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Terms of Trade of Developing Countries: What the Long Run Shows**

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Primary Commodity Prices, Manufactured Goods Prices, and the Terms of Trade of Developing Countries: What the Long Run Shows

Enzo R. Grilli and Maw Cheng Yang

The authors revisit in this article the empirical foundation of the alleged secular decline in the prices of primary commodities relative to those of manufactures. They use a newly constructed index of commodity prices and two modified indexes of manufactured good prices, and find that from 1900 to 1986 the relative prices of all primary commodities fell on trend by 0.5 percent a year and those of nonfuel primary commodities by 0.6 percent a year. They thus confirm the sign, but not the magnitude, of the trend implicit in the work of Prebisch. But even the more limited secular decline shown by their relative price indexes may be magnified by an incomplete account of quality improvements in manufactures. They then show that the evolution of the terms of trade of nonfuel primary commodities is not the same as that of the net barter terms of trade of non-oil-exporting developing countries. Finally, they find that despite the decline that has probably occurred during the current century in the terms of trade of nonfuel primary commodities, the purchasing power of total exports of these products has increased considerably. Similarly, the fall that may have occurred after World War II in the net barter terms of trade of developing countries seems to have been more than compensated for by the steady improvement in their income terms of trade.

An important focus of the analysis of commodity price movements has been on the distribution of gains from commodity production between producers and consumers. Transposed to the international domain, this type of analysis has focused on the long-term movements in the net barter terms of trade of developing countries, taken as an indicator of the distribution of gains from trade between commodity producers in developing countries and commodity consumers in industrial countries. Alternatively, and sometimes at the cost of some confusion, attention has been placed on the long-term trends in the prices of

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internationally traded primary commodities relative to those of manufactured products.

The contours of the controversy about the alleged long-term deterioration in the (net barter) terms of trade of developing countries, which was generated by the early work of Prebisch and Singer, are too well known to need another review here (see United Nations 1949; Prebisch 1950; Singer 1950; Lewis 1952; Viner 1953; Kindleberger 1956; Ellsworth 1956; Baldwin 1955, 1966; Morgan 1959; Meier 1958, 1963; Maizels 1970; Streeten 1974; Ray 1977; Macbean and Balasubramanyan 1978; and Kravis and Lipsey 1974, 1981). The empirical evidence available so far on the long-term movements in the prices of primary and manufactured products has also been recently revisited (Spraos 1980 and Sapsford 1985).

However, a common problem of the analyses that have focused on the long-run trends in the terms of trade of developing countries, or on the long-run trends in the relative prices of primary commodities, has been the inadequacy of the basic price data. Long-term movements in the terms of trade of developing countries were either inferred from those of certain industrial countries or from the movements in the prices of primary commodities relative to those of manufactured products (the so-called primary commodity terms of trade) without accounting for changes in the volume or composition of exports of the developing countries. Both practices obviously suffer from serious shortcomings. Yet instead of generating caution, the paucity of the available empirical evidence generated a tendency in the opposite direction: strong conclusions were derived from evidence that was weak in both accuracy and economic significance.

In this article we attempt, first of all, to solidify the empirical evidence on the prices of internationally traded goods, with special attention to nonfuel primary commodity prices. We go on to examine the long-run movements in the prices of nonfuel commodities relative to those of manufactures. We then investigate the statistical relationship between the movements in the relative prices of nonfuel primary commodities and those in the net barter terms of trade of developing countries at the aggregate, regional, and country levels. We also look at the evidence on the long-term movements in the purchasing power of total primary commodity exports (and in the income terms of trade of developing countries after World War II) to put in perspective the question of the gains from trade accruing to developing countries that depend on nonfuel primary commodities. We finally examine the various possible effects of growth on the relative prices of primary commodities. In this context, we review the theoretical and empirical validity of the classical economists' argument on the long-run movements in the "real prices" of primary products.

I. EXISTING AND NEW EVIDENCE ON LONG-TERM COMMODITY PRICE MOVEMENTS

There are several indexes of nonfuel commodity prices, but only the *Economist* Index (EI) and the W. A. Lewis Index (WALI) cover a sufficient amount of

time to be useful in analyzing commodity price movements in the long run (Lewis 1952; and *The Economist* 1974).¹ Both indexes, however, suffer from considerable drawbacks. The commodity coverage of the EI has been revised several times in its long history, and its weights reflect the relative values of commodities in the import trade of industrial countries. The WALI stops in 1938 and, instead of international market quotations, is based on export unit values of selected countries. The EI, moreover, does not include fuel prices, whereas the WALI does.

The available empirical evidence on long-term movements in the prices of manufactured goods is also limited. There is an index prepared by W. A. Lewis (WALI2) that goes back to 1870, but it has two gaps, which roughly correspond to the two world wars (Lewis 1952). Another index, constructed by Maizels (AMI), covers about the same period as the WALI2, but it is reported only as averages of selected subperiods (Maizels 1970). There is, finally, the possibility of constructing yet another index from U.N. sources (Manufacturing Unit Values, United Nations; MUVUN) covering the period after 1900, but there are two gaps in this index for 1914–20 and 1939–47 (United Nations 1969, 1974). All these indexes are based on unit values of exports for a selected number of industrial countries.

Confronted with the alternative of recomputing the EI on a different weight system and with uniform commodity coverage over time or of computing a new index of nonfuel commodity prices, we chose the second and built a U.S. dollar index of prices of twenty-four internationally traded nonfuel commodities, beginning in 1900 (figure 1). The basic version of this new index (Grilli-Yang Commodity Price Index; GYCPI) is base-weighted, with 1977–79 values of world exports of each commodity used as weights.² It therefore reflects the movements over time of the international prices of a given basket of primary commodities. We computed three additional versions of this index. The first two (GYCPI' and GYCPI'') differ from the basic version in the weighting systems used to construct them, whereas the third (GYCPI''') is also different in commodity coverage, as fuels are included in the sample (Grilli and Yang 1987).

Given the impossibility of computing a new price index of manufactures going back to 1900, we opted for a modified version of the MUVUN, constructed by filling its two gaps by interpolation, using export and import unit values of manufactured goods of the United States and the United Kingdom as indicators.³ The modified U.N. index (MUV) reflects the unit values of exports of

1. The *Economist* Index begins in 1860 and is regularly updated and reported by the compiler. See, for example, *The Economist*, March 2, 1964, and September 6, 1973. The W. A. Lewis Index of commodity prices starts in 1870 and goes up to 1938. It is largely based on price data reported by Schlote (1938), complemented by data from the League of Nations (1945). A more complete analysis of these indexes is in Grilli and Yang (1987).

2. This new index covers the prices of 54 percent of all nonfuel commodities traded in the world in 1977–79 (49 percent of all food products, 83 percent of all nonfood agricultural products, and 45 percent of all metals). The GYCPI and its components are shown in appendix I.

3. For the years 1915 to 1920, the interpolation was made by first regressing the MUV index (in percentage terms) on the index of export and import unit values of manufactures of the United States and

Figure 1. *Index of Nonfuel Primary Commodity Prices (GYCPI), 1900-86*

Source: Appendix I.

manufactures of a number of industrial countries. It has variable weights that reflect the relative importance of the various types of manufactures in international trade. These were updated every five to seven years until 1938 and changed again in 1959, 1963, 1970, 1975, and 1980 (United Nations 1969, 1972, 1976, 1982, and 1987).

In addition to this index of unit values of manufactures exported by industrial countries, we derived an index of domestic prices of manufactured products in the United States (United States Manufacturing Price Index; USMPI) by netting out energy, timber, and metal prices from the U.S. wholesale price index of industrial commodities (USMPIO) to eliminate overlap with goods in primary commodities indexes and rescaling it (Grilli and Yang 1987). This index is also useful as a reference, for it gives an idea of the relationship between prices and unit values of exports that existed over time and of the reasonableness of the results obtained from the interpolation procedure used to fill the gaps in the MUVUN. These two indexes of manufactured goods "prices" show a very close trend growth from 1900 to 1986 equal to 2.49 percent a year for the MUV and 2.48 percent a year for the USMPI (figure 2).⁴ The MUV, however, is slightly more erratic than the USMPI. Its average percentage deviation from trend over the 1900–86 period is 6.2 percent, whereas that of the USMPI is 5.1 percent.

The USMPI and MUV were used to compute two sets of relative prices (or "real" prices) of nonfuel primary products from 1900 to 1986. Measuring, for example, the long-term movements in the relative prices of nonfuel commodities in terms of a wholesale price index or in terms of an index of unit values of trade of manufactures obviously carries different meanings. The first set of relative prices (GYCPI/USMPI) measures the evolution of the purchasing power of nonfuel primary commodities in terms of a basket of tradable goods valued at domestic prices.

In open economies, wholesale price trends should reflect rather closely those of the international prices of the same products. This should be even more so when the time period under consideration is long enough to accommodate possible short-run deviations in the movements of tradable versus nontraded goods prices. Yet, how far one can rely on the law of one price through time is still an open question, given the obstacles to free trade in manufactures that have existed (and still exist) and the possibility that producers of manufactures facing different market conditions domestically and abroad can successfully and persistently employ price discrimination across markets. In our use of the USMPI, the degree of openness of the U.S. economy could also be considered insufficient to

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the United Kingdom (in percentage terms) obtained by averaging the subindexes and then by extrapolating the values of the MUV index on the basis of the estimated equation. For the years 1939 to 1947, the interpolation was made using the same procedure, but the MUV was regressed only against the index of import and export unit values of manufactures of the United States.

4. These are semilog trends, corrected for serial correlations using a maximum-likelihood procedure. Both are statistically significant at the 5 percent confidence level or above.

Figure 2. *Indexes of Manufactured Goods Prices (MUV and USMPI), 1900–86*

Source: Appendix I.

warrant the use of U.S. tradable goods prices as proxies for internationally traded goods prices. In making this choice we have “traded off” in favor of an index (USMPI) with a coverage of manufactured goods prices which could be carefully checked and sufficiently narrowed to allow a clear differentiation between the two baskets of goods of which the relative prices were to be measured (nonfuel primary commodities and manufactures). This would not have been possible if we had chosen instead the U.K. wholesale price index because of the greater openness of the U.K. economy.

The second set of relative prices ($GYCPI/MUV$) measures the evolution of the purchasing power of a basket of nonfuel primary commodities in terms of traded manufactures, valued at “international prices.” This type of measurement raises questions about the representativeness of trade unit values as proxies for international prices. In addition, the meaning of the time movements of the ratio of primary commodities and manufactures prices is clouded by the fact that technical progress may have differential effects on the price trends of the two types of goods.

The basic issues are quite familiar. They have to do with the appropriate construction of trade unit values, and how to adequately account for the introduction of new items in the basket of traded manufactures and the “upward bias” carried by manufactured good prices or unit values whenever they incorporate the effects of technical progress that significantly improves their quality (Viner 1953; Baldwin 1955, 1966; Meier 1958, 1963; Morgan 1959; Kravis and Lipsey 1974, 1981). In comparing primary commodities and manufactured goods prices over time, the measurement risks are those implicit in the nonhomogeneity of the two sets of prices and of the two baskets of goods of which the prices are measured. These issues deserve attention, and we will return to them in the last section of this article.

Finally, neither set of relative prices that we have calculated can be taken as an adequate proxy of the net barter terms of trade of developing countries (P_x/P_m), because the total price index of exports of developing countries (P_x) contains more than primary commodities and the total price index of imports of developing countries (P_m) contains more than manufactures. In addition, the trend shown by any index of the net barter terms of trade should not be taken, in itself, as an adequate indicator of the real income effects of trade over time. A negative trend would not automatically mean that real income has also fallen in time. The sign of the income effect would in fact depend not only on the reasons for the decline in the net barter terms of trade, but also on what happened to the purchasing power of total exports. The latter, moreover, should not be mistaken for the purchasing power of a given basket of exports. To reflect the real income effects of trade, one has to account simultaneously for the movements in the relative prices of exports and for the quantity of exports. The income terms of trade ($P_x Q_x/P_m$) is a measure of this type that reflects the purchasing power of total exports in terms of imports.

II. LONG-TERM TRENDS IN THE RELATIVE PRICES OF NONFUEL PRIMARY COMMODITIES: THE MAIN AGGREGATES

Since 1900 nonfuel commodity prices seem to have declined substantially relative to those of manufactured goods sold in the United States, as well as to those of manufactured goods exported by industrial countries. The GYCPI/USMPI series shows a negative exponential trend of 0.57 percent a year over the 1900–86 period. The GYCPI/MUV series shows a trend decline of 0.59 percent a year over the same period (table 1).

Reweightings the GYCPI (still on a 1977–79 basis) to account specifically for the importance of developing countries in world trade of nonfuel primary commodities yields a new index (GYCPI') that does not differ significantly from the original one. The weights in GYCPI' are the value share of developing countries' exports of each commodity, instead of the value shares of world exports of each commodity. The purchasing power of the basket of nonfuel primary commodities exported by developing countries measured by the GYCPI' /MUV appears to have fallen on trend by 0.67 percent a year since 1900. If the GYCPI' /USMPI is taken as a measure, the trend decline is 0.66 percent a year.

A further check on the tracking stability of our original index was conducted by recomputing it using as weights the value shares of commodities in world

Table 1. *Aggregate Trends in the Relative Prices of Primary Commodities, 1900–86*

Relative price index		Intercept ($\hat{\alpha}$)	Coefficient of time ($\hat{\beta}$)	Regression statistics ^a			
				R ²	SEE	F	DW
ln GYCPI/MUV	=	4.9810* (67.7)	–0.00589* (–4.11)	0.82	0.11	394.9	1.74
ln GYCPI/USMPI	=	4.7554* (41.9)	–0.00567* (–2.60)	0.81	0.10	359.1	1.38
ln GYCPI' /MUV	=	4.9650* (46.6)	–0.00669* (–3.23)	0.77	0.13	282.2	1.94
ln GYCPI' /USMPI	=	4.7526* (31.2)	–0.00665* (–2.29)	0.75	0.12	253.9	1.61
ln GYCPI'' /MUV	=	5.1249* (65.4)	–0.00669* (–4.38)	0.80	0.12	332.3	1.71
ln GYCPI'' /USMPI	=	4.8889* (44.4)	–0.00629* (–2.96)	0.79	0.11	314.7	1.39
ln GYCPI''' /MUV	=	5.0057* (48.4)	–0.00518* (–2.58)	0.74	0.13	242.6	1.52
ln GYCPI''' /USMPI	=	4.7821 (32.3)	–0.00501* (–1.77)	0.74	0.12	236.6	1.25

t values in parentheses.

* = significant at the 10 percent confidence level or above.

Note: The estimated model is $\ln \text{GYCPI}_t = \alpha + \beta t_t + u_t$, where t_t is a time trend. All time series are trend-stationary; ordinary least squares (OLS) estimates are based on annual data. A maximum-likelihood procedure was used to correct for serial correlation.

a. SEE = standard error of the estimate. DW = Durbin-Watson statistic.

trade in 1913, 1929, 1937, 1959, 1963, 1970, 1975, and 1980. These different weights closely reproduce those of MUV. Using this new index (GYPCI'') based on given-year weights, one finds that the purchasing power of nonfuel primary commodities in terms of manufactures declined since 1900 at an annual rate of 0.63 percent to 0.67 percent depending on whether the USMPI or MUV is used as a measure of manufactured goods prices.

Finally, if one includes fuel prices in the index of primary commodities (GYCPI'''), using the same variable weights as in the GYPCI'' to account for the considerable changes that have intervened over time in the relative importance of fuels in world trade, the rate of decline in the prices of *all* primary commodities relative to those of manufactures (GYCPI''' / MUV) becomes 0.52 percent a year. The inclusion of coal and oil prices in the basket of primary commodities for which prices are tracked over time does not change the sign of the trend shown by this index relative to that of unit values of manufactures. The relative prices of *all* primary commodities appear to have fallen on trend since 1900 at only a slightly less rapid rate than those of nonfuel commodities.

The trend rate of decline in GYCPI''' / MUV is closer in absolute value to that of the W. A. Lewis indexes (WALI1 / WALI2) for 1871–1938 (0.46 percent a year) than to that implicit in the Prebisch data for 1876–1938 (0.95 percent a year). The original U.N. series, which covers prices of “other goods” (including fuels) in addition to the prices of manufactures, shows in turn a trend rate of decline in the relative prices of these other goods (0.73 percent a year) that falls between that of the GYCPI''' / MUV and the Prebisch index (W. A. Lewis 1952; Prebisch 1950; and United Nations 1969). Our results therefore strongly support the inference made by Spraos (1980) about Prebisch’s original data: the price series he used exaggerated the adversity of the trends in the relative prices of all primary products. Yet our data indicate, from the beginning of the present century to date, a cumulative trend fall of about 40 percent in the market prices of nonfuel primary commodities relative to those of manufactured products and a cumulative trend decline of about 36 percent in the market prices of all primary commodities.⁵

A question that naturally arises is whether the exponential time trends that we computed can be considered acceptable measures of the underlying long-term trends. There is no rigorous answer to this question. Yet at least three sets of issues need to be addressed. The first regards the specification of the time regression model that we used, and the statistical acceptability of the estimates derived from it; the second pertains to the stability over time of the estimated time trend coefficients; the third has to do with the “legitimacy” of the starting point.

As shown by Nelson and Kang (1983), the use of time as an independent variable in regression models is not appropriate when the dependent variable

5. The cumulative decline for the various relative price indexes for 1900–86 are: GYPCI/MUV, 39.8 percent; GYPCI/USMPI, 38.7 percent; GYCPI' / MUV, 43.9 percent; GYCPI' / USMPI, 43.6 percent; GYCPI'' / MUV, 43.4 percent; and GYCPI''' / MUV, 35.6 percent.

follows a difference-stationary process (DSP). Conversely, it is appropriate when the dependent series follows a trend-stationary process (TSP). We used a test suggested by Dickey and Fuller (1979) to verify the trend stationarity of our relative price series and found them belonging to a TSP. The (semilog) time regression model that we used thus is correctly specified in all cases and the standard tests can be performed to judge the statistical significance of the estimated time coefficients.

First-order serial correlation, however, was to be consistently present in all the estimated time regressions. It would be expected in the price series under review, insofar as they reflect the influence of random factors (such as the two world wars, several local wars, periods of droughts affecting agricultural prices) spread over several years. We corrected for it using a maximum-likelihood procedure. The time coefficients of the regression models in their corrected version (shown in table 1) maintain statistical significance, whereas the standard error of the estimate (SEE), the F , and Durbin-Watson (DW) statistics of the regressions improve substantially with respect to the results obtained from the regressions uncorrected for serial correlation.

The second set of issues that remains to be dealt with pertains to the validity of the assumption of continuous and constant trend growth implicit in the exponential time models that we estimated. The possibility that the negative growth path shown, for example, by the $GYCPI/MUV$ or by $GYCPI'''/MUV$ may not have remained constant over time cannot be ruled out by simply looking at the statistical significance of its ordinary least-squares (OLS) estimates.

