of self-sufficiency, balance of payment effects, and budgetary effects.

If the primary interest is in self-sufficiency, governments need to know the marketed surplus available for procurement. Table 7 reproduces elasticity estimates for agricultural production, consumption, and marketed surplus. The results illustrate two points. First, even where consumption responds positively to an increase in the price of the agricultural commodity because of the profit effect, marketed surplus still responds positively. Where the consumption re-

Table 7. *Elasticities of Output, Consumption, Marketed Surplus, and Fertilizer Demand*

	Response			
Economy	*Of agricultural output*	*Of agricultural consumption*	*Of marketed surplus*	*Of fertilizer demand*
Response to changes in output prices				
Japan	0.98	−0.35	2.97	1.98
Korea	1.56	0.01	1.40	1.29
Malaysia	0.61	0.38	0.66	1.61
Nigeria[a]	0.30	0.19	0.20	—
Sierra Leone	0.11	−0.66	0.71	—
Taiwan	1.25	0.22	1.03	2.25
Thailand	0.90	−0.37	8.10	1.90
Response to changes in fertilizer prices[a]				
Japan	−0.13	−0.03	−0.09	−1.13
Korea	0.30	−0.05	−0.34	−1.10
Malaysia	−0.13	−0.03	−0.15	−1.13
Taiwan	−0.23	−0.11	−0.23	−1.23
Thailand	−0.11	−0.03	−0.41	−1.11

— Not applicable. Fertilizer is barely used in the Sierra Leone and Nigeria samples and therefore was not modeled.

Note: Each value shown is the ratio of the percentage change in the endogenous variable (the column heading) to the percentage change in the price of the agricultural commodity or fertilizer.

a. Northern portion only.

Sources: Listed for each economy in the first column of table 1.

sponse is negative, the elasticities of marketed surplus are positive and large (see, for example, the cases of Japan and Thailand). A government therefore can use pricing policy in the output market to increase marketed surplus even when it is unable to set the prices facing consumers and producers independently. Second, efforts to offset disincentives in output markets through fertilizer subsidies will not be effective unless the percentage reduction in the fertilizer price is much larger than that in the output price.

The analyst can also derive from table 7 rough estimates of the effect of pricing policies on budget revenues and foreign exchange. For example, assume that the output is exported and that fertilizer is imported. Table 7 reveals that an increase in output price will induce an increase in marketed surplus available for export but only at the expense of an increase in the use of fertilizer. The net foreign exchange effect, therefore, is given by the difference between the additional revenues from exporting and the costs of importing additional fertilizer. Similarly, if the output is taxed and fertilizer is subsidized, one can perform a similar calculation to arrive at a rough estimate of the net impact on the budget.

The policy issues analyzed above illustrate the uses that can be made of the basic framework of the agricultural household model. The framework is very flexible and can be adapted in many ways to fit particular circumstances and issues. In the next section, we discuss the main policy conclusions of these extensions but note that at present these conclusions remain somewhat more

Table 8. *Response of Caloric Intake to Price Changes, Sierra Leone*

	Price elasticity of caloric intake		
Commodity	*Low-income households*	*Middle-income households*	*High-income households*
Rice	0.19	−0.24	−0.20
Root crops and other cereals	0.43	0.13	0.11
Oils and fats	0.27	−0.03	−0.21
Fish and animal products	0.48	0.23	0.05
Miscellaneous foods	0.14	0.01	−0.01

Source: Strauss (1986a).

Note: Each value shown is the ratio of the percentage change in caloric intake to the percentage change in the price of the relevant food.

tentative than those emerging from the well-researched basic model because replications of the extensions have not yet been performed.

Extensions of Agricultural Household Models

The implications of price and other interventions on the nutritional and health status of target groups, especially the rural poor, are of special interest to international agencies and national governments. What do agricultural household models add to the debate? Strauss (1986a) demonstrates how the basic model can be elaborated to allow an investigation of the effect of pricing policy on caloric intake. In his model, the utility function (see equation 1) becomes

$$U = U(X)$$

where X is a vector of consumer goods including food items, nonfood items, and leisure. Calorie intake (K) can then be calculated from:

$$K = \sum_i a_i X_i \qquad i = 1 \ldots m$$

where a_i is the calorie content of a unit of the i^{th} food and X_i, $i = 1 \ldots m$, are quantities of different food items.

With this extension, Strauss is able to show that price changes exert a considerable effect on caloric intake with the profit effect playing an important role. One might expect that an increase in the price of a major food item would probably have a negative impact on caloric intake. However, table 8 reveals that, in the majority of cases, an increased price results in increased caloric intake because of an increase in profits. Thus, even if consumption of the commodity whose price is increased declines, the extra profits allow the purchase of increased quantities of other foodstuffs so that overall caloric intake responds positively. With profits held constant, however, increased food prices decrease caloric intake. This indicates that the nutritional impact of higher food prices on agricultural households is reversed (or substantially reduced) when the profit effect is incorporated.

In the case of Sierra Leone, Strauss is also able to demonstrate an important point regarding the distribution of calories among income groups. He shows that even if a price increase causes a reduction in the caloric intake of middle- and high-income households (see the case of rice in table 8), the intake of low-income households is increased. This suggests that, if policymakers are concerned primarily with the nutritional status of low-income households where few rural households are landless, price increases for major food items may prove to be beneficial. Increases in the prices of food items toward world prices may improve the nutritional status of low-income landed households and provide appropriate signals for resource allocation. The usual equity-growth tradeoff may be absent in this case.[8]

Policymakers are interested in nutritional status presumably because it affects health and well-being and may also affect productivity at the individual level. Pitt and Rosenzweig (1986) take the analysis one step further, therefore, and examine the interaction between prices, health, and farm profits in the context of an agricultural household model. Their extension involves incorporation of a health variable directly into the utility function—people prefer to be healthy—and into the production function—a healthy individual is more productive. To complete their model, they introduce a production function for health:

$$H = H(X_a, X_m, X_l, Z)$$

which says that health (H) depends on consumption (X_a and X_m) and hence on nutrition, on leisure (or work effort, X_l), and on a vector (Z) of other factors which affect health, some of which (for example, boiling water) are chosen by the household and some of which (for example, well water) are community-level services.[9]

Applying their model to Indonesian data, Pitt and Rosenzweig are able to show that a 10 percent increase in the consumption of fish, fruit, and vegetables reduces the probability of illness by 9, 3, and 6 percent, respectively, whereas a 10 percent increase in the consumption of sugar increases the probability of illness by almost 12 percent. These results suggest that increases in consumption cannot automatically be interpreted as contributing to health since the composition of consumption may also change in a manner detrimental to health.

In addition to estimating the health production function, Pitt and Rosenzweig also estimate a reduced-form equation that directly links prices and health. They show that a 10 percent reduction in the prices of vegetables and vegetable oil will decrease the probability of the household head being ill by 4 and 9 percent, respectively, whereas the same percentage reduction in the prices of grains and sugar will increase the probability of illness by 15 and 20 percent, respectively, albeit from a very low base. These results, however, are calculated with profits held constant. In principle, when profits are allowed to vary, some of the results

8. Smith and Strauss (1986) provide similar evidence when they simulate the results at the national level while allowing rural wages to equilibrate the rural labor market.

9. Early work on household production activities within a household-firm framework can be found in Hymer and Resnick (1969) and Gronau (1973, 1977). See Strauss (1986b), for further discussion.

may be modified. In this application, however, the coefficient on farm profits proved statistically insignificant. The results reported above, therefore, are reasonably accurate measures of the total effect of changes in price on health.

Changes in health may also affect productivity and farm profits. Pitt and Rosenzweig demonstrate that behavior can be represented by a recursive model, in which case the effects of ill health or labor supply are not reflected in reduced farm profits since households have recourse to an active labor market. Although total labor input and hence farm profits are unaffected, family labor supply is significantly reduced by illness, and the value of full income is decreased by the value of time spent ill in bed. This result indicates that the benefits of improved health (or the costs of a deterioration in health) in agricultural households will come through family labor earnings only and will be reflected in farm profits, if at all, only through the indirect route of the labor market.

Most of the policy issues considered so far have been static in nature and have been couched in a single-period framework. Iqbal (1986) provides a major departure from previous work by extending the single-period analysis to incorporate borrowing, savings, and investment decisions. Since governments and multinational agencies devote substantial funds to rural credit programs, this extension offers the possibility of using agricultural household models to address a new set of policy issues of considerable importance for many countries.

Iqbal uses a two-period model. In the first period, the household may borrow and invest in farm improvements. In the second period, the loan must be repaid with interest and the household enjoys higher farm profits as a result of its investment in period one. Accordingly, in Iqbal's model the single full-income constraint is replaced by two full-income constraints, one for each period:

$$\pi(K_1) + w_1 T_1 + B = C_1 + I$$

and

$$\pi(K_1+I) + w_2 T_2 = C_2 + B\,[1 + r(B)]$$

where K_1 is capital in period one and I is investment, so that $K_1 + I$ is capital in period two. B is borrowing in period one, r is the interest rate, and $B\,[1 + r(B)]$ is repayment in period two. C is the value of consumption of goods and leisure. Iqbal draws a parallel between his treatment of household savings and borrowing and the treatment of own-consumption and marketed surplus or family labor supply and hired labor in the standard agricultural household model. He notes that the recursive property of the standard model carries over to this two-period extension, provided the household can borrow at a fixed rate of interest. In his application to Indian households, Iqbal argues that the interest rate is influenced by household borrowing decisions (r is a function of B in the second-period constraint), and he therefore adopts a nonrecursive specification.

Iqbal's results reveal that borrowing is significantly reduced by increases in the interest rate, the elasticity being -1.2. These results support the view that interest rate policy can have a marked effect on the level of debt held by farmers.

Iqbal also shows that farmers owning more than three hectares are highly sensitive to the interest rate whereas the coefficient on borrowing by farmers owning less than three hectares is statistically insignificant. It follows that the elimination or reduction of subsidies to programs providing agricultural credit may serve the dual purpose of increasing efficiency in the capital market and simultaneously improving equity, since the reduction in borrowing by "large" farmers will exceed that by "small" ones.

As noted earlier, governments are also interested in the effects of agricultural pricing policy on more aggregate economic variables such as budget deficits and foreign exchange earnings. For example, in 1982–83, Senegalese agricultural products generated 70 percent of total export earnings, and deficits resulting from the government's policy on agricultural pricing amounted to more than 20 percent of government expenditure and 2 percent of gross domestic product. Changes in agricultural prices can be expected, therefore, to have a major impact on these aggregates. Indeed, concern with the existing levels of foreign exchange earnings and budget deficit may be the major motivation for changes in pricing policy in many countries. In Senegal, the government has explored ways, including pricing policy, to promote the production and consumption of millet in order to reduce imports of rice and hence improve the country's balance of payments.

The effect of pricing policy on foreign exchange and budget revenues was discussed briefly earlier in this article. Braverman, Ahn, and Hammer (1983) and Braverman and Hammer (1986), however, provide an important extension to the basic model that makes the analysis of these policy issues much more complete: they add market-clearing conditions for the major outputs and inputs to the basic model of an agricultural household. The changes in consumption, production, or labor supply at the household level following any change in an exogenous variable can then be aggregated and fed into the market-clearing equations. In some cases, the market is cleared through adjustments in international trade, and prices remain fixed at levels determined by the government; that is,

$$Q(\bar{P}_a) = X_a(\bar{P}_a) + E$$

where E represents net exports and the output and consumption variables now represent national aggregates. In this event, a change in production or consumption has an immediate effect on foreign exchange earnings. Alternatively, the market may clear through adjustments in price; that is,

$$Q(P_a) = X_a(P_a)$$

Now a policy-induced change in production or consumption will result in a change in price, which will generate second-round effects on production and consumption.

In their application of the model to Senegal, Braverman and Hammer (1986) assume the first form—quantity adjustment—of marketing clearing for cotton, groundnuts, and rice and the second form—price adjustment—for maize and millet. The second-round effects flowing from induced changes in the prices of maize and millet are captured fully in their model. Table 9 provides a sample of their policy results. Compare first the effect of reducing the price of groundnuts or increasing the price of fertilizer on the government's deficit arising from its agricultural pricing policy. Both policies reduce the deficit. The reduction in the price of groundnuts, however, has a relatively small effect on net foreign exchange earnings (mainly because a reduction in rice imports offsets reduced exports), although it reduces the real incomes of farmers in the groundnut basin by almost 6 percent. An increase in the price of fertilizer, however, causes a larger fall in net export earnings (a reflection of the fertilizer intensity of export crops) but only reduces farm incomes by 1 percent. This example illustrates the policy trade-offs that can be explored within this framework. It also confirms a point made earlier: to be effective, changes in the prices of inputs such as fertilizer must be larger than changes in the prices of the main outputs.

Table 9 also illustrates a quite different point regarding the formulation of policy. Assume that a policy objective is to reduce imports of rice and hence save foreign exchange by increasing domestic production of rice and increasing consumption of domestic substitutes such as millet. How can this result be achieved? One possibility is an increase in the producer price of rice. This does indeed reduce rice imports by 7 percent, but net foreign exchange earnings fall by 4.5 percent because to increase rice production farmers switch out of export crops. The desired result—an increase in net foreign exchange earnings—fails to materialize because of substitution possibilities in production. In this case, failure to recognize substitution possibilities produces a perverse result. In other situations, however, policy may be designed to take advantage of substitution possibilities. For example, the government may increase the consumer price of rice in the hope that people will change their pattern of consumption in favor of millet. Table 9, however, reveals that this policy has little impact on net export earnings, so in this case a reliance on substitution possibilities would have been misplaced.