Examination of the residuals of the semilog time regressions, as well as a priori knowledge of the exogenous factors that may have caused a structural break in the price series, indicated the possibility of breaks at three points in time: 1921, 1932, and 1945, three of the troughs shown by the series. Various tests were performed to check on the stability of the estimated time coefficients of the $GYCPI/MUV$ and $GYCPI'''/MUV$ regressions.

First we tested for shifts in the slope and the intercept of the estimated time trends using a dummy variable procedure suggested by Gujarati (1970a, 1970b). Then we tested for the possibility of a change in slope, assuming no discontinuity in the time trend, by using the piecewise regression procedure suggested by Suits, Mason and Chan (1978) to estimate the time trend of the $GYCPI/MUV$ and $GYCPI'''/MUV$. The models used and the results obtained are shown in appendix II. The main conclusion from this analysis is that no clear break seems to have occurred since 1900 in negative trends shown by the indexes of the relative prices of either nonfuel or all primary commodities.

The third set of issues has to do with the "legitimacy" of the starting point (the year 1900) of our estimated long-term trends. The cyclical instability in commodity prices is significantly greater in the first forty years covered by our series than in the subsequent ones. World War I and the great economic depression of the early 1930s seem to have generated such strong cycles in commodity prices that fitting a trend to these prices beginning in 1900 may lead to results that are largely dependent on starting points.

Given the nature of the problem, the usual empirical rule that is applicable is to extend the data sample backward. This option was precluded to us, for the range of price data necessary to do so is not available. A check on the trend of individual price series that go beyond 1900 would seem to indicate that, with very few exceptions, our starting year was quite appropriate. Yet we conducted a further check by comparing the estimated price trends of the $GYCPI/MUV$ and $GYCPI'''/MUV$ with those of the two available commodity price indexes that go beyond 1900: the EI and $WALI1$, deflated by a common index of manufactured goods prices—the $WALI2$ (figure 3).

This double comparison is necessary because the $GYCPI$ and EI do not include the prices of fuels, whereas the $GYCPI'''$ and $WALI1$ include them. Over the 1870–1900 period, the annual trend of $EI/WALI2$ is 0.48 percent, whereas that of $WALI1/WALI2$ is 0.52 percent. These trends compare quite closely with those respectively shown by $GYCPI/MUV$ (0.59 percent) and $GYCPI'''/MUV$ (0.51 percent) over the 1900–86 period. Although not conclusive per se, these comparisons of price tendencies before and after 1900 tend to support the notion that the trends in the prices of primary commodities relative to those of manufactured products that we computed after 1900 should not have been much affected by their starting years.

III. LONG-TERM TRENDS IN THE RELATIVE PRICES OF THE PRINCIPAL NONFUEL COMMODITY GROUPS

Taking advantage of the possibility of breaking the $GYCPI$ into its three main components (food prices— $GYCPIF$, nonfood agricultural raw material prices— $GYCPINF$, and metal prices— $GYCPIM$), we computed the trends in the prices of these subcategories of nonfuel commodities relative to those of manufactures. Our results show that over the 1900–86 period the decline in relative prices of nonfuel commodities was not uniform across commodity groups (table 2). Metal and nonfood agricultural product prices (relative to MUV) show a much stronger long-term trend rate of decline than agricultural food prices (0.82 percent and 0.84 percent respectively, versus 0.36 percent a year). Thus, not all producers of nonfuel primary commodities experienced the same falling trend in the purchasing power of a given volume of their products over the past eighty-six years. The export product mix has made some significant difference (figures 4–7).

But there are further significant differences. The negative trend in the $GYCPIF/MUV$ is the composite of a strong positive trend (0.63 percent a year) in the relative price index of tropical beverages ($GYCPIBEV/MUV$, comprising coffee, cocoa, and tea), and of a negative trend of similar magnitude (0.54 percent a year) in the relative price index of agricultural food products strictly defined ($GYCPIOF/MUV$) (table 2). The relatively larger weight of other food in the aggregate index ($GYCPIF$) swamps the effect of secularly rising prices of tropical beverages (especially coffee and cocoa) relative to those of manufactured products. Among all the subcategories of nonfuel commodities, tropical beverages are the only one showing rising relative prices over time. This contrasts rather clearly

Figure 3. *Linked Indexes of Relative Prices of Primary Commodities, 1870–1986*

Sources: Lewis (1952); *Economist* (1974); Grilli and Yang (1987).

Table 2. *Trends in the Relative Prices of the Principal Nonfuel Primary Commodity Subgroups, 1900–86*

Relative price index	Intercept ($\hat{\alpha}$)	Coefficient of time ($\hat{\beta}$)	Regression statistics			
			R ²	SEE	F	DW
Food:						
ln GYCPIF/MUV	4.8328* (57.5)	-0.00357* (-2.17)	0.72	0.13	215.5	1.73
Nonfood						
agricultural:						
ln GYCPINF/MUV	5.1259* (55.9)	-0.00817* (-4.57)	0.78	0.12	306.3	1.74
Metals:						
ln GYCPIM/MUV	5.1214* (34.7)	-0.00841* (-2.98)	0.77	0.12	286.2	1.52
Food:						
ln GYCPIF/USMPI	4.5973* (39.7)	-0.00320 (-1.43)	0.72	0.13	214.8	1.46
Nonfood						
agricultural:						
ln GYCPINF/USMPI	4.8933* (38.2)	-0.00777* (-3.15)	0.77	0.12	276.7	1.56
Metals:						
ln GYCPIM/USMPI	4.9129* (28.4)	-0.00820* (-2.50)	0.76	0.12	264.6	1.49
Tropical beverages:						
ln GYCPIBEV/MUV	3.7192* (26.20)	0.00630* (2.29)	0.50	0.17	84.8	1.75
Nonbeverage Foods:						
ln GYCPIOF/MUV	5.0642* (53.08)	-0.00543* (-2.92)	0.70	0.15	198.2	1.63
Cereals:						
ln GYCPICE/MUV	5.2782* (56.33)	-0.00683* (-3.74)	0.71	0.15	193.8	1.64
Tropical beverages:						
ln GYCPIBEV/USMPI	3.4880* (21.83)	0.00678* (2.20)	0.51	0.17	84.5	1.74
Nonbeverage foods:						
ln GYCPIOF/USMPI	4.8280* (38.58)	-0.00506* (-2.09)	0.70	0.14	194.1	1.38
Cereals:						
ln GYCPICE/USMPI	5.0320* (45.23)	-0.00620* (-2.87)	0.69	0.15	186.5	1.46

t values in parentheses.

* = significant at the 10 percent confidence level or above.

Note: The estimated model is $\ln \text{GYCPI}_i = \alpha + \beta t_i + u_i$, where t_i is a time trend. All time series are trend-stationary; OLS estimates are based on annual data. A maximum-likelihood procedure was used to correct for serial correlation.

Figure 4. *Indexes of Relative Prices of Nonfuel Primary Commodities, 1900-86*

Source: Appendix I.

Figure 5. *Indexes of Relative Prices of Food Commodities, 1900–86*

Source: Appendix 1.

Figure 6. *Indexes of Relative Prices of Nonfood Agricultural Commodities, 1900–86*

Source: Appendix I.

Figure 7. *Indexes of Relative Prices of Metals, 1900-86*

Source: Appendix I.

with the behavior of the relative price index of cereals (GYCPICE/MUV, comprising wheat, maize, and rice), which exhibits a long-term falling trend (table 2 and figures 8–10). To gauge the economic significance of these relative price trends, it should be recalled that developing countries are the sole exporters of tropical beverages but are large net importers of most other foods, particularly cereals. Therefore, in drawing inferences between the trends in the purchasing power of commodities and the net barter terms of trade of developing countries, considerable care must be exercised, even when commodity prices are broken down into various subgroups and examined at a fairly high level of disaggregation.

Unlike food prices, whose trends have to be interpreted with great care, nonfood agricultural commodity prices appear to have fallen strongly and steadily relative to internationally traded manufactures. Developing countries are large net exporters of these commodities. Since 1900, the purchasing power of these products in terms of manufactures has fallen on trend by more than 50 percent. The rather devastating effect of synthetic product substitution on the prices of nonfood agricultural raw materials also becomes evident if one looks at the trend over the 1953–86 period (figure 6). It was in the mid-1950s that petroleum-based synthetic products began to exercise strong downward pressure on natural rubber and natural fiber prices (cotton, jute, wool). This pressure continued throughout the 1960s, and contrary to widely held expectations, the two oil shocks of the 1970s do not seem to have significantly modified the falling trend in the prices of nonfood agricultural commodities relative to those of manufactures.

The negative trend present in the relative prices of metals from 1900 to 1986, however, is not uniform over time. A clear break in the price trend occurs in the early 1940s (figure 7). Developing countries are large net exporters of minerals and metals, even though these commodities are also exported in large amounts by resource-rich industrial countries, such as Australia, Canada, and the United States. From 1900 to about 1941, the GYCPIM/MUV shows a strong negative trend (1.7 percent a year). Between 1942 and 1986 the trend turns positive (0.5 percent a year). The rising trend of the GYCPIM/MUV after 1941 was even stronger until the early 1970s. During a period of more than thirty years, metal producers seem to have been able to capture, in terms of realized prices, a good deal of the benefits deriving from the productivity gains that were achieved. And these have been considerable, at both the extraction and refinery stages (Kendrick 1961).

Seen against the rise in productivity realized in the past half-century, this increase in the “real” prices of metals implies rather clearly the existence of effective forms of market control by producers. The market power of the few multinational corporations that long dominated the production, smelting, and primary processing of many metals seems to have been brought to bear quite effectively. However, the weakening in the role played by multinational corporations in the production of metals relative to that of newly formed national companies that has occurred since the late 1960s may have already changed, at least in part, this historical pattern.

Figure 8. *Indexes of Relative Prices of Beverages, 1900–86*

Source: Grilli and Yang (1987).

Figure 9. *Indexes of Relative Prices of Food Products (Excluding Beverages), 1900–86*

Source: Grilli and Yang (1987).

Figure 10. *Indexes of Relative Prices of Cereals, 1900–86*

Source: Grilli and Yang (1987).

The expansion in the number of independent producers (often state-owned companies in developing countries) has in itself complicated the global supply management problem.⁶ The divergent productive strategies often pursued at the national level have further increased the difficulties faced by producers in keeping an effective hold on the market. What probably used to be a game quietly and effectively played by a few decisionmakers has now become a semipublic international political affair. The case of copper is highly representative of this trend. The weakening in the real prices of metal that has become evident in the mid and late 1970s is in part the reflection of this reduced ability of metal suppliers to influence the markets.

IV. COMMODITY PRICES AND TERMS OF TRADE OF DEVELOPING COUNTRIES

As previously indicated, the trend decline in the relative prices of primary commodities that seems to have occurred from 1900 to 1986 cannot be taken without qualification as a proxy for the evolution of net barter terms of trade of developing countries during the same period. This is the case, quite apart from the possibility that the decline in either the $GYCPI/MUV$ or the $GYCPI''/MUV$ may be overstated, given that some of the increase in the MUV may be caused by new manufactured products entering international trade or by improvements in the quality of existing ones. Developing countries, aside from exporting primary commodities and importing manufactures, have traditionally also exported manufactures and imported primary commodities. Moreover, the share of manufactures in the exports of developing countries has increased substantially over the years, going from an estimated 3.7 percent in 1899 to 21.1 percent in 1979 (Grilli 1982).

Statistical evidence relative to the post-World War II period shows, for instance, that the net barter terms of trade of non-oil-exporting developing countries are positively related to the ratio of prices of nonfuel commodities and manufactures ($GYCPI/MUV$) and are negatively related to the ratio of prices of oil and manufactures ($OILP/MUV$). The net barter terms of trade of non-oil-exporting developing countries improve on average when nonoil commodity prices rise, relative to manufactured good prices, and worsen when oil prices go up relative to those of manufactures, but the partial elasticity of the net barter terms of trade with respect to the $GYCPI/MUV$ is only a fraction of one. The estimated relationships for various periods after 1950 are shown in table 3.

On the basis of the results obtained for the aggregate of developing countries from 1953 to 1983, the only period for which data on developing countries' terms of trade are available, the observed 40 percent decline in the relative prices of their nonfuel primary commodities since the turn of the century would imply,

6. Supply diffusion was helped by the breaking up of vertical integration in the industry after the first oil shock of 1973 and by the "security of supply" policies followed by large industrial countries. Japan, for example, encouraged through government finance the entry of new quasi-independent suppliers of metals in developing countries. We are indebted to Kenji Takeuchi for bringing this point to our attention.

Table 3. *Commodity Prices and Terms of Trade of Non-Oil-Exporting Developing Countries: Regression Results*

Group of countries, continent, or country	Constant term ($\hat{\alpha}$)	Coefficient		Regression statistics				Years
		GYCPI	OILP					
		MUV ($\hat{\beta}$)	MUV ($\hat{\gamma}$)	R ²	SEE	DW	Rho	
TOT: all								
non-oil-exporting	3.6301* (10.4)	0.2786* (3.55)	0.0890* (-4.05)	0.82	0.036	1.45	0.73	1953-83
	3.5382* (8.63)	0.3125* (3.37)	0.1009* (-4.22)	0.82	0.039	1.60	0.63	1965-83
TOT: Africa	3.0006* (7.03)	0.4033* (3.98)	0.0957* (-2.41)	0.88	0.046	1.62	0.91	1955-83
	2.7077* (4.46)	0.5472* (3.98)	0.1569* (-5.19)	0.87	0.047	1.42	0.54	1965-83
TOT: Southeast Asia ^a	2.4243* (4.11)	0.5691* (4.27)	0.1599* (-3.80)	0.92	0.061	1.84	0.80	1955-83
	3.7206* (7.27)	0.3409* (3.02)	0.1400* (-6.92)	0.88	0.035	1.73	0.38	1965-83
TOT: Latin America ^b	3.4199* (6.11)	0.3681* (2.72)	0.1764* (-2.22)	0.85	0.056	1.11	0.89	1965-83
TOT: Korea	5.8968* (21.3)	0.1807* (-2.98)	0.1354* (-12.7)	0.96	0.026	1.90	0.36	1965-83
TOT: Yugoslavia	5.2472* (34.8)	0.1224* (-3.49)	0.0243* (-5.36)	0.79	0.015	1.77	—	1965-83
TOT: India ^c	5.1586* (7.76)	0.0863 (0.56)	-0.1851* (-6.04)	0.80	0.056	1.49	0.48	1953-80

t values in parentheses.

* = significant at the 10 percent confidence level or above.

— Uncorrected.

Note: The estimated model is $TOT_i = \alpha + \beta (GYCPI/MUV)_i + \gamma (OILP/MUV)_i + u_i$, where TOT_i = terms of trade of country(ies)/continent; $GYCPI/MUV_i$ = prices of nonfuel commodities relative to those of manufactures; and $OILP/MUV_i$ = prices of oil relative to those of manufactures. OLS estimates are based on annual data; Cochrane-Orcutt serial correlation correction is used throughout. Equations are estimated in the levels of logarithms of all the variables. Country definitions and TOT data are from IMF *International Financial Statistics and Supplements on Trade and Prices*. "Korea" refers to the Republic of Korea.

a. Southeast Asia includes Malaysia, Philippines, Sri Lanka, and Thailand (recomputation of regional TOT index follows IMF weighting procedures).

b. Latin America includes Central America as well as South America. Data on TOT for Latin America are available only from the early 1960s onward and cover uniformly only a selected number of countries. No regression starting from the 1950s could be estimated as in the case of Africa, Southeast Asia, and all non-oil-exporting developing countries. A dummy variable for the 1976-77 coffee boom years was used in the regression. It has the right sign, and it is statistically significant.

c. India TOT data are available only to 1980. A dummy variable for the 1977 boom in tea prices was used in the regression. It has the right sign, and it is statistically significant.

other things being equal, a cumulative decline in non-oil-exporting developing countries' terms of trade of about 11 percent. Yet although there is no a priori reason to think that the set of statistical relationships bearing on the determination of net barter terms of trade of developing countries may have differed between the pre- and the post-World War II periods, the relative importance of

the individual components of these movements has probably changed over time in a manner which suggests that these results may understate the extent of the decline in the terms of trade over the earlier period. The post-World War II period did witness the sharpest increase in the relative importance of manufactured products in the total exports and of oil in the total imports of non-oil-exporting developing countries. In previous years, when dependence on nonfuel primary commodity exports and manufactured product imports was more pronounced, the nexus between net barter terms of trade and nonfuel commodity prices might have been stronger (that is, the value of $\hat{\beta}$ for all non-oil-exporting developing countries in table 3 might have been higher than 0.28). Over the entire 1900–86 period the cumulative decline in non-oil-exporting developing countries net barter terms of trade corresponding to a 40 percent decline in the GYCPI/MUV may therefore have been greater than 11 percent, but in any case a fraction of the measured cumulative trend decline in GYCPI/MUV .

If we restrict our attention to the 1953–83 period, our analysis shows that non-oil-exporting commodity price changes remained an important influence on the net barter terms of trade of African and Southeast Asian countries, but were less important in the case of Latin American countries (table 3). Moreover, although the relative importance of nonoil commodity prices seems to have increased in recent years in the case of Africa, the opposite seems to have occurred for Southeast Asia. For Southeast Asian countries, which succeeded in diversifying their exports into manufactures, changes in nonfuel commodity prices are becoming a less important determinant of their net barter terms of trade movements. For African countries, increasingly dependent on traditional commodity exports, the movement is in the opposite direction.

At the country level, the relationship between nonfuel commodity prices and net barter terms of trade is even more diversified. Not only does the intensity of the (positive) relationship between these two variables differ, but its sign is reversed in some cases. For natural-resource-poor countries that have become principal exporters of manufactures, such as the Republic of Korea and Yugoslavia, a decline in the relative prices of nonfuel primary commodities tends to improve their net barter terms of trade. These countries behave now like industrial countries. India, conversely, constitutes an interesting intermediate situation: changes in nonfuel primary commodity prices relative to those of manufactures do not seem to affect significantly net barter terms of trade in one direction or another. Oil prices, however, are shown to be negatively related to net barter terms of trade changes in a consistent and significant way across the spectrum of non-oil-exporting developing regions and countries.

This analysis of the links between nonfuel commodity prices and net barter terms of trade of non-oil-exporting developing countries in the post-World War II period shows how difficult it is to draw valid conclusions over time and across countries, even from seemingly solid aggregate relationships. The inference remains possible that those developing countries that have continued to export primarily nonfuel commodities and import mostly manufactured products may

have faced secularly worsening net barter terms of trade; but this needs to be qualified in both extent and significance.

Although the extent of the terms of trade loss suffered by any developing country or group of countries is largely an empirical question, the economic significance of any such loss is a more complex issue. If there exists an aggregate positive relationship between net barter terms of trade changes and profitability in commodity production, and between profitability in the commodity sector and investments, a secular deterioration in the relative prices of primary products may have had the consequence of holding down the growth potential of these countries via lower investment rates. Such a secular deterioration may also have led to distorted investment patterns, wherever resource mobility was constrained by lack of alternatives or by domestic price policies that did not reflect market forces.