These examples from the Senegal study of Braverman and Hammer illustrate

Table 9. *Agricultural Price Elasticities, Senegal*

Policy	*Change in real income*	*Change in export earnings*	*Change in government deficit*
Decrease producer price of groundnuts by 15 percent	−5.7	−1.9	−18.1
Increase price of fertilizer by 100 percent	−1.1	−5.2	−10.4
Increase producer price of rice by 50 percent	0.2	−4.5	−0.1
Increase consumer price of rice by 50 percent	−4.7	−0.2	−34.8

Source: Braverman and Hammer (1986).

Note: Each value shown is the ratio of the percentage change in the endogenous variable (the column heading) to the percentage change in the price of the specified commodity.

the importance of placing agricultural household models in a multimarket framework.[10] This is likely to be especially important if attention is focused on foreign exchange earnings and government revenues. Because expansion of one crop is usually at the expense of another crop, changes in the quantities of internationally traded items and in the quantities of taxed or subsidized items will influence the overall impact of policy on foreign exchange and government revenue even if a change in a government-controlled price in one market leaves the prices in all other agricultural markets unchanged. More generally, changes in government-controlled prices will induce changes in other prices so that even measures of output response, labor supply response, consumer response, and changes in farm profits will have to allow for general equilibrium effects. These remarks suggest that the multimarket analysis of Braverman and Hammer will be likely to emerge as the most useful vehicle for generating operationally relevant policy results from agricultural household models, particularly when it is based on carefully estimated parameters from good data.

IV. Conclusion

On the basis of the empirical work to date, it seems clear that for certain purposes the agricultural household modeling approach is essential. In particular, the interaction of consumption and production decisions through farm profits is essential because it matters empirically. It is less certain whether other interactions, through virtual prices, are important. This is likely to be the subject of future research. For policy analysis, especially at the aggregate level, it will generally be imperative to account for the profit effect on consumption. Analysts cannot justifiably continue to assume that rural household consumption does not vary with economic changes. As the Senegal study shows, changes in household consumption stemming from a certain policy can have important ramifications for several different outcomes. That study also highlights the advantages of moving toward general equilibrium in policy analysis, since it allows varying production and consumption substitution possibilities to be better captured. However, more household level studies are needed to improve understanding of the decisionmaking process and to extend the basic model to cover other types of decisions.

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The Extent of Nontariff Barriers to Industrial Countries' Imports

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This article examines the extent of nontariff barriers (NTBs) to the visible imports of sixteen industrial countries. It uses three alternative measures to show that governmental commodity-specific border measures affect more than 27 percent of all imports and more than 34 percent of imports from developing countries. It also shows that during the period from 1981 to 1983, NTBs became significantly more extensive. Detailed statistics reveal considerable variations in NTB coverage by commodity, type of barrier, importer, and exporter. The data on which these conclusions are based were compiled from official information at the highest level of disaggregation and are described in the article.

Since the 1940s, considerable progress has been made in liberalizing tariff barriers to international trade through a series of multilateral negotiations. For example, the Tokyo Round of the General Agreement on Tariffs and Trade (GATT) concluded in 1979 with an agreement to lower industrial countries' tariffs by about 25 percent on average, and the Geneva (1956), Dillon (1962), and Kennedy rounds (1968) produced similar reductions. In consequence, the average tariff level of industrial countries was reduced from about 40 percent in the mid-1930s to 4–8 percent after the Tokyo Round.

As the GATT rounds have brought about a significant decline in tariff obstacles to trade, nontariff barriers (NTBs) have become more prevalent. The GATT specifically allows countries to impose several kinds of measures, for example, safeguard and antidumping restrictions and countervailing duties. In addition, governments and import-competing interests have been quite inventive in expanding trade barriers. These restrictions have come about through the development and implementation of restrictions which are outside the GATT, such as "voluntary" export restraints, and through the addition of provisions to the

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GATT to sanction widespread restrictions, including those on agricultural products when the GATT was initially negotiated, and later, the adoption of the Multifibre Arrangement for textiles and clothing.

Behind this paper lies an interest in moving the international community toward the elimination of such restrictions, but we do not directly address that topic here. This paper takes up an important prerequisite to such work: the presentation of credible information on the nature and extent of nontariff barriers in international trade.[1] The quantitative work reported here concentrates on a basic dimension, the amount of trade subject to or covered by NTBs. Within this quantitative dimension, the paper addresses three questions:

- What is the prevalence of the major nontariff barriers to imports of industrial countries?
- Has that prevalence increased in recent years?
- Are imports from developing countries particularly subject to NTBs?

Section I describes the types of NTBs included in this study and discusses the way each type restricts international trade. Section II discusses the concepts, data, and statistical indicators used, while Sections III to V present the results of the analysis. Section VI provides a summary and conclusions.

I. The Nontariff Barriers Included

The array of governmental nontariff barriers to trade is very wide. For example, the table of contents of the inventory of nontariff measures which is used by the GATT Secretariat in its *Report of the Group on Quantitative Restrictions and Other Non-Tariff Measures* enumerates more than forty categories of measures.

There are many political and administrative mechanisms through which import restrictions are put in place, and many reasons, legal, political, and otherwise, why a government might argue against the application of the label "protection" or "import regulation" to its policy measures. In certain circumstances, the GATT allows the use of some types of import restrictions, but whether or not an action conforms to the GATT is not an adequate basis for defining a measure as protective. The GATT allows "safeguard actions" to protect domestic producers from injury caused by tariff binders when "unforeseen developments" occur, despite the fact that such measures are universally interpreted as trade restrictions or protection. We deal here only with the economics of such measures—only with the fact that they impose conditions on import sales which are not imposed on sales by domestic firms.

This article investigates a restricted selection of the measures included in the GATT table of contents; specifically, we examine those which are product-specific

1. Other recent attempts to estimate the extent of NTBs include Balassa and Balassa (1984) and Cline (1985), which lack precision due to the incomplete information on NTBs and aggregated trade data, and Jones (1983), which deals only with the United Kingdom.

border measures for which comprehensive and internationally comparable data are available. While there is room for debate about the composition of a complete set of NTBS, our selection, drawn from official definitions and based on official sources, represents a minimum list of nontariff trade policies. It comprises five groups of the most common and explicit border measures used to control the inflow of foreign goods.

Quantitative Import Restrictions

- *Prohibitions and embargoes on the importation of a product.* A prohibition may be total, may admit exceptions at the discretion of the competent authority, or may operate only under certain conditions.
- *Quotas.* Ceilings (specified in value or quantitative terms) are imposed on the importation of a product for a given period of time; they may be global, country-specific, or seasonal.
- *Discretionary import authorizations.* Permission to import is granted at the discretion of competent authorities. These are often used for the administration of quantitative limits.
- *Conditional import authorizations.* Permission to import is subject to the importer undertaking commitments in areas other than importation, or to specified overall economic conditions (such as export performance, or the purchase of an equivalent quantity of domestic output) or the unavailability of domestic supply.

"Voluntary" Export Restraints

"Voluntary" export restraints (VERS) are agreements between an exporter and an importer as to the maximum amount of exports (specified in value or quantity terms) to be purchased within a given period of time. This category includes, inter alia, bilateral agreements on textile trade reached within the framework of the the Multifibre Arrangement (MFA) that indicate specific limits, consultation levels, and export controls. Although voluntary export restrictions are administered by exporting countries, they are monitored by importing countries, and their imposition is the result of successful protectionist requests in importing countries.

Measures for the Enforcement of Decreed Prices

- *Variable levies.* Import charges set periodically to equalize the import price with a decreed domestic price.
- *Minimum price systems.* A minimum import price is set by the importing country, and import prices below the decreed minimum trigger an additional duty or some other penalty.
- *"Voluntary" export price restraints.* This category covers agreements between the exporter and the importer on the minimum price to be observed by the exporter.

Tariff-type measures

• *Tariff quotas.* Two tariff rates are applied, the higher rate coming into operation when the quantity of imported goods exceeds a specified level.
• *Seasonal tariffs.* Different tariff rates are applied to the same (agricultural) product according to the time of year.

Monitoring measures

• *Price and volume investigations, surveillance.* Formal investigations of charges by domestic producers about unfair trading practices of an exporting country; formal monitoring of the evolution of imports of sensitive products with or without prior import authorization being required. While an investigation is obviously necessary to determine the facts, there is evidence that the inquiry process itself has a protective effect, independent of the eventual findings (Finger 1981).

The investigative process or continued surveillance generates uncertainty about an exporter's continuing access to the market and creates an incentive for the exporting firm to raise its price, whether or not it is guilty of an illegal practice. A surveillance process is often the means by which a government monitors "voluntary" price maintenance agreements or volume restraint agreements contracted between exporting and import-competing industries or governments. Surveillance is often the precursor to more formal import restrictions,[2] or a signal to exporters to practice "self-restraint" to avoid a more formal "voluntary restraint." "Automatic" import licensing procedures are often restrictive; for example, they serve to police bans on imports from certain countries or to funnel all imports of a product through a government-authorized association of import-competing local producers of that product or of producers of a finished good made from that product.
• *Antidumping and countervailing duties.* In theory, antidumping duties are levied on a product that is sold in the importing country at a lower price than in the exporting country. Countervailing duties are levied to offset export rebates or subsidies with the rationale that such measures create a situation which more closely approximates the outcomes that would exist under free and fair trade regimes. William Dickey's study of antidumping practices in the United States (1979) finds that such measures have a greater disincentive effect on imports than do comparable "fair trade" (mainly antitrust) regulations on domestic firms' sales and that they do, in fact, constitute protection of domestic producers. There is evidence that the outcome of the pricing test in dumping and countervailing duty cases is significantly influenced by the economic variables usually used in the parallel injury test to measure injury, that is, that the *economics* of dumping and countervailing duties is much the same as the economics of safeguard cases (Finger, Hall, and Nelson 1982).

2. Indeed, the European Communities (EEC) regulations (for example, Council regulation; see EEC 1982, p. 288) explicitly refer to surveillance for this purpose. (See EEC 1982.)

While our selection of NTBs includes a broad range of policies, it still constitutes only a subset of the trade restrictions included in the GATT and United Nations Conference on Trade and Development (UNCTAD) lists (UNCTAD 1985). For example, it does not include domestic policy measures (such as subsidies to import-competing producers, government procurement, or restrictions on domestic sale of foreign goods), generalized procedures applying to all imports, restrictive business practices, the use of technical or sanitary requirements as barriers to trade, or subtle forms of import restriction such as changing ports of entry; any of these could seriously affect the level of international trade.

II. Measurements of NTB Coverage

The principal unit of measure used in this study is the amount or share of a country's imports subject to NTBs.[3] Operationally, this concept is quantified by marking on each line of a country's import list the types of NTBs which are applied to that line. Many such restrictions apply only to imports from particular countries and are not global or subject to the "most favored nation" clause; hence the import list must be disaggregated by both product and country of origin. We calculate the NTB prevalence or coverage ratios as the sum of import lines or value subject to NTB divided by the sum of all import lines or value.

The prevalence or coverage ratio is a more elementary concept than a tariff average; a more appropriate parallel is the ratio of dutiable to total (dutiable plus duty free) imports. While a tariff rate provides a measure of the intensity of restriction it entails, nontariff barriers provide no such obvious measure of intensity, nor has the analysis of NTBs yet created an estimated set of intensity figures for NTBs. We have only a "yes or no" indicator—a strictly qualitative indicator of whether or not governmental considerations, as opposed to just normal commercial considerations, influence the amount or the direction of international trade.

The Statistical Indicators

Three indexes of the prevalence of NTBs are used below. Each summarizes the presence or absence of NTBs on several tariff headings simultaneously, but each uses a different scheme to combine observations. While one might wish to combine NTBs on the basis of the amount by which they reduce trade or of the levels that trade would attain in the absence of NTBs, this is not possible. Neither of these is observable. Indeed, one *purpose* of developing an NTB coverage index is to move *toward* estimating the trade effects of these NTBs, *toward* construction of the counterfactual "free trade" pattern of imports.[4]

3. For a recent and extensive discussion of the measurement of NTBs, see Deardorff and Stern (1985).

4. There are many jokes about economists assuming away the problem, and the suggestion that the coverage ratio be based on "free trade" values is an example of why such jokes have an element of valid criticism in them.

We construct and compare three measures of nontariff barriers—the first based on the value of each country's own imports of particular commodities, the second on the world trade value of these commodities, and the third on the number of flows of these commodities. The first, the *own imports coverage ratio*, I_c, measures the sum of the value of a country's import groups affected by NTBS over the total value of its imports of that group. The *world trade coverage ratio*, I_w, for each of the commodities imported by a country, measures the sum of the value of world trade of an import group affected by that country's NTBS, over the total value of world trade in that commodity group. The *frequency ratio*, I_f, simply registers the relative frequency with which countries impose NTBS on their commodity imports; it counts the number of a country's import flows covered by NTBS and divides this sum by the total number of import flows for that country.

For the actual calculation of the three ratios, for any importer (i) and type of nontariff barrier (b) let $N_{qx} = 1$ if there is a barrier on imports of the commodity, q, from exporter x, and $= 0$ otherwise. For sets of commodities (Q) and exporters (X), all three indexes take the form:

$$I = \frac{\sum_{q \epsilon Q} \sum_{x \epsilon X} W_{qx} N_{qx}}{\sum_{q \epsilon Q} \sum_{x \epsilon X} W_{qx}}$$

We define W_{qx} differently for each ratio.

- I_c defines W_{qx} as the value of i's actual imports of q from x.
- I_w for each of the commodities, q, imported by i, defines W_{qx} as the value of world imports of q, aggregated across all exporters.
- I_f defines W_{qx} as the presence or absence of a flow of q from x to i; thus $W_{qx} = 1$ if imports of q from x are non-zero, $= 0$ otherwise.