The link between worsening net barter terms of trade and worsening sector profitability depends critically on factor productivity. It is only when reduction in the input of factors per unit of output does not fully compensate for the decline in relative output prices, and the returns to the factors employed in the primary commodity-producing sectors may diminish over time, that overall output growth is limited by lower profitability and underinvestment. The existence of such circumstances, however, is a factual question which is not only time- and country-specific but also probably specific to various export subsectors within the same country.

Even for those developing countries whose commodity and net barter terms of trade may have shown a secularly deteriorating trend, the conclusion that trade has been harming their growth should not be drawn solely on the basis of this type of evidence. Country- and sector-specific information is needed to measure the possible compensating effects of productivity growth in agriculture and mining. Even in the presence of deteriorating commodity terms of trade and net barter terms of trade, single factorial terms of trade may have moved in the opposite direction. At the global level—that is at the level at which our analysis of relative prices has been conducted—no strong evidence exists on secular factor productivity trends in the agriculture and mining sectors of non-oil-exporting developing countries. The growth-constraining effects of deteriorating commodity and net barter terms of trade, via production, for those developing countries that mainly export nonfuel primary products and mainly import manufactures thus remain indeterminate.

The reduction in real income (or purchasing power) evidenced by falling commodity and net barter terms of trade may also have constrained the growth possibilities of non-oil-exporting developing countries, and especially of those that have remained most dependent on nonfuel commodity exports, given that their capacity to import capital goods and other essential inputs was thereby reduced. Here, too, caution must be exercised in drawing conclusions from price evidence alone. The total real income effect of trade, under less than full employment conditions, depends on export quantities as well as on relative export

prices. Under these conditions, a fall in purchasing power occurs only if the growth of export volumes is not enough to offset the decline in relative prices.

The evidence on the size of the real income effects of trade on developing countries is much stronger than evidence on the production effects. Both direct and indirect indicators point to a positive real income effect over time. The purchasing power of exports of all primary commodities in terms of manufactures increased at a trend rate of 4.5 percent a year from 1900 to 1913. Between 1921 and 1938 its growth was much smaller (0.4 percent a year), but still positive, notwithstanding the unfavorable trend of relative prices, which declined at 1.2 percent a year. In the period between 1955 and 1983 growth resumed strongly, with a trend rate of 4.2 percent a year. The purchasing power of developing countries' exports of nonfuel primary commodities also rose in the post-World War II period—at 2.8 percent a year between 1955 and 1983—as export volumes grew strongly (3.2 percent a year) in the face of a mild decline in relative prices (−0.4 percent a year). If oil is included in the sample, growth of purchasing power of commodity exports becomes even stronger (United Nations 1969; UNCTAD 1972, 1976, 1983, 1984; IMF 1982, 1985).

The direct evidence on the behavior of the income terms of trade of non-oil-exporting developing countries is even more persuasive from the early 1950s onward (Wilson, Sinha and Castree 1969). More recent data show that these improved on trend by 5.3 percent a year between 1953 to 1983, a period during which the net barter terms of trade of developing countries declined at about 0.6 percent a year, but overall export quantities rose at almost 6 percent a year. These trends are represented in figure 11, which shows the long-run tendency of the purchasing power of exports of primary products to grow in terms of manufactures.

In the presence of a strong improvement in the purchasing power of commodity exports and in the income terms of trade of non-oil-exporting developing countries, the negative welfare significance of falling relative prices of nonfuel primary commodities should not be overstated. Nor does there appear to be any strong reason to infer from available evidence either that trade per se or trade in nonfuel primary products has in the aggregate been harmful to countries specializing in their production. Obviously, immiserizing growth might have occurred in specific commodities or in specific periods, but its existence cannot be assumed. It must instead be proven and possibly explained in terms of the balance between autonomous factor supply growth (and/or technical progress), market structures, and government price and investment policies affecting output in the export sector. More important, one has to keep in mind that gains from trade are dynamic, far reaching in their effects, and cumulative over time. They go well beyond the direct production and real income effects of terms of trade changes.

V. THE EFFECT OF GROWTH ON RELATIVE PRIMARY COMMODITY PRICES: DID CLASSICAL ECONOMISTS GO WRONG?

The observed decline in the prices of nonfuel primary commodities relative to those of manufactures appears to contradict the tightly held belief of classical

Figure 11. *Purchasing Power of Primary Commodity Exports and Income Terms of Trade of Developing Countries, 1900–83*

Source: United Nations (1969 and 1974); UNCTAD (1972, 1976, 1983, and 1984); IMF (1982, 1985).

economists that the expected outcome had to be in the opposite direction. Diminishing returns in primary commodity production and growing population, viewed against the effects of increasing specialization and technological progress in manufacturing, led these economists to expect a falling tendency in the prices of manufactures relative to those of raw materials (Ricardo 1817; Torrens 1821; Mill 1848).

The validity of the position of the classical economists not only remained virtually unquestioned throughout the nineteenth century but was reaffirmed in the current century by modern economists such as Keynes. Constant returns to scale in industry and decreasing returns in agriculture, along with population growth, Keynes argued, would have caused in the long run a decline in the relative prices of manufactured products and thus of the net barter terms of trade of the European countries (Keynes 1912, 1920). This is a conclusion that neo-classical trade theorists would find hard to accept without a precise specification of the shape of the production functions, in a situation where the greater capital intensity of manufacturing production relative to that of agricultural production is normally assumed to exist. It is only by postulating a relatively faster growth of capital (and not labor) in the manufacturing exporting sector, and by assuming away technical progress, that the presumption of deteriorating terms of trade of Europe could have been built on neoclassical grounds.

Yet notwithstanding the apparent theoretical shakiness of the classical economists' case, the Ricardian tradition on terms of trade developments was not seriously challenged until quite recently, with orthodox neoclassical economists not only sitting more or less on the sidelines, but alternating in their judgments on the very importance of the concept of terms of trade.⁷ Prebisch and Singer independently—if almost simultaneously and much along the same lines—provided the economic rationale for the counterthesis that terms of trade were bound to deteriorate for developing countries exporting primary commodities and importing manufactured products from industrial countries. Though couched in seemingly unconventional terms, the original Prebisch-Singer counterargument in its essence is based on orthodox economic concepts. If productivity growth systematically shifts the supply curve for primary commodities to the right more than that for manufactured products, and income growth systematically shifts the demand curve for manufactures to the right more than that for primary commodities, the relative price of primary commodities in terms of manufactured goods will tend to decline over time (and to the extent that developing countries export primary products and import manufactures, their net barter terms of trade will tend to fall).

Cast in these terms, the original Prebisch-Singer conclusion on terms of trade between primary commodities and manufactures seems inescapable. Because the

7. Viner (1937) and Kindleberger (1956), among others, have stressed the importance of terms of trade changes, whereas economists such as Graham (1948) have not hesitated to call the terms of trade an irrelevant concept.

point on the higher income elasticity of demand for manufactured products is hardly debatable, what remains to be explained is why productivity growth has a different impact on the supply schedule of primary commodities with respect to that of manufactures. Prebisch and Singer assume competitive market structure in the case of primary commodities and oligopolistic market structure in the case of manufactures (Prebisch 1950; Singer 1950). This assumption is used to explain why the distribution of productivity gains between primary commodity producers and producers of manufactures is uneven (manufacturers would reap the benefits of the gains in terms of rising returns to factors of production, while primary commodity producers would pass it on to consumers in the form of falling prices). However, the device of resorting to the notion of different market structures and referring to the differential effects of productivity under oligopoly, although plausible on the surface, breaks down when one considers that productivity growth can hardly be taken as given and is probably in itself a function of the market form.

If the options for innovation are positively related to the size of the firm, which is much larger under oligopolistic market conditions than under competitive conditions, the rate of technical progress would tend to be greater under oligopolistic (or monopolist) market conditions than under free competition (Sylos-Labini 1956). If this is the case, and there is considerable empirical evidence that shows at least that firm concentration and productivity growth are positively related (Greer and Rhoades 1976; Scherer 1984), then the simple comparative static conclusions regarding prices and output under monopolistic or oligopolistic market conditions, as compared to competitive conditions, are no longer applicable. Output growth would also tend to expand faster under the push of technical progress in noncompetitive markets, a point that had not escaped Schumpeter (Schumpeter 1942).

Pending a more comprehensive analysis of the actual effects of growth on the terms of trade, it is incorrect to suggest that our empirical results on long-term relative price trends of nonfuel primary commodities simply validate the original Prebisch-Singer thesis (with which they appear to be compatible) and invalidate the classical conclusion (with which they appear to be incompatible). Other explanations of the empirical results that we obtained can be found outside both the classical and the original Prebisch-Singer models.

Within the neoclassical model of trade, if growth occurs in the export sector of developing countries and is the consequence of growth in factor endowments (say labor, producing labor-intensive goods), supplies of exports will rise and, other things being equal, developing countries' terms of trade will worsen. The size of the terms of trade effect will depend on elasticity conditions. If growth in exports occurs as a consequence of technical progress in the export sector, the effects will be similar.

Outside the neoclassical framework, one can find models of relations among unequal trading partners that would lead to the conclusions that developing countries' terms of trade are bound to decline (Emmanuel 1969; Amin 1973).

Singer himself has recently come close to this unorthodox tradition of unequal development, which strongly emphasizes the importance of the asymmetry that exists between different types of countries, instead of (or together with) the differences between various types of commodities (Singer 1975).

Methodological, as well as theoretical, explanations can also be put forward to explain the outcome of falling terms of trade. Exponential trends, such as those that we estimated to examine the basic tendencies shown by the relative prices of nonfuel primary commodities, are not always appropriate to depict an underlying reality that is changing significantly over time. An example of this can be found in the trend in the relative prices of metals in the 1900–86 period, which shows a clear primary tendency to fall, but a secondary tendency in the opposite direction. If one computes a parabolic (or log-parabolic) trend for the GYCPIM/MUV, the second term of the fitted parabola is found to be positive and statistically significant, whereas the first term is negative and statistically significant (table 4).⁸ The explanatory power of the log-parabolic time model is also superior to that of the exponential model. No other subgroup of nonfuel commodity prices shows significant parabolic or log-parabolic trends over the period.

Such a time profile of the relative prices of nonrenewable resources such as metals can be thought of as the result of two sets of forces affecting their long-run costs of production: on the one hand, technological improvements make it possible to lower directly the unit costs of production of these commodities (for example, new mining and smelting techniques) or to augment the possibilities of producing them (for example, access to new lands and new ore deposits); on the other, limitations are imposed by the finiteness of available physical resources and the effects of decreasing returns (beyond a certain point). The impact of the first set of forces, which has so far been dominant and has tended to push down the real prices of metals, may have been progressively offset by the impact of the second set of forces, the net effect of which is in the opposite direction. Classical economists may have underestimated the extent and possibly the effects of emerging technical progress, and thus misjudged the “length of the long-run,” but may still be on the right track in terms of the direction of expected changes in the relative prices of many primary commodities in the longer term.

VI. STATISTICAL LIMITS OF THE PRESENT RELATIVE PRICE ESTIMATES

The question that arises at this point is how reliable are the aggregate price indexes that were used here to measure long-term commodity and manufactured price movements. We have little doubt about the representativeness of the non-

8. Slade (1982) found evidence of a parabolic time pattern of prices at the level of single metals. She showed that this pattern is consistent with a model of long-run price determination where price equals marginal extraction costs and the rate of change of price is equal to that of marginal cost because of changes in technology, plus the discount rate times the rent.

Table 4. *Quadratic Trends in the Relative Prices of the Principal Nonfuel Primary Commodity Subgroups, 1900–86*

Relative price index	Intercept ($\hat{\alpha}$)	Linear coefficient of time ($\hat{\beta}_1$)	Quadratic coefficient of time ($\hat{\beta}_2$)	Regression statistics			
				R ²	SEE	F	DW
Tropical beverages:							
GYCPIBEV/MUV	42.859* (3.59)	0.21190 (0.34)	0.00187 (0.27)	0.08	11.73	3.6	1.80
Nonbeverage foods:							
GYCPIOF/MUV	149.67* (8.23)	-0.11903 (-0.12)	-0.00601 (-0.57)	0.14	20.67	6.8	1.80
Nonfood agricultural:							
GYCPINF/MUV	173.71* (10.60)	-1.4919* (-1.74)	0.00540 (0.57)	0.31	15.73	18.9	1.74
Metals:							
GYCPIM/MUV	208.25* (12.31)	-3.7843* (-4.26)	0.03035* (3.11)	0.39	18.96	27.27	1.43
Tropical beverages:							
ln GYCPIBEV/MUV	3.7854* (19.12)	0.00151 (0.15)	0.00005 (0.48)	0.50	0.17	42.30	1.75
Nonbeverage foods:							
ln GYCPIOF/MUV	4.9667* (35.90)	0.00145 (0.20)	-0.00008 (-0.98)	0.70	0.15	99.53	1.65
Nonfood agricultural:							
ln GYCPINF/MUV	5.1384* (40.03)	-0.00905 (-1.34)	0.00001 (0.14)	0.79	0.13	152.21	1.73
Metals:							
ln GYCPIM/MUV	5.3570* (39.00)	-0.02609* (-3.63)	0.00020* (2.58)	0.81	0.12	184.07	1.47

t values in parentheses.

* = significant at the 10 percent confidence level or above.

Note: The estimated model is $\ln \text{GYCPI}_i = \alpha_0 + \beta_1 t_i + \beta_2 t_i^2 + u_i$. All time series are trend-stationary, and OLS estimates are based on annual data. A maximum-likelihood procedure was used to correct for serial correlation.

fuel commodities price index that we built. Within the class of index to which it belongs, the tracking behavior of the GYCPi should be more than acceptable, given its coverage, the care taken in choosing representative quotations for each of the twenty-four products included in it, and the results of the various experiments that were conducted to test its sensitivity to different weight schemes. The MUV, on the other hand, is an index of unit values of exports and thus potentially open to more serious questions about its ability to represent market prices.

Although comparison with the USMPI, which represents domestic prices of tradable manufactured products in the United States, seems to confirm the

broad representativeness of the MUV as an indicator of long-term trends in manufactured good prices, the appropriateness of the use of the MUV is still open to doubt on account of possible differences between unit values of exports and international market prices. Available empirical evidence on international prices of manufactured goods is still limited. Kravis and Lipsey have built an index of manufactured good prices (KLI) covering the 1953–77 period and the same SITC product categories as are included in the MUV. Compared with the MUV, this new price index shows a much smaller cumulative increase over the period (127 percent as opposed to 153 percent), leading them to conclude that the U.N. unit value index overestimates the growth of prices of internationally traded manufactured goods (Kravis and Lipsey 1981).

The KLI, however, shows a markedly different behavior from that of the MUV only from 1973 onwards. From 1953 to 1972, KLI and MUV movements are remarkably close to one another: their cumulative increase at end points is respectively 41.1 percent and 45.6 percent. It is only in the following five years, characterized by severe monetary and exchange rate turmoil in the world economy and by a major supply shock (1973–74), that the two indexes apparently diverge widely. The KLI shows an increase of 60.7 percent (at end points), whereas the MUV goes up by 73.9 percent.

This strong divergence of the two indexes after 1972 is magnified by several factors. The KLI, apart from its different construction, covers only the prices of manufactures exported by six industrial countries—Canada, the Federal Republic of Germany, Japan, the Netherlands, the United Kingdom, and the United States—whereas the MUV reflects the unit value of exports of five additional countries—Belgium, France, Italy, Sweden, and Switzerland. Of this latter group, the first four are countries that experienced relatively high inflation rates, reflected in part in their faster-than-average growth in the dollar unit values of the manufactures that they exported after 1972.

Moreover, Kravis and Lipsey have complete price information only up to 1975.⁹ A strict comparison between the two indexes is thus possible only for the 1973–75 period and should be conducted not on the basis of the overall U.N. MUV index, but of a subindex including the same six countries covered in the KLI. When this is done, one finds that over the 1953 to 1972 period the two indexes show a very similar behavior: the KLI increases by 41.1 percent at end points and the modified MUV by 43.9 percent. Between 1973 and 1975 the KLI increases by 46.1 percent, whereas the modified MUV increases by 59.5 percent. The difference is still large, but we feel that no strong conclusion can be reached on the basis of the behavior of the two indexes over such a short and atypical period of time. The problem of the representativeness of export unit value therefore remains. On the basis of available evidence, it seems that its practical importance may have been exaggerated.

9. Prices for the Netherlands in 1976 and 1977 are missing from KLI, and German prices are not available for 1977 (Kravis and Lipsey 1981, table 2).

The remaining open question regarding our measures of long-term relative price changes has to do with the so-called quality bias, which is potentially worrisome, particularly in the case of manufactured goods. The quality bias has two dimensions. The first has to do with the rate of increase in the number of new manufactured products entering trade, causing changes in the internal composition of the various commodity groups over time. The second has to do with the direct improvement in the quality of the same goods whose prices are measured over time. Even if it were possible to keep unchanged over time the basket of manufactured goods whose prices are to be measured and to deal in this way with the problem of new goods, part of the increase shown by the index would simply represent the effects of improvements in the quality and performance of existing goods.

Some quality improvement of this type should also be reflected in the prices of primary commodities. Our index is based on uniform weights and a single representative market quotation for each product. Quality improvements in commodities such as tea, coffee, rubber, cotton, and vegetable oils did occur over time, even if they are not fully reflected in our index. If quality improvements could be measured by averaging market quotations of various grades and by accounting for the changes in their relative importance, one could presume that such a price index would be positively affected over time by quality improvements. An index of export unit values would also reflect this effect. Yet it can be reasonably assumed that manufactured goods prices reflect more of this upward drift on account of both changes in composition and quality improvement of traded goods. The question that arises is how much more. The empirical evidence on this point is still very scarce.

Kravis and Lipsey have recently constructed an index of U.S. prices of machinery and transport equipment (SITC7) and corrected it for quality improvements, showing that the quality bias accounted for about a quarter of the cumulative price increase over the 1953–76 period (Kravis and Lipsey 1981, table 3). They are inclined to think that a quality bias of such magnitude may be common to the price indexes of SITC7 manufactures exported by the major industrial countries over the same period. We find it hard to accept this assumption, given that for this group of manufactured goods—which includes electrical, electronic, and telecommunication equipment—and for most of the time period covered by this Kravis and Lipsey index, the rate of technological change has probably been faster in the United States than elsewhere.

Whatever may be the merit to this objection to the geographical representativeness of this U.S.-based index, using it to correct for quality improvements across the spectrum of manufactures, as Kravis and Lipsey do, necessitates the acceptance of an even stronger assumption: that the quality improvement factor present in the prices of SITC7 manufactures be considered representative of that of all other categories, from chemical products (SITC5), to manufactured goods classified chiefly by material (SITC6), to miscellaneous manufactures (SITC8). We find that there is no logical or empirical basis for accepting this assumption of

equal rate of technological change in such different categories of goods. If anything, one would be prone to assume the opposite, that is, that the quality improvement factor reflected in the prices of SITC7 manufactures may be much larger than that reflected in the prices of SITC5, SITC6, and SITC8 manufactures.