Note that while both N_{qx} and W_{qx} must refer to particular years, these need not be the same, provided that, as here, both have been converted to the same classification.[5]

Each of the three indexes has strengths and weaknesses. The own imports coverage ratio is possibly the most appropriate in that the extent of an NTB is represented by the size of the particular trade flows it affects. Its drawback is that more restrictive NTBS tend to receive lower weight than less restrictive ones because they reduce imports by more. In the extreme, a total prohibition shows up as zero imports covered by NTBS. This difficulty is reduced by allowing W_{qx} to refer to a year in which there were relatively few barriers.

5. The UNCTAD converts NTB information from the trade classification current when they are reported to the 1981 classification used for the trade data. To the extent that this is occasionally impossible, such data are not used and thus our figures may slightly understate the prevalence of NTBS.

To the degree that a country's own restrictions are not correlated with those on world trade, the weight that the world trade coverage ratio applies to a particular NTB will be largely independent of the latter's restrictiveness. If all importers restrict a particular commodity (such as textiles), however, its weight in world trade will presumably be understated relative to the free trade case and the NTBs it faces correspondingly underweighted in the overall index. The exceptions would include cases in which discriminatory NTBs result in trade diversion to higher-cost sources of supply. Also, the upgrading effect of NTBs could result in an observed value of trade above the free trade level. There are two major drawbacks of I_w as a measure of the "free trade" coverage of individual countries' NTBs. First, world imports may not be representative of the import pattern of a particular importer because import bundles differ across countries quite independently of the level of NTBs. Second, there are inevitable inaccuracies in estimating world trade for each tariff line of each importer's trade classification.[6]

Most current protection is of recent origin and is intended to prevent further increases in import shares rather than to roll back imports drastically. Moreover, most industrial countries do tend to protect the same sectors, for example, agriculture, textiles, and iron and steel. Thus, when comparing NTB *coverage* between countries, we believe that "own imports" is a better proxy for free trade imports than are our constructed "world trade" data.

The frequency ratio goes still further toward avoiding the downward bias in I_c relative to free trade imports coverage. The extent of NTBs is measured by the number of trade flows that are affected, so that every barrier to every observed trade flow receives equal weight.[7] Its difficulties are twofold, however. First, it ignores differences in the sizes of trade flows of the various commodity categories. Second, it is exaggerated by the tendency of trade classifications to become more fragmented for the more sensitive and restricted categories of trade.

None of our indexes allows for the fact that some barriers are inherently more restrictive than others. For example, discretionary licenses could reflect either just the threat of, or the actual presence of a restriction, but our measures are insensitive to such dimensions. Thus it remains a large and speculative step to draw conclusions about the restrictiveness of trade regimes on the strength of these indexes.

In making comparisons of NTB coverage across time, we use import values from *one* period to calculate NTB coverage for both periods. Thus we get a reliable indicator of changes of the *extent* of NTBs but, as the reader has been reminded before, not of the changes in their restrictiveness.

6. See appendix 1 of Nogués, Olechowski, and Winters (1986) for details.

7. The use of "observed" trade flows means that prohibitions are still excluded in I_f. This could be overcome by defining W_{qx} as unity wherever $N_{qx} = 1$, even if actual imports were zero. This involves a certain arbitrariness, however, since it is not guaranteed that every zero trade subject to an NTB would be positive in the absence of the NTB. For example, suppose an importer has a global quota of zero on bananas: thus $N_{qx} = 1$ for all x when q = bananas. While we may like to have $W_{qx} = 1$ for Trinidad, we would not wish it so for Iceland.

The Data

The import data used in construction of the coverage ratios are provided by national authorities to the GATT and thence to UNCTAD. These data classify imports by tariff line and distinguish trade with all partner economies, except for EEC countries, in which intra-Community trade is ignored. All trade data are annual and refer to 1981.

Sixteen industrial country markets are examined in this paper: the ten EEC countries (with Belgium and Luxembourg combined), Australia, Austria, Finland, Japan, Norway, Switzerland, and the United States. In 1981, these markets accounted for about 60 percent of total world imports and about 70 percent of imports from developing countries.

The data on nontariff barriers have been collected by UNCTAD within the framework of its Data Base on Trade Measures. This contains information on governmental product-specific border nontariff measures applied in most developed market-economy countries. The data are recorded at the tariff-line level (that is, the level at which they are legally defined and applied) and are derived from official national and intergovernmental (for example, the GATT) publications. After the preliminary collection of information, or if substantive changes are introduced, governments are invited to verify and comment upon the accuracy of the data on their import regimes.[8] Since the data use the same definition of commodities as do the legal instruments defining them, there is no loss of information through aggregation. Either all imports in a particular tariff line are subject to the particular NTB, or none are. This means that our trade-based indexes, I_c and I_w, are quite independent of the level of fragmentation of the trade classification.

The UNCTAD data contain information on the dates of introduction and elimination (if applicable) of individual NTBs and thus make possible the investigation of changes in NTB import coverage over time. Our estimates refer to periods of one year, and we set $N_{qx} = 1$ for a barrier even if it has applied for only part of the period concerned. This possibly imparts an upward bias to our ratios, but it allows us to capture a more representative sample of short-term and seasonal barriers than would a snapshot view.

III. Results: NTBs on Imports of Industrial Countries

Tables 1, 2, and 3 below summarize the prevalence in sixteen industrial economies of the NTBs we have been able to document. The discussion in this section will be focused on aggregate results. However, an earlier paper (Nogués, Olechowski, and Winters 1986) provides detailed estimates for particular markets, products, and barriers. The figures quoted in the discussion, except for those shown in the tables and documented in the notes, have been drawn from that source.

8. For fuller details of the Data Base on Trade Measures, see UNCTAD (1983a, 1985).

Table 1. *The Extent of Industrial Countries' NTBs by Product Category, 1983*

Imports	Coverage ratios: Own Imports (I_c)	Coverage ratios: World trade (I_w)	Frequency ratio (I_f)
All products	27.1	21.8	12.8
All products, less fuels	18.6	18.5	12.7
Fuels	43.0	31.0	23.9
Agricultural	36.1	40.4	29.5
All manufactures	16.1	14.9	10.8
Textiles	44.8	37.8	38.1
Footwear	12.6	17.7	13.5
Iron and steel	35.4	35.8	18.3
Electrical machinery	10.0	10.8	5.4
Vehicles	30.4	25.9	7.4
Other manufactures	8.8	7.2	3.2

Note: Sixteen industrial markets, all exporters, all NTBs.

The Overall Prevalence of NTBs

Overall, 13 percent of these countries' tariff lines are subject to NTBs, and 27 percent of their imports fall into these categories. In comparison, tariff concessions negotiated at the Tokyo Round covered about 18 percent of the imports of the major developed countries.[9] The value of imports influenced by the nontariff trade policies of these sixteen industrial country governments (some $231 billion, based on 1981 trade flows) is almost half again as large as the *total* imports of the state-trading East European centrally planned countries.

Sectoral Coverage

While NTBs affect almost all internationally traded goods,[10] table 1 shows that in the case of industrial countries they are especially prevalent in certain sectors. In particular, textiles, agricultural products, mineral fuels, and iron and steel generally show a greater prevalence of NTBs than other product groups. It is quite common for imports of agricultural products to be regulated to such an extent that their origin, quantity, quality, price, and time of entry are specified in advance by the importing country authorities. While the management of imports is particularly elaborate in the EC, in which, for example, minimum import prices for certain products are adjusted almost daily, agricultural products face a wide array of NTBs in all industrial countries. Among the measures employed are various kinds of quotas (global, bilateral, seasonal); varying (seasonal) tariff duties; minimum import prices; and import authorizations which include permits dependent, for example, on the purchase of equivalent quantities of locally

9. The total value of trade affected by most favored nation (m.f.n.) tariff reductions and bindings at prevailing rates amounted to 17.8 percent ($125 billion; billion is 1,000 million) of 1976 imports of the major developed import markets (see GATT 1979, p. 118).

10. For example, about 98 percent of four-digit Customs Cooperation Council Nomenclature (CCCN) product groups face some sort of volume restriction somewhere in the world (UNCTAD 1983b, p. 11).

grown products. Their use is so widespread that they cover 73 percent of imports in Switzerland, 42 percent in Austria and Japan, and 36 percent in Australia.

Even so, agriculture is certainly a case where our indexes underestimate the extent of NTBs. First, we do not account for such measures as quality standards or state trading, which are particularly frequent in agriculture and can restrict imports just as effectively as volume or price measures. Second, existing trade restrictions are quite strenuous[11] and hence tend to push both the own imports and world trade coverage ratios downward; international trade in those agricultural products currently subject to restriction would certainly be considerably greater under free trade.

Textile imports generally face NTBs to the same or a higher degree as does agriculture. Most international trade in textiles and clothing is governed by the MFA, an umbrella Multifibre Arrangement under which voluntary export restraints of varying restrictiveness are negotiated between (industrial country) importers and (developing country) exporters. Countries which do not apply the MFA restrictions resort to other devices. Australia, for example, imposes tariff quotas (with higher rates set at prohibitive levels), Switzerland applies automatic licensing and monitors prices of products from certain suppliers, and Norway implemented global quotas until July 1984, when it introduced MFA measures.

As in the case of agriculture, our indexes probably underestimate the extent of NTBs on textiles. First, textile trade regulations are generally highly restrictive. For example, under the current MFA, the annual growth rate of U.S. imports from Hong Kong is limited to 1.5 percent for textiles and 0.7 percent for clothing, while EEC imports of textiles from Colombia are allowed to grow by 0.3 percent and from Mexico by 0.1 percent. The GATT Textiles Surveillance Body recently concluded that "under MFA III, restraints have been more extensive and in many cases more restrictive [than under MFA II]. Most importing countries, in restraining imports under the MFA, had recourse to extensive invocation of 'exceptional circumstances' or of the need to maintain 'minimum viable production' " (GATT 1984a, p. 10).

Second, volume and price restrictions are frequently accompanied and reinforced by other measures, particularly requirements of origin, which our indexes do not include. Recent instances suggest that these measures are becoming progressively more restrictive; for example, the new Customs Regulating Amendments Relating to Textiles and Textile Products in the United States provide more stringent guidelines for the determination of the origin of textile imports.

Contrary to a popular belief that raw materials are free of trade barriers, mineral fuels are among the product groups most subject to government control. The average own-import coverage ratio for fuels is a high 42.9, which reflects the licensing or quota requirements for all or selected imports of hydrocarbons into Australia, Finland, France, Norway, Switzerland, and the United States.

11. See, for example, Bale and Koester (1983).

For example, in France, petroleum imports are subject to a global quota. In the United States, a license is required for imports of natural gas, petroleum, and all petroleum products. In all these categories, the licensing is "intended to restrict the quantity of imports" (GATT 1983, p. 10) and, in the case of natural gas, to exclude those imports which are not "consistent with the public interest" (U.S. Natural Gas Act 1938, section 3). Because of falling consumption, current petroleum imports are not formally restricted, but the authority to license imports enables government to affect the source and level of petroleum trade; for example, imports into the United States from Libya are prohibited.

The fourth product group strongly affected by nontariff barriers is iron and steel. Iron and steel imports, which were relatively free in the 1970s, have become—in a remarkably short period of time—almost as tightly regulated as the textile trade, particularly in the EEC, the United States, and Australia. These economies shield their structurally ailing iron and steel industries from foreign competition. The EEC closely monitors its imports through a system of automatic licenses "to ensure that traditional trade patterns in steel products are not disturbed" (GATT 1984b, p. 4). A number of voluntary export arrangements limit imports from the major suppliers, and minimum ("basic") import prices are established for selected products.

In the United States, additional duties and a global quota were imposed on the imports of specialty steel in 1983, and subsequently a number of voluntary export restraint (VERs) arrangements have been concluded with major suppliers.[12] For certain carbon and alloy steel products, a maximum level of import penetration was set (18.5 percent) and is enforced by VERs and "surge control" arrangements with major suppliers and countries whose exports have increased rapidly.

In Australia, the Steel Industry Plan provides for an "import watch system" and reviews of levels of protection (which rely on tariffs and bounties) if the domestic producers' market share falls below 80 percent or rises above 90 percent in specified product categories.

A common feature of iron and steel protection is a frequent resort by all the countries to antidumping and countervailing actions. For example, in 1982 149 cases were initiated in the United States, 19 in the EEC, and 13 in Australia (UNCTAD 1984a, p. 8). Antidumping and countervailing duty actions are explicitly provided for in the presidential decision on protection for the U.S. steel industry, while a "fast track dumping mechanism" is one element of the Australian Steel Industry Plan (Australian Industries Assistance Commission 1983–84, pp. 21–27). Both are examples of measures that were established to regulate trade practices being applied to problems of a structural character.

Other product groups are less restricted by NTBs. The relatively high ratios for

12. To "encourage" such agreements, the United States has advised its suppliers that the global quota would be divided between countries which concluded orderly marketing arrangements and that only a small part (about 5 percent) would be left for other producers.

vehicles reflect VERs on Japanese exports and surveillance of car imports in the EEC. Ratios for footwear and electrical machinery are moderate. This latter group includes electronics (particularly from Japan, Republic of Korea, and Hong Kong), which meets increasing restrictions. However, because of the still relatively low value of trade in this category and the selective nature of import restrictions (usually VERs or quotas by country), the ratios for the whole group of electrical products are not large.

Types of Barriers

Table 2 gives the breakdown of NTBs by type. Monitoring measures and quantitative import restrictions are the most pervasive of barriers according to all three indexes. Since these measures are predominantly concerned with the quantity of imports, it seems that quantitative measures outweigh price measures in the set of NTBs we examine.