Our conclusion is that the cumulative trend decline shown by the relative price indexes of nonfuel primary commodities that we computed over the 1900–86 period cannot be assumed away simply resorting to either the notion of unit value bias or of quality bias. The available evidence to the contrary is neither totally persuasive nor sufficiently precise to cast overwhelming doubt on it.

VII. CONCLUSIONS

Our new series indicate that, relative both to the prices of manufactured goods traded within the United States and to the export unit values of manufactures from industrial countries, nonfuel commodity prices have fallen considerably between 1900 and 1986. A cumulative trend decline of about 40 percent, though possibly magnified by the relatively greater effect of quality improvements on the prices of manufactured products, probably reflects a net fall in the purchasing power of a given basket of nonfuel primary commodities during the past century. No strong evidence of change was found in the negative trend shown over this period by our index of nonfuel commodity prices deflated by the index of unit value of exports of manufactures.

The long-run tendencies in the relative prices of the major subgroups of nonfuel primary commodities, however, are far from uniform. Nonfood agricultural raw materials appear to have sustained the steadiest reduction in purchasing power in terms of manufactured products. Metals, conversely, though showing the strongest overall negative trend in their relative prices over the current century, did experience a precipitous fall until the early 1940s and a strong inversion of that tendency since then. Agricultural food products, considered together, exhibit a substantially smaller trend decline in their relative prices than that of the other two major commodity groups. The trend in the aggregate of food product prices, however, is the result of sharply different within-group tendencies. Beverage prices have increased substantially over time relative to those of manufactures, while those of other food products, including cereals, have declined markedly over the same period.

We also found that the prices of all primary commodities (including fuels) relative to those of traded manufactures declined by about 36 percent over the 1900–86 period, at an average annual rate of 0.5 percent. These results tend to confirm those of Lewis, which were derived using different price information and over a different time period. The results also indicate, however, that the decline in the net barter terms of trade of all primary commodities shown by the data used by Prebisch represents a considerable overstatement of the long-term trend.

The average rate of decline of about 0.6 percent a year in the relative prices of nonfuel commodities that we found over the 1900–86 period does not indicate a similar rate of decline in the net barter terms of trade of non-oil-exporting developing countries. These countries in fact have exported over time increasing amounts of fuel products and manufactures, in addition to nonfuel commodities, and always have imported fuels and nonfuel primary commodities, in addition to manufactures. We found that in the post–World War II period, other things being equal, a decline of 1 percent in the relative prices of nonfuel primary commodities is associated with a 0.28 percent decline in the net barter terms of trade of non-oil-exporting developing countries considered as a whole. It is conceivable that in the earlier part of the century the value of this partial elasticity might have been higher, because of the lower share of manufactures in their exports and of oil in their imports. But to judge even notionally the extent of the effective fall that might have taken place since 1900 one should not forget that: (a) the cumulative trend decline that we observed in our price data may have been somewhat exaggerated by an imperfect account of quality improvements in manufactures, and (b) considerable differences in the relationships between net barter terms of trade and relative prices of nonfuel primary commodities are evident both at the regional and at the country level.

Even greater caution needs to be exercised in drawing conclusions on gains from trade for the developing countries on the basis of export price information alone. Although a deterioration in net barter terms of trade indicates a reduction in real income gains, with respect to a situation of unchanged terms of trade, the actual magnitude of the real income effect over time also depends critically on export quantities. The assumption of constant full employment of resources is not tenable in the analysis of the effects of trade over time. Available evidence indicates that, even if one disregards trade in manufactures and fuels, exports of nonfuel primary commodities by developing countries have grown in terms of volume at appreciably positive rates since 1900. This has given rise to a positive growth in the total purchasing power of nonfuel commodity exports. In the post–World War II period, moreover, available empirical evidence on the income terms of trade of non-oil-exporting developing countries indicates that consistent and substantial gains were obtained by them.

The extent of production effects of falling relative prices of primary commodities is uncertain, given the lack of evidence on long-term factor productivity growth in the agricultural and mining sectors of the developing countries. The presumption, however, is that the negative effects of declining real export prices may have been at least in part mitigated by productivity growth.

There is no comprehensive empirical analysis of the effects of growth on the net barter terms of trade of primary commodities. What can be said about the reasons for this apparent secular deterioration in the relative prices of primary commodities therefore is limited. The simple primary trends that we measured appear to go against the expectations of classical economists regarding the rela-

tive price movements of manufactured goods and instead to be consistent with the original Prebisch-Singer counterargument. It is not difficult, however, to show how these empirical findings can be theoretically explained outside both the classical and the original Prebisch-Singer frameworks. Neoclassical analysis of the effects of growth on relative trade prices offers numerous possible alternative explanations, and so does unequal development theory.

APPENDIX I. PRICE INDEXES OF PRIMARY COMMODITIES AND MANUFACTURES

<i>Year</i>	<i>GYCPI</i>	<i>GYCPI'</i>	<i>GYCPI''</i>	<i>GYCPI'''</i>	<i>MUV</i>	<i>USMPI</i>	<i>GYPIF</i>	<i>GYPINF</i>	<i>GYCPIM</i>
1900	19.309	20.748	20.391	19.214	14.607	15.382	15.587	21.310	27.778
1901	18.236	18.802	18.765	17.604	13.858	15.169	14.716	19.292	27.522
1902	18.145	17.703	18.772	17.532	13.483	16.180	15.209	19.268	25.518
1903	19.006	19.808	20.543	19.099	13.483	16.340	14.634	22.860	26.668
1904	20.586	21.790	22.220	20.581	13.858	16.393	16.444	24.450	27.526
1905	21.621	23.101	23.765	21.938	13.858	16.499	16.924	26.226	29.150
1906	21.610	23.344	23.877	22.054	14.607	17.032	15.422	27.547	31.726
1907	22.757	23.489	23.793	22.070	15.356	17.883	16.672	25.967	36.699
1908	20.427	20.670	22.570	20.970	14.232	17.245	18.276	22.291	24.245
1909	21.554	23.244	25.506	23.541	14.232	18.575	18.143	28.973	20.822
1910	22.630	26.053	26.618	24.561	14.232	19.373	18.088	32.924	21.026
1911	21.909	24.722	25.328	23.385	14.232	17.830	19.498	28.122	19.923
1912	22.640	24.911	26.023	24.077	14.607	18.948	19.739	28.188	23.176
1913	20.461	21.817	23.443	21.820	14.607	19.161	17.149	25.440	23.134
1914	20.210	20.383	23.579	21.933	13.858	18.130	19.509	22.239	19.291
1915	24.468	23.140	26.851	25.012	14.232	18.594	22.292	24.388	31.321
1916	31.933	29.920	32.753	30.710	17.603	24.105	26.497	30.897	50.327
1917	39.396	33.817	44.339	41.277	20.974	31.419	37.074	40.257	45.271
1918	42.028	36.036	47.002	43.852	25.468	33.943	43.861	42.841	35.121
1919	39.208	34.348	48.802	46.069	26.966	35.334	39.902	43.292	30.853
1920	41.951	40.925	50.275	48.313	28.839	44.141	47.052	39.641	29.684
1921	21.356	18.987	26.111	24.911	24.345	28.689	21.602	21.605	20.219
1922	21.910	20.047	28.973	27.213	21.723	28.020	21.147	24.771	19.919
1923	26.407	26.013	33.632	31.482	21.723	28.638	25.234	29.989	24.587
1924	26.521	24.951	33.292	31.066	21.723	27.350	26.086	28.365	25.066
1925	29.381	28.716	36.139	33.563	22.097	28.123	26.637	36.978	26.315
1926	25.758	24.828	30.987	28.854	20.974	27.402	24.250	28.691	25.962
1927	25.143	23.462	30.585	28.450	19.850	26.355	24.677	26.823	24.028
1928	24.423	21.756	30.216	28.012	19.850	26.327	24.217	25.393	23.585

(Table continues on the following page.)

APPENDIX I. CONTINUED

<i>Year</i>	<i>GYCPI</i>	<i>GYCPI'</i>	<i>GYCPI''</i>	<i>GYCPI'''</i>	<i>MUV</i>	<i>USMPI</i>	<i>GYPIF</i>	<i>GYPINF</i>	<i>GYCPIM</i>
1929	23.266	20.637	26.437	24.516	19.101	25.882	23.098	22.332	25.210
1930	18.277	15.365	19.797	18.570	18.727	23.935	17.838	16.949	21.655
1931	13.610	11.282	13.977	13.240	15.356	21.441	12.675	12.308	18.479
1932	10.797	8.9658	10.685	10.150	12.734	19.156	9.7342	8.9577	16.883
1933	12.591	10.490	13.650	12.893	14.232	19.691	10.833	12.357	18.388
1934	15.763	13.522	17.523	16.513	16.854	21.609	14.522	16.427	18.591
1935	17.294	14.592	18.781	17.631	16.479	21.468	17.465	16.229	18.383
1936	18.418	15.659	20.491	19.213	16.479	21.723	18.369	18.348	18.677
1937	21.361	17.501	24.733	22.798	16.854	23.561	21.988	20.366	20.931
1938	16.552	14.025	18.504	17.389	17.603	22.472	16.105	16.198	18.474
1939	16.019	14.369	18.551	17.324	16.105	22.697	14.267	17.499	19.188
1940	17.237	15.230	20.407	19.100	17.603	23.219	15.063	20.547	18.932
1941	20.093	18.263	23.857	22.337	18.727	24.913	18.288	24.844	18.452
1942	23.073	21.359	27.217	25.403	21.723	27.010	22.419	27.716	18.039
1943	24.283	21.319	29.168	27.193	24.345	27.264	23.905	29.094	18.132
1944	25.243	21.912	30.246	28.222	27.715	27.469	24.816	30.786	18.132
1945	25.832	22.643	31.109	29.021	28.464	27.864	26.186	30.112	18.232
1946	31.232	26.216	36.901	34.182	28.839	30.603	34.314	32.688	19.485
1947	40.389	34.875	45.858	42.408	34.831	37.474	46.952	37.349	24.709
1948	38.722	35.114	44.106	41.895	35.581	40.044	41.107	40.934	27.980
1949	35.845	32.359	41.753	39.009	33.333	39.557	38.930	35.727	26.479
1950	39.263	38.393	47.761	44.316	30.337	40.858	40.130	45.060	27.767
1951	48.093	47.245	58.834	54.094	35.955	45.348	47.929	58.702	32.466
1952	40.508	39.284	46.741	43.925	36.704	44.134	40.623	45.983	31.825
1953	37.897	36.348	42.910	36.998	35.206	44.386	38.289	40.839	32.214
1954	38.565	39.134	43.612	37.620	34.457	44.657	39.738	39.797	33.066
1955	38.233	39.165	44.655	38.450	34.831	45.447	36.107	42.537	38.267
1956	39.895	40.585	45.133	39.075	36.330	47.517	38.747	41.517	40.977
1957	40.108	41.108	45.080	39.227	36.704	49.149	40.525	42.372	35.376

1958	36.231	35.998	40.368	35.226	36.330	49.742	36.235	38.647	32.546
1959	37.113	35.951	42.153	36.144	36.330	50.514	35.926	40.667	35.379
1960	37.327	36.183	42.312	35.965	37.079	50.490	35.305	41.799	36.781
1961	36.466	34.491	40.374	34.605	37.453	50.267	34.917	40.424	35.242
1962	36.486	34.275	40.715	34.888	37.453	50.310	35.377	39.893	34.734
1963	41.419	41.656	46.842	39.787	37.453	50.229	44.723	39.084	34.747
1964	41.046	39.962	45.517	38.659	38.202	50.502	42.774	39.782	37.620
1965	38.119	35.314	40.953	35.063	38.951	50.918	36.429	39.990	40.499
1966	37.935	34.192	40.766	34.879	39.700	51.891	37.325	37.445	40.568
1967	36.846	33.593	39.162	33.585	39.700	52.713	36.830	33.813	41.509
1968	37.431	34.033	39.357	33.605	39.326	53.973	36.718	34.620	43.914
1969	39.761	37.565	42.378	36.046	40.449	55.521	38.322	37.459	47.712
1970	42.201	40.421	43.668	37.161	42.697	57.627	41.381	36.438	53.500
1971	42.324	39.919	43.429	37.397	45.318	59.583	42.051	37.638	50.293
1972	46.625	45.176	50.407	43.318	48.689	61.325	47.037	43.823	49.613
1973	69.472	63.184	76.502	65.043	58.801	63.977	74.123	69.054	55.720
1974	102.41	104.01	111.28	103.46	71.161	74.371	123.33	74.718	79.813
1975	85.156	83.693	91.786	88.288	79.026	83.260	97.598	65.807	76.090
1976	83.110	83.077	85.553	83.775	78.652	87.946	85.707	78.946	81.408
1977	93.125	98.295	92.723	90.871	86.517	92.641	96.064	90.681	87.752
1978	93.627	93.165	93.198	91.662	98.876	99.163	94.159	94.173	91.149
1979	113.25	108.54	114.54	120.82	114.61	108.20	109.78	115.15	121.10
1980	138.83	140.34	155.33	182.10	125.47	119.65	142.99	126.49	144.72
1981	117.94	112.00	128.81	183.92	119.10	130.30	120.38	108.87	124.21
1982	96.784	90.110	100.51	178.32	115.73	135.62	92.364	96.727	110.54
1983	102.78	95.356	107.86	163.00	110.49	138.31	97.566	103.15	118.37
1984	103.54	94.533	104.21	159.30	108.61	142.54	99.686	105.29	112.81
1985	91.268	82.578	92.665	151.62	109.59	144.91	87.022	90.490	105.59
1986	88.358	84.059	90.788	93.759	130.30	144.36	84.013	86.026	105.34

Note: GYCPI, GYCPI' and GYCPI'' = indexes of prices of nonfuel primary commodities; GYCPI''' = index of prices of all primary commodities; MUV = index of unit values of exports of manufactures from industrial countries; USMPI = index of wholesale prices of manufactures in the United States; GYCPIF, GYCPIF', GYCPIF'' = index of prices of food, nonfood agricultural raw materials and metals (sub-indexes of GYCPI).

Source: Grilli and Yang (1987).

APPENDIX II

TESTS ON THE STABILITY OF THE ESTIMATED TIME TREND OF GYCPI/MUV

Given that both the GYCPI/MUV and the GYCPI'''/MUV price series show three possible common breaks in 1921, 1932, and 1945, we tested first for equality between the estimated coefficients of the regression covering the years before the possible break and those of the regression for the years subsequent to it. To do so we used the dummy variable procedure suggested by Gujarati (1970a, 1970b). This test involves the OLS estimates of the following single regression model:

$$(1) \quad \ln (P_c/P_m)_i = \alpha_0 + \beta_1 t_i + \alpha_1 D_i + \beta_2 (D_i t_i) + u_i$$

where P_c/P_m is either GYCPI/MUV or GYCPI'''/MUV, t_i is a time trend, and D_i is a dummy variable = 0 up to (but excluding) the year of break, and = 1 in subsequent years.

In this model α_1 is the differential intercept coefficient, and β_2 is the differential slope coefficient. The standard statistical significance tests can be performed on their estimated values ($\hat{\alpha}_1$ and $\hat{\beta}_2$) to judge whether the two regressions implicit in this model have a common intercept, a common slope, or both.

The regression results, shown in appendix tables 1 and 3, indicate that there is no strong evidence of parameter shifts, in terms of either slope or intercept, of the estimated trend lines of the GYCPI/MUV and the GYCPI'''/MUV at any of the assumed break points. None of the $\hat{\alpha}_1$ and $\hat{\beta}_2$ parameters is statistically significant at at least the 10 percent level.

After testing for shifts in the slope and intercept of the estimated exponential time trend of the GYCPI/MUV and GYCPI'''/MUV, we tested for the possibility of a change in slope, assuming no discontinuity in the time trends, by using the following piecewise model (Suits, Mason, and Chan 1978):

$$(2) \quad \ln (P_c/P_m) = \alpha_0 + \beta_1 t_i + \beta_2 (t_i - t^*) D_i + u_i$$

where t_i is a time trend; D_i is a dummy variable = 1 when $t_i > t^*$, and = 0 when $t_i < t^*$; and t^* is the threshold year.

In this model β_1 gives the slope of the first segment of the regression line, while $(\beta_1 + \beta_2)$ gives the slope of the second segment of the regression line. The threshold years are 1921, 1932, and 1945. The hypothesis of no break in the slope of the regression lines at the threshold years can be tested by looking at the statistical significance of $\hat{\beta}_2$.

The results, shown in appendix tables 2 and 4, again indicate that at none of the possible break years is there evidence that a break may have actually occurred in the regression lines.¹⁰ The statistical significance of the $\hat{\beta}_2$ coefficients in either lines 2-1 to 2-3 or lines 4-1 to 4-3 is consistently below 10 percent.

10. We also tested for multiple structural breaks but found no evidence of them.

Appendix table 1. *Dummy Variable Analysis of Trends in the Relative Prices of Nonfuel Primary Commodities, 1900–86*

Relative price index	Intercept ($\hat{\alpha}_0$)	Coefficient of dummy ($\hat{\alpha}_1$)	Coefficient of time ($\hat{\beta}_1$)	Coefficient of time and dummy ($\hat{\beta}_2$)	Regression statistics			
					R ²	SEE	F	DW
1-1 ln GYCPI/MUV	4.89149* (51.3)	-0.12237 (-0.90)	0.01262* (1.83)	-0.01521* (-2.07)	0.80	0.09	108.9	1.55
1-2 ln GYCPI/MUV	5.05227* (51.7)	-0.24853 (-1.37)	-0.00908* (-1.90)	0.00596 (1.04)	0.74	0.11	77.3	1.69
1-3 ln GYCPI/MUV	5.03845* (63.0)	-0.08256 (-0.34)	-0.00900* (-3.20)	0.00377 (0.80)	0.74	0.11	76.8	1.71

* = significant at the 10 percent confidence level or above.

Note: t values in parentheses.

The estimated model is $\ln \text{GYCPI}/\text{MUV}_i = \alpha_0 + \alpha_1 D_i + \beta_1 t_i + \beta_2 (D_i t_i) + u_i$, where t_i is a time trend, D_i is a dummy variable = 0 up to 1920 in 1-1, 1931 in 1-2, and 1944 in 1-3 and = 1 in subsequent years; OLS estimates on annual data; a maximum-likelihood procedure was used to correct for serial correlation.

Appendix table 2. *Piecewise Regression Analysis of the Trends in the Relative Prices of Nonfuel Primary Commodities, 1900–86*

Relative price index	Intercept ($\hat{\alpha}_0$)	Coefficient of time ($\hat{\beta}_1$)	Coefficient of time and dummy ($\hat{\beta}_2$)	Regression statistics			
				R^2	SEE	F	DW
2-1 ln GYCPi/MUV	5.01402* (50.7)	−0.00838 (−1.57)	0.00313 (0.49)	0.74	0.11	114.9	1.72
2-2 ln GYCPi/MUV	5.04433* (57.3)	−0.00943* (−2.64)	0.00544 (1.08)	0.74	0.11	116.0	1.71
2-3 ln GYCPi/MUV	5.01496* (59.2)	−0.00746* (−2.78)	0.00358 (0.70)	0.74	0.11	115.2	1.71

* = significant at the 10 percent confidence level or above.

Note: t values in parentheses.

The estimated model is $\ln \text{GYCPi}/\text{MUV}_i = \alpha_0 + \beta_1 t_i + \beta_2 (t_i - t^*) D_i + u_i$, where t is a time trend, D_i is a dummy variable = 0 up to 1920 in 2-1, 1931 in 2-2 and 1945 in 2-3 and = 1 in subsequent years, and $t^* = 1921$ in 2-1, 1932 in 2-2, and 1945 in 2-3. OLS estimates on annual data; a maximum-likelihood procedure was used to correct for serial correlation.

Appendix table 3. *Dummy Variable Analysis of Trends in the Relative Prices of All Primary Commodities, 1900–86*

Relative price index	Intercept ($\hat{\alpha}_0$)	Coefficient of dummy ($\hat{\alpha}_1$)	Coefficient of time ($\hat{\beta}_1$)	Coefficient of time and dummy ($\hat{\beta}_2$)	Regression statistics			
					R ²	SEE	F	DW
3-1 ln GYCPI ^{'''} /MUV	4.87483* (33.3)	-0.05912 (-0.28)	0.01711* (1.68)	-0.01937* (-1.75)	0.73	0.12	72.6	1.37
3-2 ln GYCPI ^{'''} /MUV	5.06205* (37.7)	-0.29885 (-1.19)	-0.00667 (-1.03)	0.00520 (0.66)	0.68	0.13	58.4	1.50
3-3 ln GYCPI ^{'''} /MUV	5.05007* (42.4)	-0.21785 (-0.61)	-0.00739* (-1.81)	0.00490 (0.69)	0.68	0.13	57.0	1.51

* = significant at the 10 percent confidence level or above.

Note: t values in parentheses.

The estimated model is $\ln \text{GYCPI}'''/\text{MUV}_i = \alpha_0 + \alpha_1 D_i + \beta_1 t_i + \beta_2 (D_i t_i) + u_i$, where: t_i is a time trend, and D_i is a dummy variable = 0 up to 1920 in 3-1, 1931 in 3-2, and 1944 in 3-3 and = 1 in subsequent years. OLS estimates on annual data; a maximum-likelihood procedure was used to correct for serial correlation.

Appendix table 4. *Piecewise Regression Analysis of the Trends in the Relative Prices of All Primary Commodities, 1900–86*

Relative price index	Intercept ($\hat{\alpha}_0$)	Coefficient of time ($\hat{\beta}_1$)	Coefficient of time and dummy ($\hat{\beta}_2$)	Regression statistics			
				R^2	SEE	F	DW
4-1 $\ln \text{GYCPI}'''/\text{MUV}$	4.99781* (36.9)	-0.00481 (-0.67)	-0.00030 (-0.03)	0.68	0.13	86.0	1.52
4-2 $\ln \text{GYCPI}'''/\text{MUV}$	5.05294* (40.1)	-0.00803 (-1.58)	0.00455 (0.63)	0.68	0.13	86.5	1.51
4-3 $\ln \text{GYCPI}'''/\text{MUV}$	5.04872* (43.4)	-0.00728* (-1.98)	0.00493 (0.70)	0.68	0.13	86.5	1.51

* = significant at the 10 percent confidence level or above.

Note: t values in parentheses.

The estimated model is $\ln \text{GYCPI}'''/\text{MUV}_i = \alpha_0 + \beta_1 t_i + \beta_2 (t_i - t^*) D_i + u_i$, where t is a time trend, D_i is a dummy variable = 0 up to 1920 in 4-1, 1931 in 4-2, and 1945 in 4-3 and = 1 in subsequent years, and $t^* = 1921$ in 4-1, 1932 in 4-2, and 1945 in 4-3. OLS estimates on annual data; a maximum-likelihood procedure was used to correct for serial correlation.

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Price and Income Elasticities of Demand for Modern Health Care: The Case of Infant Delivery in the Philippines

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The economic determinants of the demand for infant delivery services in the Cebu region of the Philippines are examined in this article. Although user charges can be a significant source of revenues to pay for maternal and child health services, important policy questions are whether charging for such services will significantly deter use, and how service quality can be improved.

Price and income elasticities of the demand for types of services are computed, and simulations are carried out on the effects of different delivery service characteristics on the type of delivery method chosen.

The results suggest that increasing the availability of modern public practitioners and facilities in rural areas, increasing the hours that health care facilities are open, making drugs available, and providing trained midwives for delivery will increase the use of modern delivery services. Perhaps the most important finding—which suggests an area for further investigation—is the apparent relative insensitivity of the choice of delivery service to changes in prices and household income in our model.

In the Philippines, most births take place at home, and a significant proportion are attended either by a traditional midwife or by friends and relatives of the mother. Women continue to choose this pattern of delivery despite large investments by the health sector in modern prenatal and obstetrical health service systems. Even though a large majority of the pregnant women have direct con-

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tact with modern delivery services, there appears to be a preference for traditional home deliveries. It turns out that this choice can to a large extent be explained by the characteristics of the modern and traditional delivery systems and the socioeconomic characteristics of the households.

Important questions to be answered in order to make health policy decisions relate to how to provide and finance modern delivery care in low-income countries in which traditional and modern health providers coexist. The factors that affect mothers' choices of types of health care are ultimately those choices that determine whether many infants live or die or are healthy or chronically ill. We examine the determinants of the choice of type of delivery care, including economic facts (such as money prices, time prices, and household income), health facility characteristics, and delivery practitioner characteristics of both the traditional and modern delivery providers in one region of the Philippines. The sensitivity of the choice of birth delivery method to factors such as these has important implications for the placement, organization, and financing of modern delivery services. The analysis emphasizes the factors most amenable to policy change by the government of the Philippines, such as the location of clinics and the fees charged.

The data come from a survey of health facilities and delivery practitioners combined with a survey of over 3,000 women who delivered babies during 1983–84 in the Cebu region of the Philippines. In the first section below we describe the traditional and modern delivery sectors in low-income countries, in the second we present an overview of the economic model that guides the analysis, and in the third we discuss the data and provide descriptive statistics. In the fourth section we discuss the estimation technique and the results of the multivariate analysis, and in the fifth present policy implications and conclusions.

I. BACKGROUND

The Traditional Sector

Over two-thirds of the babies born in low-income countries are delivered by traditional birth attendants, who often are poorly educated and have no formal medical training. A national survey of traditional midwives conducted in 1974 in the Philippines found that over 50 percent had only elementary school training and most had either learned midwifery on their own or from relatives (Mangay-Angara 1981; Akin and others, 1984). It is this lack of formal medical training which differentiates traditional midwives from modern medical professionals. The modern health sector consists mainly of physicians and nurses with university educations and licensed midwives with some formal medical training.

The heavy reliance on traditional birth attendants in developing countries may be related to the heavy concentration of modern practitioners in urban areas and traditional ones in rural areas. Typically, 60 to 80 percent of the population and 70 to 90 percent of the doctors reside in urban areas (Akin and others, 1984).

The urban facilities at which these doctors work are often inaccessible (either for geographic or economic reasons) to the lower-income and rural populations.

The traditional sector generally provides greater coverage of the rural population than does the modern sector. Whereas in Asia and Africa the modern sector usually is physically accessible to only 10 to 30 percent of the population, in many countries 100 percent of the population is within walking distance of a traditional midwife. It is not unusual for the population-per-practitioner ratio for traditional midwives to be only a fifth to a half that of modern practitioners. The traditional midwives are readily accessible to most of the population in almost all developing countries.

The work of the traditional midwives is diverse. They not only deliver babies but also assist women during the prenatal and postnatal periods and are involved in a number of important aspects of maternal and child health care. During prenatal care they often

use massage to relax muscles, relieve discomfort, and estimate the progress of pregnancy. As delivery approaches, massage is used to position the fetus. . . . During labor the traditional midwife may massage the woman and administer herbal beverages. . . . At delivery many midwives help to extract the baby and the placenta. [Simpson-Hebert and others, 1980, pp. J-444-5].

It is generally believed that some of the practices of the traditional birth attendants are harmful, and that many others, while probably harmless, are of uncertain effect. Harmful practices, or those which can be potentially harmful, include dietary restrictions, mishandling of the umbilical cord (associated with neonatal tetanus), misuse of drugs (for example, heavy use of inappropriate antibiotics), postpartum feeding practices which exclude the feeding of colostrum, and incorrect responses to complications of pregnancy (Popkin and others 1984). Both surveys of modern medical personnel and data from hospital records repeatedly identify neonatal tetanus as the major infant mortality risk associated with deliveries attended by untrained midwives (Mangay-Angara 1981).

Modern Obstetrical Care and Primary Health Care

In the last decade there has been a major effort to expand modern health services in developing countries. One principal goal of the expansion has been the provision of inexpensive modern prenatal and delivery services. Usually, in determining the allocation of these services, the planners have concentrated on simple formulas related to geographic distribution of health services rather than on how best to provide services given the available resources and the benefits of alternative approaches.

Few studies have documented the impact of changes in health facilities and practitioners on the proportion of deliveries attended by modern practitioners,

and even fewer have evaluated the health effects of such changes. An exception is a project in the province of Bohol, Philippines, which implemented and evaluated a maternal and child health and family planning project. Over the period of the project, the availability of low-cost modern care was found to lead to a decline from 67 percent to 1 percent in births attended by untrained midwives. Concurrent declines in the number of cases of neonatal tetanus and in the prevalence of many inappropriate delivery practices (for example, the use of bamboo slivers to cut the umbilical cord) were observed (Williamson 1982; Parado 1979). Another study found that the introduction of modern care to the area led to a reduction in fetal deaths (Akin and others 1984).

The Realignment of Delivery Patterns

In order for government investments in improved delivery services to achieve their objectives, it is essential that the determinants of the choice of type of infant delivery be considered. Surprisingly few systematic studies have considered the factors associated with the choice of delivery services—be it for modern or traditional public or private care—although several recent World Bank studies examine the broader question of demand for health services (see, for example, Dor and van der Gaag, forthcoming; Gertler, Locay, and Sanderson 1987; Dor, Gertler, and van der Gaag forthcoming; Mwabu forthcoming; and Birdsall and Chuhan 1983). Elsewhere the authors have reviewed the earlier studies and presented the results of a small case study of the factors associated with the choice of modern or traditional delivery services (Akin and others, 1984, 1986). That earlier research, based on an analysis of about five hundred births from the Bicol region of the Philippines, concluded that the choice between a modern or traditional birth attendant was made mainly on noneconomic grounds. The important explanatory variables were found to be mother's education and urban residence.

Previous studies of choice of infant delivery method, including the earlier work of these authors, have been based on small samples and, more significantly, have failed to control for some important economic and quality of service characteristics. In this study we expand on previous work by analyzing a large data set which includes information not only on the socioeconomic characteristics of the users of delivery services but also on the economic cost and service quality characteristics of all suppliers of delivery services in the community being analyzed. Moreover, because the data were collected on a prospective basis, they represent a significant improvement over those for other studies based on retrospective recall data.

II. ECONOMIC DEMAND MODEL

In this section we briefly outline a delivery service demand model which is detailed elsewhere (Akin and others, 1984, 1986). We assume that a model for analysis of delivery services must take into account the facts that delivery serv-

ices can be provided either publicly or privately, either by untrained or trained practitioners, and either at home or away from home. In the model each type of delivery has an associated set of characteristics, including time and money prices, availability, and service quality. We assume that a woman maximizes her own well-being, which is a function of the health of her infant. The outcomes predicted as a result of this maximization process are that a woman's choice of type of delivery service will be determined by the prices, availability, and quality of the services plus a set of socioeconomic, demographic, and community factors. In general terms, the relationship between type of delivery used and the exogenous factors is as follows:

$$Y_i = f(P_i, T_i, H_i, Q_i; Z)$$

where Y_i = the i^{th} delivery type

- i = at home by relatives, at home by traditional practitioners, at home by modern public practitioners, at home by modern private practitioners, away from home (at clinics or hospitals) by modern public practitioners, or away from home by modern private practitioners (six possible choices)
- P_i = cash price paid to delivery service provider of type i
- T_i = time price of traveling between the delivery provider of type i and the woman's residence
- H_i = the hours of availability for delivery service of type i
- Q_i = the perceived quality of delivery service of type i
- Z = the set of household and community characteristics (such as income, assets, education, insurance coverage, residence, and household composition) affecting the income available to, the time constraints of, and the knowledge and preferences of, the mother.

III. SURVEY BACKGROUND

The study site is metropolitan Cebu, an area embracing both the city of Cebu and rural areas of the Island of Cebu in the central Philippines. Metropolitan Cebu includes, besides Cebu City, coastal towns and a number of mountain villages. Although basically of Malayan stock, the metropolitan Cebu population (particularly in the urbanized areas) also contains people who are of Spanish and Chinese ancestry.

Metropolitan Cebu is composed of three administratively distinct cities (among them Cebu City, the second largest city of the country) and six other municipalities. At the time of the 1980 census, the administrative entities contained 243 barangays (the barangay is the smallest administrative unit in the Philippines and, in the rural areas, is usually identical with a village) with 171,702 households and slightly more than 1 million inhabitants. The barangay is the initial sampling unit for the survey from which the data are derived.

Separate random samples taken from urban and rural metropolitan Cebu barangays resulted in a sample of 17 urban and 16 rural barangays.

All households in the 33 barangays were surveyed to collect data on all women who had births between May 1, 1983, and April 30, 1984. Baseline surveys were obtained during the sixth month of pregnancy for the 3,327 pregnant women who gave birth during the twelve-month period. For the analysis of delivery patterns, the sample consists of 3,075 women for whom both baseline and birth information were collected and who delivered non-twin births. Of the 3,327 baseline women, 38 (1.1 percent) had stillbirths, 13 (0.4 percent) had miscarriages, 26 (0.8 percent) had twin births, 135 (4.1 percent) outmigrated between the baseline and birth interviews, and 17 (0.5 percent) refused birth interviews. An additional 57 women in the sample communities who gave birth during the twelve-month period but either did not live in the communities during their pregnancy or were missed in the screening for pregnant women are omitted from this analysis.

The public and private health facilities serving the 33 sample barangays also were surveyed. Included in the facility sample are all facilities and personnel located in each barangay, plus personnel and facilities located outside the barangays but identified by proximity to the barangay, by legal jurisdiction over the community (for public clinics and hospitals), or by barangay informants (on questions asked during the baseline) as servicing the sample households. In total, data from 48 modern public and modern private hospitals, clinics, and health center facilities and 88 private modern and traditional health practitioners were used in this analysis. In addition, data were collected from part-time government health facilities (Barangay Health Stations, or BHSS) located in 23 of the 33 barangays.

Variables

Household income and an inventory of the resale value of all household assets were collected from each household at the time of the baseline survey. Because the baseline survey for each household occurred at different points in time over the collection period, income and assets were discounted by an appropriate price index to a common point in time at the beginning of the collection period. This adjustment ensures comparability of the value of income and assets across all households in the survey.

Delivery price data were collected from all health practitioners and facilities in the sample described above. Barangay averages were computed for each possible delivery option (at home by traditional practitioner, at home by modern public practitioner, at home by modern private practitioner, away from home by modern public practitioner, and away from home by modern private practitioner). In addition, households were surveyed to determine the amount of money given to relatives when they assist in delivery. In the Philippines there is a cultural norm which dictates payment for delivery in the form of a gratuity even when there is no explicit market price. Thus even relatives are paid a "fee for service" and

Table 1. *Pattern of Delivery Service Choices Made, 1983-84*

<i>Delivery type</i>	<i>Urban</i>		<i>Rural</i>		<i>Total</i>	
	<i>Number</i>	<i>Percent</i>	<i>Number</i>	<i>Percent</i>	<i>Number</i>	<i>Percent</i>
Relatives and friends, at home	130	5.45	64	8.84	194	6.25
Traditional practitioner, at home	511	21.77	460	63.54	971	31.62
Public practitioner, at home	405	17.26	112	15.47	517	16.83
Private practitioner, at home	200	8.48	14	1.93	214	6.94
Public practitioner, away from home	508	21.64	35	4.83	543	17.68
Private practitioner, away from home	597	25.40	39	5.39	636	20.68
Total	2,351	100.00	724	100.00	3,075	100.00

Source: Original surveys; information about the data sets is available, upon written request, from the authors.

barangay averages of this fee are included in our empirical specification as an expected price, to control for differences in money prices across all delivery options. The average money price by barangay for each type of delivery is used to construct a full menu of delivery prices for each household in the survey. There is fairly wide variation in the money prices paid for the different types of delivery. The price differences are notably large between home and away delivery in general, as well as between public and private away-from-home delivery.

The travel time between the mother and delivery practitioner represents the proximity of each delivery option, whether the mother chooses to travel to the practitioner or to have the practitioner travel to her home for delivery. The quantification of this variable is complex. From the location of the household we determine the facilities available for each type of delivery and from the facilities we determine their populations served. We carry out an analysis of transportation patterns, topography, and distance to estimate the travel time of each household to the relevant public, private, or traditional delivery practitioner. We do not, however, have information on the number of people accompanying the mother (for away-from-home delivery) so that even this very detailed evaluation of travel time considerations may be incomplete for some households.

The pattern of delivery choice across the six methods represented in the dependent variable is presented in table 1. Table 2 describes each independent variable used, and table 3 shows the mean values and standard deviations of the independent variables. All variables are presented separately for urban and rural samples for reasons discussed below.

IV. ESTIMATION METHOD AND RESULTS

The complexity of the issues addressed here is reflected in the range of overlapping methodological choices available for our analysis. We have used the mixed multinomial logit technique to estimate the relationships between delivery

Table 2. *Variable Descriptions*

<i>Delivery-specific variables</i>	
Price	The average price, in pesos, for each delivery type in each barangay is used as the price facing women in each barangay.
Travel time	The time, in minutes, between the household and the delivery practitioner.
Hours available	The number of hours per week that the practitioner and/or facility is available.
Drugs available	Whether drugs are available at the public or private facility (yes = 1; no = 0).
Untrained practitioner	Whether the delivery practitioner has had formal medical training (yes = 0; no = 1).
Trained midwife	Whether the usual delivery practitioner at the public or private facility was a trained midwife (yes = 1; doctors, nurses, or combinations of doctors, nurses, and midwives = 0).
<i>Individual and household characteristics</i>	
Household income	Annual household income, in thousands of pesos.
Household assets	Total value of assets, in thousands of pesos, owned by the household including, among other things, land, housing, consumer goods, and vehicles.
Mother's education	Years of formal schooling.
Father's education	Years of formal schooling interacted with whether the father was present.
Father present	Whether the father is present in the household (yes = 1; no = 0).
Mother's age	Age in years.
Children under age 6	Number of children between the ages 0–6 years.
Females over age 13	Number of females in the household aged 13 and older.
Cebuano	Ethnic origin indicated by language spoken in the household (Cebuano spoken by both husband and wife = 1; otherwise = 0).
Electricity	Whether the household has electricity (yes = 1; no = 0).
Insurance coverage	Whether the woman is covered by health insurance (yes = 1; no = 0).
Wet season	Whether the childbirth occurred during the rainy season (June–October = 1; otherwise = 0).
Dry season	Whether the childbirth occurred during dry months (February–April = 1; otherwise = 0).
Private prenatal visit	Whether a prenatal visit was made to a private practitioner (yes = 1; no = 0).
Public prenatal visit	Whether a prenatal visit was made to a public practitioner (yes = 1; no = 0).
Traditional prenatal visit	Whether a prenatal visit was made to a traditional practitioner (yes = 1; no = 0).