At a more detailed level, it is obvious that different policies are emphasized in different sectors. Agricultural protection comprises mainly price measures and quantitative restrictions. The former are particularly important in the EEC, where much trade is subject to variable levies, but in other countries direct quantity restrictions are relatively more important. In Japan, for example, more than 46 percent of imports from developing countries are affected; in Switzerland, 47 percent of imports from industrial countries are covered. Manufacturing is primarily protected by quantity and monitoring measures. In Europe, surveillance is common—much of it quite explicitly warning exporters to restrain themselves (see note 2)—but so too are more rigid controls in the form of quantitative restrictions and VERs. The United States's protection of manufacturing, which appears to be both more limited and more subtle, relies almost exclusively on monitoring through mechanisms intended to police trade practices and on voluntary agreements. Japan's manufactured imports appear to face very few barriers of the type discussed here.

Country Comparisons

All three indexes in table 3 point to France, Australia, and Switzerland as the countries where NTBs are most prevalent, while the two coverage ratios are also

Table 2. *The Extent of Industrial Countries' NTBs by Type of Measure, 1983*

Index	*Quantitative import restrictions*	*Voluntary export restrictions*	*Decreed prices*	*Tariff-type*	*Monitoring measures*	*All* NTBs[a]
Coverage ratios:						
Own imports (I_c)	8.6	3.0	1.7	1.3	14.8	27.1
World trade (I_w)	9.5	1.4	3.4	1.6	9.8	21.8
Frequency ratio (I_f)	5.0	3.4	1.7	1.4	4.6	12.8

Note: Sixteen industrial markets, all exporters, all products.

a. This represents the union of the first five columns of the table. The sums of the ratios across groups of measures frequently exceed the totals quoted. This is because individual trade flows are often subject to NTBs of two or more classes. Such flows are counted once for each class and once (only) for the total.

Table 3. *The Extent of Industrial Countries' NTBs by Importing Country, 1983*

Industrial country market	*Coverage ratios* — *Own imports* (I_c)	*Coverage ratios* — *World trade* (I_w)	*Frequency ratio* (I_f)
EEC	22.3	18.9	13.8
Belgium and Luxembourg	26.0	21.0	11.6
Denmark	11.7	13.3	11.4
France	57.1	44.2	24.0
Germany, Fed. Rep.	12.4	14.7	12.5
Greece	13.4	19.0	13.6
Ireland	13.4	13.0	9.1
Italy	6.9	10.0	9.7
Netherlands	25.5	21.4	13.1
United Kingdom	14.3	13.9	13.8
Australia	34.1	44.4	18.3
Austria	4.9	7.5	5.4
Finland	34.9	34.3	13.4
Japan	11.9	9.0	9.3
Norway	5.7	6.1	9.7
Switzerland	32.2	42.9	19.4
United States	43.0	34.3	7.0
All sixteen markets	27.1	21.8	12.8

Note: All products, all exporters, all NTBS.

high for the United States and Finland. However, when fuels are excluded from the product coverage, the United States and Finland shift to the group of countries with small or moderate ratios. Thus, NTBS on fuels are the prime source of their high coverage indexes.

Whether or not restrictions on imports of fuels are taken into account, France, Australia, and Switzerland remain among the countries with the highest NTB ratios. For the first two, this is a reflection of an extensive system of quotas and licensing: about 10 percent of import flows accounting for more than 47 percent of import value face these measures in France, and about 13 percent of import flows or 27 percent of imports in Australia. Quantitative restrictions are also significant in Switzerland (8 percent of import flows, or 12 percent of import value, is subject to these restrictions), but the most extensive barrier is the system of automatic licensing, which covers about 11 percent of Swiss import flows and 32 percent of total imports.

Imports into Austria and Norway appear to face relatively few border NTBS, but both countries apply other trade-restricting measures such as state trading, import charges, technical standards, and direct assistance to several import-competing industries. In addition, Austria maintains relatively high tariff duties.[13]

13. The post–Tokyo Round weighted average ratio for Austria is 10.1 percent compared with a 3.6 percent average for the major developed economies (see Olechowski and Yeats 1982, p. 81).

Table 4. *The Extent of Industrial Economies' NTBs to Exports from Industrial and Developing Economies, 1983*

		Developing economies		
Index	*Industrial economies*	*All*	*Major manufacturing exporters*	*Major borrowers*
Coverage ratio				
Own imports (I_c)	21.0	34.3	26.5	35.4
World trade (I_w)	17.1	27.0	24.6	29.4
Frequency ratio (I_f)	8.8	18.6	18.1	19.4

Note: Sixteen industrial market importers, all products, all selected NTBs.

The NTB ratios are also relatively low for Italy and Japan. Italy appears to apply fewer but tighter border measures than other EEC countries; its frequency ratios consistently and significantly exceed its own-import coverage ratios. Japan, as is well known, is often suspected of using measures not covered in our exercise—for example, testing procedures, restrictions on retail outlets for foreign products, and administrative guidances—to restrict imports.

In comparing the NTB coverage figures between countries, the reader should remember that the information we have measures the *extent* of NTBs and not their restrictiveness. It would be inappropriate to use these figures to argue, for example, that countries with higher indexes "owe" the international community a unilateral "round" of trade liberalization or that a country with a low coverage index is justified in imposing restrictions against its trading partners.

IV. The Extent of NTBs on Exports of Developing Countries

Having discussed the prevalence of NTBs in the aggregate, we now turn to the question of whether NTBs impinge more heavily on the exports of developing countries than on intra-industrial country trade. The indexes in table 4 are aggregates for the sixteen industrial markets for which we have NTB information and present NTB coverage ratios for imports from four groups of exporters—industrial countries, all developing economies, developing economies that are major exporters of manufactures, and developing economies that are major borrowers (these groups are defined in the appendix).

Table 4 shows that NTBs are significantly more prevalent on imports from developing economies than from industrial economies and this is replicated for nearly all individual markets.

Not only the relative but also the absolute extent of NTB coverage is larger in the case of developing economies' products. For example, the value (in 1981 U.S. dollars) of imports from developing economies subject to NTBs is $86 billion compared with $81 billion in the case of imports from industrial countries (Nogués, Olechowski, and Winters 1986).

Another important implication of table 4 is that NTBs are relatively extensive on the exports of the developing economies that are major borrowers. For these

Table 5. *A Comparison of Industrial Economies' NTBs on Agricultural and Manufactured Exports of Industrial and Developing Economies, 1983*

	Industrial economies		*Developing economies*	
Index	*Agriculture*	*Manufactures*	*Agriculture*	*Manufactures*
Coverage ratio				
Own imports (I_c)	40.5	14.5	31.2	21.3
World trade (I_w)	46.1	13.2	30.5	20.5
Frequency ratio (I_f)	31.9	6.7	25.6	17.4

Note: Sixteen industrial markets, all selected NTBs.

economies, all three indexes assume values which are 1–2 percentage points higher than those for all developing economies and 7–8 percentage points higher than those for all exporters. This difference is partly caused by the presence of three large oil exporters (Indonesia, Mexico, and Venezuela) among the major borrowers. However, even if fuels are excluded, the coverage indexes for major borrowers remain higher than those for all developing economies while the frequency ratio is marginally lower.[14] Given that the major borrowers' ability to cope with their current balance of payments difficulties depends to a large degree on their ability to export to the industrial economies, these figures emphasize how closely linked are debt and trade policy issues.