Source: Original surveys; information about the data sets is available, upon written request, from the authors.

Table 3. *Sample Means and Standard Deviations of Independent Variables*

Variable	Urban		Rural		All	
	Mean	SD ^a	Mean	SD	Mean	SD
DELIVERY-SPECIFIC						
<i>Price (in pesos)</i>						
Relatives	48.66	(20.14)	27.36	(8.47)	43.64	(20.22)
Traditional	56.96	(15.85)	48.33	(17.09)	54.92	(16.56)
Public, home	51.27	(14.74)	41.17	(6.62)	48.89	(13.96)
Private, home	66.98	(16.11)	66.37	(39.92)	66.83	(23.94)
Public, away	169.80	(48.75)	162.13	(70.33)	167.99	(54.69)
Private, away	426.81	(104.70)	378.04	(102.93)	391.94	(121.84)
All	136.61	(28.28)	120.27	(13.80)	128.95	(25.40)
<i>Travel time (in minutes)^b</i>						
Traditional	7.27	(4.73)	24.15	(21.13)	11.25	(13.16)
Public	11.23	(5.66)	32.51	(24.67)	16.24	(15.79)
Private	4.39	(2.91)	30.15	(25.16)	10.46	(16.57)
All	6.41	(2.44)	24.99	(15.21)	10.78	(11.04)
<i>Hours available (per week)^c</i>						
Public, away	127.77	(58.06)	58.74	(42.25)	111.49	(62.09)
Private, away	148.95	(36.16)	127.94	(42.76)	143.99	(38.85)
<i>Drugs available</i>						
Public, away	0.51	(0.50)	0.53	(0.26)	0.51	(0.49)
Private, away	0.45	(0.49)	0.36	(0.42)	0.43	(0.49)
Untrained practitioners ^d	0.33	(0.06)	0.33	(0.06)	0.33	(0.06)
<i>Trained midwives</i>						
Public, home	0.41	(0.49)	0.59	(0.49)	0.44	(0.50)
Private, home	0.45	(0.50)	0.43	(0.48)	0.45	(0.47)
Public, away	0.32	(0.47)	0.95	(0.21)	0.47	(0.50)
Private, away	0.00		0.00		0.00	
INDIVIDUAL AND HOUSEHOLD CHARACTERISTICS						
Household income	0.30	(0.47)	0.19	(0.27)	0.28	(0.44)
Household assets	14.25	(54.42)	5.76	(19.35)	12.25	(48.63)
Mother's education	7.62	(3.29)	5.46	(2.29)	7.11	(3.31)
Father's education	7.49	(3.41)	5.09	(3.01)	6.93	(3.51)
Father present	0.94	(0.24)	0.95	(0.21)	0.94	(0.23)
Mother's age	25.88	(5.84)	26.70	(6.46)	26.07	(6.00)
Children under 6	1.49	(1.14)	1.67	(1.12)	1.53	(1.14)
Females over 13	0.51	(0.90)	0.36	(0.76)	0.47	(0.87)
Cebuano	0.91	(0.29)	0.95	(0.21)	0.92	(0.27)
Electricity	0.60	(0.49)	0.18	(0.38)	0.50	(0.50)
Insurance	0.12	(0.32)	0.05	(0.21)	0.10	(0.30)
Wet season	0.50	(0.50)	0.47	(0.50)	0.49	(0.50)
Dry season	0.18	(0.38)	0.20	(0.40)	0.19	(0.39)
Private prenatal visit	0.24	(0.43)	0.07	(0.26)	0.20	(0.40)
Public prenatal visit	0.53	(0.50)	0.47	(0.50)	0.52	(0.50)
Traditional prenatal visit	0.47	(0.50)	0.58	(0.50)	0.49	(0.50)

Note: Numbers in sample: urban, 2,351; rural, 724; all, 3,075.

a. SD = standard deviation.

b. Travel time for relatives assumed equal to zero.

c. Hours available per week for at-home deliveries equals 168.

d. Sample average across all choices.

Source: Original surveys; information about the data sets is available, upon written request, from the authors.

characteristics, mothers' characteristics, and delivery choice. The dependent variable in the delivery model is in the form of a set of unordered, mutually exclusive categories. This estimation procedure allows two types of independent (explanatory) variables to be used—conditional variables, such as the price of delivery, which differs in value for any given mother on the basis of delivery choice made; and unconditional variables, such as mother's age, which does not change as a result of the choice.

An implicit assumption of the multinomial logit (MNL) estimation technique is the "Independence of Irrelevant Alternatives" (IIA). This means that the model cannot be appropriately applied when there are different degrees of substitutability or complementarity among the various choices. In our application, it would imply that each of the six delivery choices is independent and has different characteristics. It also implies that as the value of a variable pertaining to a particular delivery method changes and mothers adjust their choices in response, the proportionate distribution of their movement between that particular delivery type and the five alternatives will be identical to the initial distribution of choices over the five alternatives.

The effect of this assumption is possibly to lessen the simulated effect of changes on some specific variable values, which may change the policy implications of the findings. For instance, an increase in drug availability in public facilities might be expected to draw women almost exclusively out of the other *modern* options while not reducing the use of traditional practitioners.

We do not have information to suggest that any such grouping or covariance among the alternatives exists, and further research would be required to determine if such grouping is the case (for further information on the IIA property and its appropriateness see also Domencich and McFadden 1975; McFadden, Tye, and Train 1986; and Hausman and Wise 1978). Alternatively, the Hausman-McFadden specification test for multinomial logits (1984) can be used to determine if the MNL assumptions are valid. The IIA assumptions do not apply to a nested model, and future research using this methodology may also provide interesting results. We believe, however, that the IIA assumptions are appropriate for the issues being analyzed and that any limitations of the IIA assumptions are outweighed by the model's positive attributes.

X_{ij} represents a vector of values for a set of independent variables (for example, the set of prices in table 3) that vary by choice ($j = 1, 2, \dots, N$) and by woman ($i = 1, 2, \dots, M$), and Z_i represents a vector of independent variables that vary only by woman. The log of the odds of any particular choice being made (choice 1, for example) is:

$$\left[\frac{\text{Prob}(Y_i = j)}{\text{Prob}(Y_i = 1)} \right] = \gamma(X_{ij} - X_{i1}) + \beta_j Z_{ij} \quad (j = 2, \dots, N)$$

where the T s represent coefficients associated with the choice-varying (conditional) independent variables. A positive value for a particular coefficient implies that an increase in the value of that variable is considered a favorable change by the individual (that is, that the corresponding independent variable has positive weight in the individual's indirect utility function), and that an increase in the value of that variable for a particular choice will make it more likely that the choice affected will be made. If the coefficient on the quality of delivery is positive, for example, this indicates that adding to the service quality at any type of provider will tend to increase the individual's likelihood of choosing to use that type of delivery service, and that because of this service quality increase the individual is able to obtain a higher level of welfare.

The β_j coefficients vary by choice of delivery type. In determining the probability of woman i choosing delivery type 1, the β s reflect the influence of the woman's personal circumstances (the Z variables) on her choice of any particular j delivery system. A positive value for a particular coefficient implies that as the corresponding independent variable increases, the probability that choice j will be chosen increases relative to other choices. The use of choice 1 in the denominator of the equation, as the basis for comparison of other choices defining the log odds, is arbitrary. All odds ratios can be computed, and we present all comparisons in our results (tables 4, 5, and 6 below).

The estimation of this model entails solving the above equations for probabilities and setting up a likelihood function (details of the procedure can be found in Maddala 1983).

Model Specification Issues

Urban or rural residence. Because urban and rural residents could reasonably be expected to behave differently in seeking delivery services, we test for such differences. A likelihood ratio test of the null hypothesis, "no behavioral difference between urban and rural residents," is rejected at the 1 percent level of significance, indicating that the two samples do behave differently. Because of this structural difference, we stratify the sample into urban and rural subsamples, and all results are presented for both urban and rural groups.

Choice of prenatal care. The type of prenatal care chosen by the mother (traditional, public, or private practitioner) may be an important factor in the choice of delivery practitioner. It is not unlikely that the choices of prenatal care and delivery practitioner are jointly determined, however, and that the choice of prenatal care is therefore endogenous to the delivery model. A statistical procedure to correct for endogeneity is to estimate the probability that each type of prenatal care is chosen by the mother and then enter these probabilities in the delivery model as lagged (predelivery) endogenous variables. Unfortunately, this procedure is inappropriate in the multinomial logit model because the error term assumptions for the instrumental variables violate the necessary logit model error assumptions. Because no perfect answer to the endogeneity problem in the

logit model exists, we carry out two alternative estimation procedures, each of which is consistent with a specific set of assumptions about the true model. We estimate a reduced form model, in which prenatal care type is not included as an explanatory factor, and assume the results and simulations to be appropriate if the choice of prenatal care actually is endogenous to the model. As an alternative we present estimation and simulation results for a model in which the prenatal care choice is included as an exogenous explanatory variable, a model which is appropriate if in reality the choice of prenatal care type is not jointly determined with the choice of type of delivery service. We compare the results from the two approaches.

Qualifications of delivery practitioner. For each type of delivery service, we also account for the level of training of the person providing the delivery service. We include two binary dummy variables that indicate whether (1) the actual practitioner has received little or no formal medical training (that is, relatives and traditional practitioners) and (2) whether the practitioner who normally makes the delivery is a certified trained midwife. The omitted variable implicit in the inclusion of these two categories is defined as the practitioner performing the delivery being a doctor, a nurse, or a combination (team effort) of doctors, nurses, and midwives. In the sample, the second most common provider of a modern delivery, next to a trained midwife, is a combination of practitioners.

Lack of data on some spouses. There are nearly 200 observations for which the spouse was not present in the household and no information was obtained for the spouse's education. In order to control for the presence of the spouse we have included a binary variable to indicate whether the father was present. As an additional variable, we have accounted for the father's education if he is present in the household.

Income and assets. Household income and assets may have separate influences on the choice of delivery type. Present income, which is immediately spendable, may have a different effect on delivery choice (both in statistical significance and magnitude) than accumulated assets, against which borrowing is possible. In order to control for these differences we enter income and assets separately in the estimation and provide simulation results for both income and asset changes.

While this specification does allow a more exact accounting of the "wealth" of the households, we have not determined the extent of correlation between the two variables, which if significant may bias downward the significance of each variable separately. The asset variable was not used in the calculation of the income elasticities to allow comparability with other income elasticities calculated in the standard manner (that is, excluding assets). However, exclusion of the asset variable from calculation of income elasticity may reduce the elasticity measurement.

We have also chosen not to interact the income/asset and price variables. Thus we do not address the issue of the differential impact of price changes on various income groups. This approach relies on the assumption that price elasticity is independent of income. If, however, demand for delivery services is more

sensitive to price among lower income groups (as suggested by Gertler, Locay, and Sanderson 1987), our averaging of price effects may obscure this difference. Alternative specification of the model would be necessary to determine the extent of any difference in price elasticities among income groups.

Multivariate Results

Tables 4, 5, and 6 present the results from estimation of the mixed multinomial logit model for both the urban and rural samples. (Goodness of fit statistics for the urban and rural models are given in an appendix.) The coefficients for the conditional variables indicate how changes in each of the variables affect the household's utility (welfare), and represent the effect of these factors irrespective of the delivery choice actually made (table 4). For example, because the coefficient on price is found to be negative for both the urban and rural samples, it follows that increasing the price of any of the delivery choices will decrease the utility of the household and will decrease the probability of choosing that option for which price was increased relative to the other delivery options. The coefficients on the unconditional variables are allowed to differ for each delivery method choice (tables 5 and 6). The data indicate how a change in each of these variables affects the probability of choosing each specific type of delivery.

Money and time prices. For the urban households, an increase in the money price of delivery services is a statistically significant and negative factor in the choice of delivery. For rural mothers, price is found to have a negative influence on the choice but is not statistically significant. The negative coefficient findings

Table 4. *Effect of Change in Delivery System Characteristics (Conditional Variables) on Household Welfare*

<i>Characteristic</i>	<i>Urban households</i>	<i>Rural households</i>
Price	-0.0016*** (-3.380)	-0.0002 (-0.148)
Travel time	-0.0088 (-1.283)	-0.0312*** (-8.639)
Hours available	0.0149*** (12.386)	0.0073** (2.048)
Drugs available	0.2621*** (3.174)	0.3889 (0.963)
Untrained midwife	0.8457** (2.088)	1.3886* (1.693)
Trained midwife	0.5035*** (5.631)	0.4924* (1.841)

*** = significant at $\alpha = 0.01$.

** = significant at $\alpha = 0.05$.

* = significant at $\alpha = 0.10$.

Note: Figures in parentheses are *t* statistics.

Source: Original surveys; information about the data sets is available, upon written request, from the authors.

Table 5. *Urban Sample: Effect of Background Characteristics of Mothers (Unconditional Variables) on Probability of Choice of Delivery Service Type*

<i>Delivery type</i>	<i>Household income</i>	<i>Household assets</i>	<i>Mother's education</i>	<i>Father's education</i>	<i>Father present</i>	<i>Mother's age</i>
<i>Choices relative to probability of public practitioner, away from home</i>						
Home: relatives	-0.6367 (-1.065)	-0.0655 (-0.863)	-0.1283 (-3.132)***	-0.0527 (-1.316)	0.0307 (0.064)	-0.0148 (-0.879)
Home: traditional practitioner	-0.1153 (-0.396)	-0.0035 (-1.272)	-0.1154 (-4.335)***	-0.0682 (-2.618)***	0.3656 (1.078)	0.0059 (0.529)
Home: modern public practitioner	0.2725 (1.189)	-0.0025 (-1.078)	-0.0810 (-3.060)***	-0.0572 (-2.117)**	0.4238 (1.285)	-0.0007 (-0.064)
Home: modern private practitioner	-0.1299 (-0.341)	-0.0029 (-0.818)	-0.1452 (-4.355)***	-0.0603 (-1.801)*	0.3512 (0.865)	0.0053 (0.395)
Away from home: modern private practitioner	0.3624 (1.790)*	0.0007 (0.519)	0.1126 (4.570)***	0.1325 (5.118)***	-1.8167 (-5.645)***	0.0143 (1.321)
<i>Choices relative to probability of public practitioner, at home</i>						
Home: relatives	-0.9092 (-1.529)	-0.0030 (-0.454)	-0.0473 (-1.139)	0.0045 (0.111)	-0.3931 (-0.806)	-0.0141 (-0.837)
Home: traditional practitioner	-0.3878 (-1.387)	-0.0010 (-0.306)	-0.0344 (-1.253)	-0.0110 (-0.414)	-0.0582 (-0.167)	0.0066 (0.592)
Home: modern private practitioner	-0.4024 (-1.075)	-0.0004 (0.099)	-0.0643 (-1.880)*	-0.0031 (-0.092)	-0.0726 (-0.176)	0.0060 (0.442)
Away from home: modern private practitioner	0.0899 (0.447)	0.0032 (1.405)	0.1936 (7.098)***	0.1897 (6.678)***	-2.2404 (-6.409)***	0.0150 (1.283)
<i>Choices relative to probability of private practitioner, at home</i>						
Home: relatives	-0.5068 (-0.768)	-0.0026 (-0.368)	0.0170 (0.368)	0.0076 (0.170)	-0.3205 (-0.592)	-0.0200 (-1.082)
Home: traditional practitioner	0.0146 (0.036)	-0.0006 (-0.143)	0.0298 (0.875)	-0.0079 (-0.237)	0.0144 (0.034)	0.0007 (0.048)
Away from home: modern private practitioner	0.4923 (1.332)	0.0036 (1.020)	0.2579 (7.556)***	0.1928 (5.565)***	-2.1679 (-5.148)***	0.0091 (0.649)
<i>Choices relative to probability of private practitioner, away from home</i>						
Home: relatives	-0.9990 (-1.687)*	-0.0062 (-0.970)	-0.2409 (-5.786)***	-0.1852 (-4.497)***	1.8474 (3.733)***	-0.0291 (-1.675)*
Home: traditional practitioner	-0.4777 (-1.726)*	-0.0041 (-1.542)	-0.2280 (-8.244)***	-0.2007 (-7.210)***	2.1822 (6.078)***	-0.0084 (-0.696)
<i>Choices relative to probability of relatives, at home</i>						
Home: traditional practitioner	0.5213 (0.859)	0.0020 (0.303)	0.0129 (0.324)	-0.0155 (-0.395)	0.3349 (0.740)	0.0207 (1.324)

*** = significant at $\alpha = 0.01$.

** = significant at $\alpha = 0.05$.

* = significant at $\alpha = 0.10$.

Note: First figures in parentheses are *t* statistics. The estimated parameters are the log of the ratio of two probabilities. For example, the interpretation of the first coefficient, -0.6367, is that for an increase

<i>Children under 6</i>	<i>Females over 13</i>	<i>Cebuano spoken</i>	<i>Electricity</i>	<i>Insurance</i>	<i>Wet season</i>	<i>Dry season</i>
<i>Choices relative to probability of public practitioner, away from home</i>						
0.1541 (1.665)*	-0.1648 (-1.112)	-0.9016 (-2.663)***	-0.4383 (-1.992)**	0.3579 (1.012)	-0.1650 (-0.742)	0.0335 (0.112)
0.1155 (1.912)*	-0.1150 (-1.348)	-0.5014 (-1.933)*	-0.4612 (-3.214)***	0.2943 (1.264)	0.0365 (0.244)	0.5099 (2.638)***
0.0469 (0.741)	0.0166 (0.203)	-0.3840 (-1.546)	-0.2459 (-1.637)	0.2792 (1.151)	0.0791 (0.512)	0.3152 (1.540)
0.0895 (1.160)	-0.1921 (-1.664)*	-0.7133 (-2.480)**	0.2761 (1.481)	0.1312 (0.418)	-0.3880 (-2.014)**	0.3916 (1.689)*
-0.1615 (-2.616)***	0.0345 (0.473)	-0.8000 (-4.159)***	0.6858 (4.207)***	0.4623 (2.278)**	0.1968 (1.350)	-0.0318 (-0.154)
<i>Choices relative to probability of public practitioner, at home</i>						
0.1072 (1.149)	-0.1813 (-1.212)	-0.5207 (-1.544)	-0.1924 (-0.868)	0.0788 (0.221)	-0.2441 (-1.080)	-0.2816 (-0.945)
0.0686 (1.114)	-0.1316 (-1.497)	-0.1175 (-0.459)	-0.2154 (-1.477)	0.0151 (0.063)	-0.0427 (-0.274)	0.1948 (1.014)
0.0426 (0.540)	-0.2086 (-1.766)*	-0.3293 (-1.141)	0.5220 (2.771)***	-0.1480 (-0.462)	-0.4672 (-2.344)**	0.0764 (0.328)
-0.2084 (-3.106)***	0.0179 (0.218)	-0.5080 (-2.199)**	0.9317 (5.470)***	0.1831 (0.805)	0.1177 (0.721)	-0.3469 (-1.589)
<i>Choices relative to probability of private practitioner, at home</i>						
0.0646 (0.625)	0.0273 (0.160)	-0.1914 (-0.525)	-0.7144 (-2.892)**	0.2267 (0.555)	0.2231 (0.878)	-0.3580 (-1.128)
0.0260 (0.342)	0.0770 (0.643)	0.2118 (0.727)	-0.7374 (-4.044)***	0.1631 (0.525)	0.4245 (2.184)**	0.1184 (0.534)
-0.2510 (-3.119)***	0.2265 (1.944)*	-0.1767 (-0.663)	0.4097 (2.006)**	0.3311 (1.092)	0.5848 (2.928)***	-0.4233 (-1.734)*
<i>Choices relative to probability of private practitioner, away from home</i>						
0.3156 (3.296)***	-0.1992 (-1.333)	-0.0147 (-0.045)	-1.1241 (-4.792)***	-0.1044 (-0.302)	-0.3618 (-1.575)	0.0653 (0.211)
0.2770 (4.248)***	-0.1495 (-1.706)*	0.3885 (1.643)	-1.1471 (-6.932)***	-0.1680 (-0.762)	-0.1603 (0.997)	-0.5417 (2.575)**
<i>Choices relative to probability of relatives, at home</i>						
-0.0386 (-0.426)	0.0497 (0.331)	0.4032 (1.297)	-0.0230 (-0.106)	-0.0636 (-0.184)	0.2014 (0.921)	0.4764 (1.666)*

in household income, the woman would be less likely to choose at home with relatives, than away from home with a public practitioner.

Source: Original surveys; information about the data sets is available, upon written request, from the authors.

Table 6. *Rural Sample: Effect of Background Characteristics of Mothers (Unconditional Variables) on Probability of Choice of Delivery Service Type*

<i>Delivery type</i>	<i>Household income</i>	<i>Household assets</i>	<i>Mother's education</i>	<i>Father's education</i>	<i>Father present</i>	<i>Mother's age</i>
<i>Choices relative to probability of public practitioner, away from home</i>						
Home: relatives	-4.0438 (-2.512)**	-0.0011 (-0.060)	-0.3032 (-3.195)***	0.0112 (0.118)	1.4149 (1.388)	-0.0578 (-1.509)
Home: traditional practitioner	-0.3176 (-0.495)	-0.0085 (-0.820)	-0.1374 (-1.795)*	-0.1290 (-1.680)*	2.3200 (2.770)***	-0.0180 (-0.567)
Home: modern public practitioner	-0.3655 (-0.510)	-0.0046 (-0.401)	-0.0396 (-0.508)	-0.0583 (-0.718)	1.3530 (1.592)	0.0010 (0.032)
Home: modern private practitioner	-1.8023 (-0.723)	0.0065 (0.290)	0.1202 (0.881)	-0.0756 (-0.558)	2.7420 (1.602)	-0.1568 (-2.133)**
Away from home: modern private practitioner	-0.1903 (-0.282)	0.0100 (1.344)	-0.1716 (-1.863)*	0.0193 (0.202)	-0.3155 (-0.313)	0.0480 (1.321)
<i>Choices relative to probability of public practitioner, at home</i>						
Home: relatives	-3.6782 (-2.315)**	0.0034 (0.183)	-0.2636 (-3.459)***	0.0695 (0.933)	0.0619 (0.072)	-0.0589 (-1.977)**
Home: traditional practitioner	0.0480 (0.077)	-0.0039 (-0.351)	-0.0978 (-1.854)*	-0.0706 (-1.372)	0.9670 (1.504)	-0.01904 (-0.904)
Home: modern private practitioner	-1.4368 (-0.579)	0.0110 (0.480)	0.1598 (1.282)	-0.0173 (-0.141)	1.3890 (0.865)	-0.1579 (-2.271)**
Away from home: modern private practitioner	0.1752 (0.238)	0.0145 (1.367)	-0.1321 (-1.792)*	0.0776 (0.997)	-1.6685 (-1.965)**	0.0469 (1.672)*
<i>Choices relative to probability of private practitioner, at home</i>						
Home: relatives	-2.2414 (-0.788)	-0.0076 (-0.281)	-0.4234 (-3.130)***	0.0868 (0.658)	-1.3270 (-0.770)	0.0990 (1.366)
Home: traditional practitioner	1.4848 (0.605)	-0.0150 (-0.668)	-0.2576 (-2.098)**	-0.0534 (-0.445)	-0.4220 (-0.260)	0.1388 (2.002)**
Away from home: modern private practitioner	1.6120 (0.647)	0.0035 (0.159)	-0.2918 (-2.180)**	0.0948 (0.711)	-3.0575 (-1.790)*	0.2048 (2.860)***
<i>Choices relative to probability of private practitioner, away from home</i>						
Home: relatives	-3.8534 (-2.391)**	-0.0111 (-0.619)	-0.1316 (-1.454)	-0.0081 (-0.090)	1.7304 (1.724)*	-0.1058 (-3.099)***
Home: traditional practitioner	-0.1272 (-0.196)	-0.0185 (-1.960)**	0.0343 (0.486)	-0.1482 (-2.103)**	2.6355 (3.284)***	-0.0660 (-2.531)**
<i>Choices relative to probability of relatives, at home</i>						
Home: traditional practitioner	3.7262 (2.469)**	-0.0074 (-0.439)	0.1659 (2.589)***	-0.1401 (-2.179)**	0.9051 (1.240)	0.0398 (1.616)

*** = significant at $\alpha = 0.01$.

** = significant at $\alpha = 0.05$.

* = significant at $\alpha = 0.10$.

Note: Figures in parentheses are *t* statistics. The estimated parameters are the log of the ratio of two probabilities. For example, the interpretation of the first coefficient, -4.0438, is that for an increase in

<i>Children under 6</i>	<i>Females over 13</i>	<i>Cebuano spoken</i>	<i>Electricity</i>	<i>Insurance</i>	<i>Wet season</i>	<i>Dry season</i>
<i>Choices relative to probability of public practitioner, away from home</i>						
0.1260 (0.575)	0.3774 (1.228)	-0.2292 (-0.301)	0.4184 (0.730)	-0.3974 (-0.702)	0.0115 (0.023)	-0.3519 (-0.510)
-0.0243 (-0.130)	0.1659 (0.679)	0.4230 (0.634)	-0.1674 (-0.349)	-0.5009 (-1.125)	-0.0503 (-0.1179)	0.2733 (0.481)
0.0052 (0.027)	0.0264 (0.105)	0.0986 (0.156)	0.0851 (0.172)	-0.2716 (-0.584)	-0.2023 (-0.450)	-0.1991 (-0.334)
0.2701 (0.759)	-0.5463 (-0.915)	-0.7159 (-0.754)	0.2279 (0.290)	0.9548 (1.290)	-1.1097 (-1.479)	-0.8203 (-0.835)
-0.4792 (-1.950)*	-0.3715 (-1.094)	0.0382 (0.050)	0.4726 (0.817)	0.3098 (0.574)	-0.0391 (-0.072)	0.0218 (0.031)
<i>Choices relative to probability of public practitioner, at home</i>						
0.1207 (0.741)	0.3510 (1.384)	-0.3278 (-0.546)	0.3333 (0.752)	-0.1258 (-0.276)	0.2138 (0.563)	-0.1528 (-0.292)
-0.0296 (-0.249)	0.1395 (0.804)	0.3244 (0.669)	-0.2524 (-0.786)	-0.2293 (-0.764)	0.1520 (0.551)	0.4723 (1.348)
0.2649 (0.816)	-0.5728 (-1.004)	-0.8145 (-0.980)	0.1429 (0.204)	1.2264 (1.860)*	-0.9074 (-1.344)	-0.6212 (-0.711)
-0.4845 (-2.410)**	-0.3979 (-1.315)	-0.0804 (-0.096)	0.3876 (0.841)	0.5814 (1.339)	0.1632 (0.372)	0.2209 (0.403)
<i>Choices relative to probability of private practitioner, at home</i>						
-0.1442 (-0.426)	0.9237 (1.548)	0.4867 (0.529)	0.1904 (0.252)	-1.3521 (-1.844)*	1.1212 (1.577)	0.4684 (0.497)
-0.2944 (-0.923)	0.7123 (1.253)	1.1389 (1.356)	-0.3953 (-0.576)	-1.4556 (-2.256)**	1.0594 (1.604)	1.0935 (1.276)
-0.7494 (-2.093)**	0.1749 (0.282)	0.7541 (0.797)	0.2447 (0.321)	-0.6450 (-0.893)	1.0706 (1.444)	0.8421 (0.882)
<i>Choices relative to probability of private practitioner, away from home</i>						
0.6052 (2.760)***	0.7489 (2.165)**	-0.2674 (-0.354)	-0.0543 (-0.101)	-0.7071 (-1.329)	0.0506 (0.104)	-0.3737 (-0.580)
0.4549 (2.448)**	0.5374 (1.870)*	0.3849 (0.595)	-0.6400 (-1.498)	-0.8106 (-2.041)**	-0.0112 (-0.028)	0.2514 (0.500)
<i>Choices relative to probability of relatives, at home</i>						
-0.1503 (-1.091)	-0.2115 (-0.965)	0.6522 (1.183)	-0.5858 (-1.454)	-0.1035 (-0.249)	-0.0618 (-0.193)	0.6251 (1.358)

household income the woman would be less likely to choose at home with relative, than away from home with a public practitioner.

Source: Original surveys; information about the data sets is available, upon written request, from the authors.

suggest that an increase in the user charges for any type of delivery will tend to reduce the likelihood that type will be chosen.

The relationship between travel time from the household to the delivery practitioner and the type of delivery chosen is also found to be negative for both samples but is statistically significant only for the rural sample. This finding suggests that increased distance to a facility will reduce its usage in the rural areas. Note that in this model it can't be assumed that the ratio of the time to price coefficients provides an implicit value of time for the urban and rural samples. Further work would be needed before any implications about the relative value of time between the rural and urban samples could be determined. (For a study that specifically examines the implicit value of time in health care choice, see Mwabu forthcoming.)

An explanation of the lack of statistical significance for time (distance) prices in the urban areas is that the urban sample is relatively close to all delivery options (6.41 minutes, on average) and that there is little variation in the time required to travel across all options (2.44 minutes). It appears that in these urban situations, time spent to reach a practitioner, though negatively related to delivery choice, is not an important factor in the choice. The opposite is true for the rural households who live much farther away from all types of delivery care (24.99 minutes, on average) and for whom the variation in travel time to the choices can be great. For this rural sample, time is negatively related to delivery choice and the statistical tests suggest that it is an important factor in the choice.

Hours of availability of services and availability of drugs. The hours per week that each delivery choice is available is a positive and statistically significant factor for both the urban and rural samples, indicating that an increase in its hours of availability will increase the probability that any delivery option will be chosen. Whether or not drugs are available at the public and private facilities is entered as a quality of service variable, and, as expected, is positively related to delivery choice. The availability of drugs is statistically significant for the urban sample, but we have less confidence in the finding for the rural households.

Training of practitioner. The results suggest that households prefer delivery services from midwives, whether they are formally trained or not, to deliveries performed by combinations of doctors, nurses, and midwives (the excluded category). For the delivery practitioner either to be a midwife with no formal training or a formally trained midwife is found to be positively associated with the selection of the delivery service with which that practitioner is associated, and this association is statistically significant for both the urban and rural samples.

Income, assets, and other factors. The results found for the unconditional variables (factors which do not change according to the delivery method chosen) may be interpreted as the influence of these factors on each delivery option relative to each other option. In most cases, our model finds household income and household assets not to be statistically significant factors in delivery method choice in either the urban or rural samples. In the rural sample, however, in three of the fifteen categories, having greater income or assets does appear to signifi-

cantly increase the probability that deliveries away from home (at both public and private facilities) will be chosen.

Having insurance coverage appears to increase the probability that modern private practitioner deliveries will be chosen but to have little effect on other delivery choices. Only approximately 10 percent of the women in our sample have insurance, so the effect of price on behavior is not likely to be captured by the insurance variable in this case. It is important to note, however, that where medical insurance is more widespread, it will reduce the effective price faced by insured women. This will bias downward the measured sensitivity of delivery choice to nominal price changes. We include the dummy as a control variable to reduce any bias on the price variable caused by the few women who do have insurance coverage.

Urban mothers with a higher educational level are more inclined to choose away-from-home delivery than are their less-educated counterparts, whereas more educated rural mothers are more likely to choose modern delivery.

Simulation Results

Simulations were carried out to examine the effects of changes in the characteristics of public delivery services on the choice of home and away-from-home delivery in order to examine the policy implication of such changes. The changes examined are in travel time, money price, hours of operation, and drug availability—the factors most likely to be affected by government service provision and financing decisions. To complete the picture, the effects of changes in factors less amenable to government policy manipulation, such as household income, assets, insurance coverage, mother's education, and choice of prenatal care, are also examined.

The interpretation of the meaning of the *magnitude* of the coefficients in a multinomial logit model is difficult because the estimated parameters are the logarithm of the ratio of two probabilities. Table 7 presents simulations performed using the logit estimates to obtain predicted probabilities. Probabilities of choices are estimated for hypothetical households having the sample means for all independent variables, and then changes in these probabilities are determined which result from changes in the specific conditional and unconditional variables. The simulation results are revealing because the statistical significance of a relationship does not necessarily indicate that the effect of the independent variable on the dependent variable will be large. An effect could in fact be strongly significant but almost infinitely small, and therefore not "significant" in the nonstatistical sense of the word.

From the information presented in table 7, we see that if each woman in the sample had a value for each independent variable set at its sample mean (see table 3), approximately 27 percent of the urban sample and 73 percent of the rural sample would choose to deliver at home, with either a traditional practitioner or relative attending; about 26 percent of the urban sample and 17 percent of the rural sample would choose delivery at home with a modern public or

Table 7. *Predicted Probabilities and Changes in Probabilities of Delivery Choice by Residence*

Mean values and changes in independent variables	Urban home				Urban away		Rural home				Rural away	
	REL	TRAD	HPUB	HPRIV	APUB	APRIV	REL	TRAD	HPUB	HPRIV	APUB	APRIV
MEAN VALUES	0.0553	0.2130	0.1717	0.0930	0.2124	0.2546	0.0828	0.6455	0.1573	0.0166	0.0445	0.0533
CHANGES IN PROBABILITY												
For price increased by one standard deviation												
Public, home ^a (51–66 for urban; 41–48 for rural)	0.0003	0.0010	–0.0037	0.0004	0.0011	0.0009	0.0	0.0002	–0.0002	0.0	0.0	0.0
Public, away ^a (170–218 for urban; 162–232 for rural)	0.0010	0.0042	0.0037	0.0017	–0.0142	0.0036	0.0001	0.0007	0.0002	0.0	–0.0010	0.0
For travel time increased by one standard deviation (11–16 for urban; 33–57 for rural)												
Public, home	0.0005	0.0022	–0.0078	0.0009	0.0024	0.0018	0.0071	0.0694	–0.0889	0.0008	0.0079	0.0037
Public, away	0.0004	0.0027	0.0024	0.0011	–0.0090	0.0024	0.0027	0.0259	0.0074	0.0003	–0.0377	0.0014
For hours available increased by one standard deviation												
Public, away (128–68 hours/week for urban; 60–100 hours/week for rural)	–0.0081	–0.0343	–0.0304	–0.0141	0.1161	–0.0292	–0.0016	–0.0159	–0.0045	–0.0002	0.0231	–0.0008
For drugs made available at public facilities (from 0–1)												
Public, away	–0.0034	–0.0142	–0.0126	–0.0059	0.0482	–0.0121	–0.0016	–0.0155	–0.0045	–0.0002	0.0226	–0.0008

<i>For trained midwife changed (from 0–1)</i>												
Public, home	–0.0054	–0.0229	0.0821	–0.0094	–0.0249	–0.0195	–0.0057	–0.0538	0.0716	–0.0007	–0.0064	–0.0030
Public, away	–0.0068	–0.0286	–0.0253	–0.0117	0.0967	–0.0243	–0.0019	–0.0189	–0.0054	–0.0002	0.0274	–0.0010
<i>For household income increased by one standard deviation (from 0.30–0.77 urban; 0.19–0.46 rural)</i>												
	–0.0147	–0.0181	0.0199	–0.0080	–0.0073	0.0282	–0.0041	–0.0260	–0.0050	0.0025	0.0098	0.0228
<i>For household assets increased by one standard deviation (from 14–69 urban; 6–25 rural)</i>												
	–0.0101	–0.0216	–0.0095	–0.0062	0.0223	0.0251	0.0006	–0.0236	0.0004	0.0021	0.0085	0.0120
<i>For insurance coverage (from 0 to 1)</i>												
	–0.0053	–0.0281	–0.0134	0.0094	0.0528	0.0153	–0.0025	–0.0869	0.0162	0.0166	0.0290	0.0278
<i>For mother's education increased by one standard deviation (8–11 for urban; 5–8 for rural)</i>												
	–0.0150	–0.0564	–0.0322	–0.0296	0.0225	0.1107	–0.0330	–0.0438	0.0337	0.0057	0.0116	0.0258
<i>For prenatal care changed (from 0–1)</i>												
Public	–0.0102	–0.0045	–0.0099	–0.0282	0.1023	–0.0495	–0.0469	–0.0988	0.1077	0.0035	0.0241	0.0104

REL = probability of home delivery with relatives

TRAD = probability of home delivery with traditional practitioner

HPUB = probability of home delivery with public practitioner

HPRIV = probability of home delivery with private practitioner

APUB = probability of away-from-home delivery with public practitioner

APRIV = probability of away-from-home delivery with private practitioner

a. Simulations of the effects of public prenatal care are from a separately estimated model in which prenatal care is assumed not to be jointly determined with the choice of delivery.

Source: Original surveys; information about the data sets is available, upon written request, from the authors.

private practitioner; and 47 percent of the urban and 10 percent of the rural would choose away-from-home delivery with a modern public or private practitioner.

The simulation results, indicating expected changes in these average probabilities that result from changes in the explanatory variables, show that changes in money and time prices for public delivery services have differential impacts on women in the urban and rural samples. When the money prices of public deliveries, either at home or away, are increased by one standard deviation, the results suggest that there will be little or no change in the choices of delivery care made by the rural sample. The women in the urban sample also appear to be relatively insensitive to moderate changes in money prices, although the urban women are more responsive to changes in public delivery prices than are the rural. In the urban areas a tradeoff between traditional and public delivery is evident: increases in the price of public delivery (especially away-from-home) increase the likelihood of the choice of traditional delivery.

The simulation results for changes in the time prices of public practitioners indicate only limited responsiveness for the urban sample; the rural sample appears to be more sensitive to changes in time prices. When the travel time between a rural mother and a public practitioner for home delivery is increased by one standard deviation, the model predicts a decrease of about 0.09 in the probability that the mother will choose to use the public-practitioner-at-home option, and a 0.07 increase in her likelihood of switching to a traditional practitioner. Increasing the travel time to public facilities for away-from-home deliveries also appears greatly to decrease the probability of a rural woman choosing this option (-0.0377). Note that the probability of this choice at the *mean* is only 0.0445.