In the case of major exporters of manufactures, the evidence is less clear-cut. It is often alleged that the newly industralized economies are the prime targets of protective actions, but the figures in table 4 do not support this thesis. However, when fuels are excluded, the values of all three indexes for the exporters of manufactures are higher than those for all developing economies.[15] And our analysis, of course, has not considered the comparative effect of tariff barriers.

The structure of the apparent discrimination against developing economies is explored in table 5. It shows that, almost universally, NTBs are less prevalent on industrial economies' imports of agricultural goods from developing economies than on those from other industrial economies, but that the reverse is true for manufactures. Nonetheless, developing economies still generally face more barriers to agricultural exports than to manufactures, and since agriculture accounts for a higher share of imports from developing economies than from industrial ones, agricultural protection still contributes to the differential incidence at the aggregate level. In the manufacturing sector, developing economies face more barriers than industrial ones to their large-volume exports, such as in textiles and footwear, and fewer to their small-volume ones, such as electrical machinery and vehicles.

A striking feature of the restrictions on imports of manufactures from developing economies is the much greater prevalence of VERS than in the case of

14. The respective values are 25.5 (own imports coverage ratio), 24.0 (world trade coverage ratio), and 18.1 (frequency ratio) for major borrowers and 22.4, 22.7, and 18.5 for all developing exporters.

15. They are: 23.8 (own imports coverage ratio), 24.5 (world trade coverage ratio), and 19.4 (frequency ratio).

Table 6. *The Change in the Extent of Industrial Economies' NTBs on Imports from Industrial and Developing Economies*

Index	*All economies*	*Industrial economies*	*Developing economies*
Coverage ratio			
Own imports (I_c)	1.5	2.2	1.1
World trade (I_w)	1.8	2.3	1.1
Frequency ratio (I_f)	0.3	0.1	0.9

Note: Sixteen industrial markets, all products, all selected NTBS, differences between indexes for 1983 and 1981 in percentage points.

imports from industrial ones. For example, the overall world imports coverage ratio of VERS for developing economies' manufactures is 10.9 percent, compared with 0.4 percent for industrial ones, and this pattern is repeated for every market with VERS. While our figures do not reflect the restrictiveness of trade regimes, the evidence of a widespread bias in the application of voluntary export restraints seems overwhelming.

V. The Growth of NTBS

The final issue we examine is the expansion of NTB coverage through time. Table 6 compares the coverage of NTBS in 1981 and 1983. The UNCTAD data base does not provide precise information on the dates of introduction before 1981 and, at the time our investigation was carried out, did not contain data on measures imposed after June 1984.

All three measures indicate that NTBS have encroached further on international trade. For the sixteen markets whose NTBS have been tabulated, there was, between 1981 and 1983, a net increase of 2,486 in the number of NTBS recorded. The NTBS in place in 1983 covered $12.8 billion more of 1981's imports than did those in place in 1981. This additional $12.8 billion which came under NTBS was approximately 1.5 percent of these countries' total imports in 1981 and approximately 6 percent of the value of imports subject to NTBS. Note that these figures refer only to new NTBS and not to any tightening or reinforcement of existing ones.

According to the coverage ratios, the new measures seem to be aimed mostly at imports from the industrial economies.[16] When the coverage and frequency indicators are compared, it appears that new NTBS were imposed on a larger number of small trade flows from developing economies and a smaller number of large flows from industrial ones. This is a reflection of concentration of new NTBS in areas such as iron and steel and electrical machinery, where developing economies are only now entering international trade. This pattern does not mean, however, that developing economies were exempt from the rise in protec-

16. For a description of new NTBS, see UNCTAD (1984, 1985) and IMF (1984).

tionism, for their main exports (such as textiles and clothing) experienced a considerable tightening of the existing restrictions.

VI. Summary and Conclusions

Given the lack of sound empirical evidence on the extent of nontariff barriers, this article has attempted to identify some basic features of the situation. By employing the most comprehensive and detailed existing NTB and trade information and calculating three indexes of the prevalence (but not restrictiveness) of NTBs we have generated the most comprehensive analysis extant.

Four major conclusions emerge from the results. First, the extent of NTBs is indeed large. At least 27 percent of the sixteen major industrial economies' imports, some $230 billion of 1981 imports, would have been covered by one or more of the selected NTBs as they applied in 1983. NTBs are particularly widespread in agricultural products, textiles and clothing, mineral fuels, and iron and steel.

Second, quantitative controls appear to be the most prevalent of individual NTBs—much more so than price controls, which are applied mainly to agricultural imports.

Third, all the measures investigated indicate that NTBs are significantly more prevalent on imports from developing economies than from industrial ones. The NTBs applied in 1983 by the sixteen industrial markets examined here would have covered $86 billion of imports from developing economies and $79 billion of imports from industrial ones if 1981 trade flows remained unchanged. Particularly significant is the higher coverage of the exports of the most heavily indebted developing economies.

In relative terms, developing economies face more barriers than industrial ones in manufactured trade and fewer in agricultural trade. However, developing economies still generally encounter more barriers to agricultural exports than to manufactures, and since agriculture accounts for a higher share of their exports than of industrial economies' exports, protection in this sector contributes to the differential incidence observed at the aggregate level.

Finally, the results provide evidence that the use of NTBs has increased and has done so at a significant pace. In the period from 1981 to 1983, a net increase of 2,486 NTBs covering $12.8 billion of 1981 imports was observed. Since this increase does not reflect the tightening or reinforcement of existing measures, the growth of NTBs and their effect on international trade should be taken very seriously.

Appendix. *Definitions of Product and Country Groups*

Product	*TSUSA*[a] *headings*	CCCN[b] *four-digit headings*
All	10001–87045	0101–9906
All, less fuels	10001–47462, 48005–52121 52141–87045	0101–2604, 2801–9906
Agricultural goods	10001–19324	0101–2402
Manufactured goods	20003–47462, 48005–49520, 53101–54805, 60502–87045	2801–9906
Textiles	30010–39060	5001–6302
Footwear	70005–70095	6401–6406
Iron and steel	60600–61081	7300–7399
Electrical machinery	68205–68847	8501–8528
Vehicles	69202–69260	8701–8714

Economy Groups

Developing economies that are major exporters of manufacturers

Argentina, Brazil, Hong Kong, Israel, Republic of Korea, Philippines, Portugal, Singapore, South Africa, Taiwan, Thailand, Yugoslavia

Developing economies that are major borrowers

Argentina, Brazil, Chile, Egypt, India, Indonesia, Israel, Korea, Mexico, Turkey, Venezuela, Yugoslavia

All had more than $15 billion in long-term debt at the end of 1983.

Industrial and developing countries

World Bank definitions (World Bank 1984), except that Greece is transferred from developing to industrial countries because its trade policy is determined with that of other industrial countries in the EEC.

a. Tariff Schedules of the United States, Annotated.

b. Customs Cooperation Council Nomenclature.

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