Often the degree of sensitivity of a dependent variable is represented by a measure called elasticity—the percentage change in the dependent variable resulting from a 1 percent change in the explanatory variable. Our results for changes in money and time prices and income are expressed as elasticities below, in order to make the comparisons more interpretable. The elasticity estimates indicate the changes in the dependent variable caused by an equal percentage change in each of the explanatory variables.

The elasticity results suggest that although many policy factors are statistically significant determinants of the choice of delivery, the choice is relatively insensitive to many of the economic determinants (money prices, time prices, and income) of demand:

<i>Money price</i>	<i>Urban</i>	<i>Rural</i>
Public, home	-0.0733	-0.0074
Public, away	-0.2368	-0.0520
<i>Time price</i>		
Public, home	-0.0999	-0.7771
Public, away	-0.0932	-1.1648
<i>Income</i>		
Public, home	0.0739	-0.0224
Public, away	-0.0219	0.1550

All money price effects are found to be in the inelastic range, indicating low responsiveness of the probability of choosing a modern public practitioner for delivery to a change in the price of these practitioners. The largest of these, -0.2368 for an urban away-from-home public facility delivery, indicates that the probability of choosing this option will decrease by 0.2368 percent for a 1 percent increase in price (that is, a 1 percent change in the mean price will lead to a change in the probability that is about 0.2 percent as large as the mean probability). Our findings suggest, therefore, that a policy designed to increase the use of modern publicly provided delivery services by decreasing money prices may do little to increase demand, just as an increase in prices to raise revenues may reduce usage very little. As noted above, however, our analysis has not accounted for the differential impact of price changes among income groups. Thus, the price elasticity of demand may vary across income groups, and the results of a price increase may differ among them.

That time prices for the urban sample are also inelastic suggests that decreasing the time required to travel between public practitioners and urban expectant mothers also may have a minor effect. The elasticities of time prices for the rural sample, however, are seen to be much larger than those for the urban women, with the travel time to public facilities actually falling in the elastic range. The elasticity coefficient suggests that a 1 percent decrease in the mean travel time to modern public facilities will increase the probability of choosing that option by 1.16 percent of its mean value. It appears that locating more public practitioners and facilities in rural areas could effectively increase the use of modern delivery in these areas. Furthermore, the simulation results shown in table 6 suggest that decreasing the travel time to these modern public practitioners would lead primarily to a decrease in the use of traditional practitioners, while leaving the use of other (private) modern practitioners relatively unchanged.

Household income is found to be inelastically related to delivery method choices for both the urban and rural samples. It is interesting to note that for the urban sample, public facilities for away-from-home deliveries seem to be viewed as inferior goods in that an increase in income tends to decrease the likelihood that this delivery option will be chosen. The simulation results suggest that if they experienced income increases, mothers would substitute toward the use of private facilities and at-home deliveries with public practitioners. Conversely, for the rural sample, at-home, public-practitioner delivery seems to be viewed as an inferior good. An increase in income would tend to shift the pattern of delivery away from this public at-home option toward private at-home and both private and public away-from-home delivery.

The number of hours per week that public facilities are available is increased by 40 hours for the purpose of the simulation exercise. For the urban sample this change represents an increase to 168 hours per week (that is, 24-hour-a-day availability) and is seen to significantly increase the odds that public away-from-home delivery will be chosen. The predicted 0.116 increase represents an increase of over 50 percent in the probability that a woman in the urban sample

with mean characteristics would choose this option. The rural sample also appears to be very responsive to increases in the hours of availability of public facilities. When hours of operation are increased from 60 to 100 hours per week, women become 0.0231 more likely to choose this modern away-from-home option, an increase of over 50 percent of the probability predicted at mean values (table 7).

A dummy variable for whether drugs are available at the public facility is entered in the model as a proxy for the quality and range of services offered there. The simulation results indicated that adding drug availability at a public facility where drugs are not available will cause a relatively large increase in the probability that the public delivery option will be chosen. When drugs are made available the likelihood that this modern away-from-home option will be chosen is increased by 0.0482 for the urban sample, representing an increase of over 20 percent of the predicted probability when all variables are at their mean values. For the rural sample the increase is 0.0266 and represents a change of over 50 percent of the probability predicted at the mean values.

In general, both the urban and rural samples are highly responsive to having trained midwives perform deliveries either at home or at public facilities away from home. For the urban sample, having trained public midwives as the only practitioners to perform at-home deliveries would increase the probability of this option's choice by 0.0821. For away-from-home deliveries at public facilities the result of having trained midwives as the practitioners is similar, a 0.0967 increase. For the rural sample, attendance of trained midwives in at-home public deliveries is predicted to increase the probability of the choice of at-home public delivery by 0.0716, and for away-from-home public delivery by 0.0274. In each of these four cases the increase in the probability of choosing the delivery option represents over 45 percent of the predicted probability at sample mean values. Also, in each case large reductions in the likelihood of selecting traditional delivery practitioners occur. It is obvious that for the Cebu samples trained midwives are highly regarded as birth attendants.

If household income is increased by one standard deviation, the model predicts that urban mothers will be more likely to choose both home deliveries by public practitioners and away-from-home deliveries at private facilities, although the magnitudes of these predicted changes are relatively small. For the rural sample an increase in household income is seen to increase the likelihood of both public and private away-from-home deliveries, as well as that of home deliveries by private practitioners.

Increases in household assets appear to increase the probability of choice of the modern away-from-home option for the urban sample, and to shift the pattern of delivery away from the traditional types of delivery for the rural sample. While the magnitudes of the simulation results suggest that changes in household wealth do not affect the pattern of delivery to a large extent, once again, inclusion of both the income and asset variables in the specification of the

model may create some downward bias in their measured influence on delivery choice.

The results for the effect of the mother's having insurance coverage indicate that insurance increases the likelihood of choosing private at-home, public away-from-home, and private away-from-home deliveries for members of both the urban and the rural samples. In the urban sample the largest response to insurance coverage is an increase of 0.0528 in the probability of the choice of public away-from-home deliveries, a change which represents about 25 percent of the predicted probability of choosing that option at mean values for all variables. For the rural sample insurance coverage is seen to greatly increase the probability of choosing private at-home, and both public and private away-from-home delivery. With coverage, the probability of a home delivery with a private practitioner is doubled, and the predicted probability of public away-from-home deliveries is increased by 0.0290, roughly 65 percent of the expected probability at the means. The increase in private away-from-home deliveries (0.0278) represents more than 50 percent of the mean expected probability of choosing this option.

Simulations to test the effect of increases in the mother's education (increasing the number of years of education by one standard deviation) indicate that urban mothers who are more highly educated will be more likely to choose modern public and private away-from-home deliveries than will those with less education. In the rural sample, more highly educated mothers become more likely to choose modern practitioners, both at home and away-from-home, rather than relatives and traditional practitioners.

Using the coefficient results from the alternative estimations, which included dummy variables for whether the women had received prenatal care from a traditional, public, or private practitioner, simulations were performed to test the effect of the woman's choosing public prenatal care. The use of this model implies that choice of type of prenatal care is exogenous to the choice of delivery service model. For the urban sample the effect of using public prenatal care is seen to be a 0.1023 increase in the likelihood that a modern, public, away-from-home delivery is chosen, representing nearly a 50 percent increase over the probability of this choice when all variables are at their mean values. For the rural sample choosing public prenatal care increases the probability that a modern delivery—whether away-from-home, at-home, or from public or private practitioners—will be chosen. The largest increase (0.1077) is for the probability of a home delivery with a public practitioner, an increase of 68 percent over the probability at the means. The increase in the probability of choosing delivery at a public facility for those who use public prenatal care is also relatively large (0.0241), representing a 54 percent increase over the probability at the means. For the rural sample the effect of using public prenatal care is to decrease the likelihood of choosing a traditional delivery by 0.0988, a decrease of 15 percent of the probability at the mean values. For the urban sample, the largest effects of

using public prenatal care are reductions in the probabilities of choosing both at-home (-0.028) and away-from-home (-0.05) private practitioner delivery.

V. SUMMARY AND POLICY IMPLICATIONS

The provision of modern birth delivery services has been a major concern in many low-income countries. The study reported on here examines the determinants of the choice of delivery in the Cebu region of the Philippines. The study focuses on the effects of money prices, time prices, characteristics of delivery services, and socioeconomic characteristics of the households on the choice of type of delivery care, especially modern delivery care. A unique data set, with money and time prices and facility quality measures, designed expressly for this analysis and providing prospective information for over 3,000 mother-infant pairs, is used. We examine the effect of factors which are specific to each delivery type, as well as unconditional factors which vary between households. The findings raise questions about some prior assumptions and analyses on the effect of travel time and prices of delivery, and other factors crucial for policymaking.

The results found for the travel time price of infant delivery suggest that in urban areas decreasing the travel time between expectant mothers and modern public delivery services would have a minor effect on the use of these services. In rural areas, however, decreasing the travel time between expectant mothers and modern public delivery services by locating practitioners and facilities nearby would increase the use of modern delivery services.

In addition to increasing the accessibility of public delivery practitioners and facilities in rural areas, other public policy changes, including increasing the hours of operation, increasing the availability of drugs, and providing trained midwives at public facilities are found to cause increases in the use of modern delivery services.

The results also suggest that the choice of delivery service type is relatively insensitive to changes in money prices. Thus this model suggests that policies designed to increase the use of modern publicly provided delivery services by decreasing money prices may do little to increase demand for these services. Conversely, an increase in the money price for modern publicly provided delivery services for cost recovery purposes may decrease usage very little.

Because these results run counter to some expectations, further research—most particularly, variations in the estimation of the model—would assist in evaluating the extent to which these findings may serve to guide future policy on modern delivery services in developing countries.

APPENDIX: GOODNESS OF FIT STATISTICS

<i>Urban Sample</i>		
	<i>Log likelihood</i>	<i>Chi-square</i>
<i>Full model</i> (66 d.f.)	-3,408.15	1,596.22
<i>Variable excluded</i> (61 d.f.)		
Household income	-3,412.58	1,585.37
Household assets	-3,410.99	1,588.52
Mother's education	-3,461.19	1,488.14
Father's education	-3,452.50	1,519.86
Father present	-3,436.93	1,536.66
Mother's age	-3,410.17	1,590.17
Children under 6	-3,419.44	1,571.64
Females over 13	-3,411.77	1,586.99
Cebuano	-3,418.92	1,572.67
Electricity	-3,439.09	1,532.33
Insurance	-3,411.02	1,588.47
Wet season	-3,413.08	1,584.35
Dry season	-3,413.69	1,588.13

<i>Rural Sample</i>		
	<i>Log likelihood</i>	<i>Chi-square</i>
<i>Full model</i> (66 d.f.)	-665.99	1,190.81
<i>Variable excluded</i> (61 d.f.)		
Household income	-670.62	1,181.55
Household assets	-669.02	1,184.75
Mother's education	-675.96	1,170.87
Father's education	-670.89	1,181.01
Father present	-673.92	1,173.96
Mother's age	-674.52	1,173.76
Children under 6	-670.77	1,181.25
Females over 13	-669.65	1,183.49
Cebuano	-667.35	1,188.10
Electricity	-667.86	1,187.07
Insurance	-699.12	1,196.22
Wet season	-667.54	1,187.71
Dry season	-668.17	1,186.46

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The Management of the Developing Countries' Debt: Guidelines and Applications to Brazil

Daniel Cohen

Some principles which may be useful in formulating a debt management strategy are articulated. There are four major policy recommendations: (1) stretch out the repayment of the debt; (2) monitor both exports and GDP; (3) ignore the capital loss of the creditors; and (4) watch the domestic deficit. The goal of the recommendations is the maximization of the intertemporal welfare of the country under the constraint that it services its debt.

The financial crisis of 1982 sent a simple message: the developing countries' debt could not be rolled over according to the previous rules of the financial game. In order to service their debts, debtors were required to reduce their imports and boost their exports. At that time, the main uncertainty was: would a debtor country default rather than adjust? Today, this question has been partially answered. Brazil, for example, chose to generate a \$10 billion (billion is 1,000 million) (noninterest) surplus rather than default on its external debt, an action which can help to change the view that some may have had of the developing countries' debt problem. Furthermore, the shocks which now seem to affect the world economy are more idiosyncratic than the earlier worldwide recession and high real interest rates. They arise from terms of trade uncertainty, which penalizes some and helps others, or from domestic financial difficulties, which call for country-specific remedies. In brief, the developing countries' debt management may have gained, in the aggregate, some margin for action.

In this article, some principles which may be useful in formulating a debt management strategy for the coming years are articulated. There are four major policy recommendations which draw on an analysis presented in the appendixes: (1) stretch out the repayment of the debt; (2) monitor both exports and gross domestic product (GDP); (3) ignore the capital loss of the creditors; and (4)

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watch the domestic deficit. The goal of the recommendations is the maximization of the intertemporal welfare of the country under the constraint that the debt is serviced.

Stretching Out the Repayment of the Debt

As emphasized in previous work (Cohen 1985), a country need repay neither the principal nor even all the interest falling due on its external debt in order to remain solvent. Solvency requires only that the debt grow less rapidly than the interest rate. To be feasible, this requires that the debt grow no faster than the country's revenues. Yet this is certainly not a sufficient guide for monitoring the debt. It is not only the capability of the country to service its debt which matters but also its willingness to do so. Credit ceilings are required which are low enough to keep the country from defaulting (at least under some set of events). Out of a simple deterministic intertemporal framework, drawing on Eaton and Gersovitz (1981) and Cohen and Sachs (1985), I show how these credit ceilings can be calculated. The basic result is as follows: the credit ceiling must be low enough that the country would prefer to keep its debt-over-"resource" ratio a constant "on average" rather than default. ("On average" and "resource" are defined below; here exports can serve as a proxy for "resource.")

From this, one can see that a country which is believed to have reached its credit ceiling should not be asked to reduce its debt-to-export ratio; it would default rather than so do. Instead, it should be asked to stretch out the service of its debt so as to keep its debt-to-resource ratio constant (on average).

Watching Both GDP and Exports

Which measure of resources should one take? Exports are too narrow, GDP too broad. Even if factors of production could be inexpensively transferred from one sector of the economy to another, GDP would still be an inadequate measure upon which to base reschedulings. In effect, if the country were to understand that its new loans were to depend upon its GDP growth (in dollars), then it would have an incentive to overvalue its currency so as to inflate the dollar value of its GDP artificially. Conversely, if exports were taken as the sole measure of resources, this would create a bias in the opposite direction. What is needed is a measure of resources which is invariant with respect to the real exchange rate, a version of the "invariant measure of wealth" (the "standard commodity") calculated by Sraffa (1960) for wage-profit sharing. In a simple framework, I show that such a measure can be derived from GDP and exports. A numerical estimate is provided for the case of Brazil: it is 10 percent of GDP plus 90 percent of exports.

Ignoring the Creditors' Capital Loss

In view of the repayment strategy sketched above, one could expect lenders to be more than happy with Brazil's recent trade balance as the debt-to-export ratio has declined substantially. Yet, they are not: on the secondary markets, Brazil's

debt is discounted. To see why this is so, consider an oil exporting country. Assume it is servicing its debt with interest being paid when due. If this were expected to last forever, then the debt should be priced at its face value. Now, instead, assume that there is always a 20 percent probability that the price of oil will fall to zero. Whatever the face value of the country's debt, however good its servicing intentions, there will always be a 20 percent discount on its debt. If the banks were to grant a 20 percent moratorium, a 20 percent discount would still apply to the newly written-down debt. What this example suggests is that the market value of the debt is of little help in assessing the repayment strategy of an indebted country. In a framework in which all uncertainties are assumed to be perfectly assessed, I show that the simple maxim indicated in the first point, "stretch out the repayment of the debt," should continue to be applied to the face value of the debt, even when it does not coincide with its current market value.

Watching the Domestic Government Deficit

Assume that a country does achieve the external adjustment expected of it. This does not imply that the country's government has undertaken the appropriate adjustment. The rationing of imports may create a trade balance surplus, but it does not necessarily bring the government the income it needs to repay *its* debt. If the government postponed its own adjustment, then a secondary burden would exist: the raising of taxes to repay the government's domestic debt.

To investigate this problem, I proceed as follows. Assume, as a first approximation, that all external debt is government debt. Then any transfer of resources abroad can only be accompanied by a combination of the following three changes: (a) an increase in the government budget surplus; (b) an increase in government domestic debt; (c) money creation. I decompose the respective share of these three terms in the case of Brazil (for 1983–85) and find that 71 percent of the trade surplus was financed by an increase in domestic debt. As a result, domestic debt increased by 84 percent and domestic real interest rates rose sharply, to more than 20 percent in 1985. In contrast, I show that the repayment scheme outlined above would have allowed the domestic debt to rise by just 22 percent. I conclude from this analysis that Brazil should allow its external debt to grow faster and should slow the growth of its domestic debt.

Each of the four policy recommendations is elaborated on in the remainder of the article. Mathematical derivations are presented in the corresponding appendixes.

I. STRETCHING OUT THE REPAYMENT OF THE DEBT

In this section, I assume that the economy is managed by a social planner; this assumption avoids the issue of taxation and domestic finance, which is the topic of section IV. The social planner can be viewed as an economic agent whose income is equal to all the resources of the country. To simplify the discussion, I postulate that these resources can be unambiguously defined and assume that the

economy produces only one good which can be traded freely on the world market. This good is the numeraire of all international transactions. This assumption is relaxed in the next section, in which the issue of defining a measure of wealth based on GDP and/or exports is tackled. Finally, I assume that the future can be predicted perfectly, that is, I assume away any uncertainty. The issue of uncertainty is dealt with in section III.

Assuming No Threat of Debt Repudiation

Consider a debtor-to-be country at some initial time, before it has started to borrow on the world financial markets. The future can be characterized by a sequence of fluctuating expected rates of growth of the country's income. The social planner discounts the future at some fixed rate. How is his decision to borrow (or to lend) taken? Contrary to the intuition derived from the analysis of a stationary economy, it is not solely the comparison of the world interest rates to the domestic discount factor which matters. If the country expects a very sharp decrease in its income in the future, it will not be induced to borrow, but rather it will lend now so as to match the shortfall in its future income. The decision to borrow will depend upon three factors: the domestic discount factor, expected interest rates, and expected growth rates. This problem is examined in appendix 1. Under a suitable set of assumptions, I show that the problem boils down to a comparison between the domestic discount factor and an "average" difference between expected interest and growth rates. The thinner this difference, the larger the incentive to borrow. The "average" difference is defined as follows: it is that constant difference which would yield the same wealth to the country as the actual (fluctuating) difference.

Once the initial decision to borrow has been taken, the law of compound interest takes over and there must come a point when the country starts "servicing" its debt, that is, generating a sequence of trade balance surpluses with a discounted sum equal to the country's external debt. Assuming that the country does not repudiate its debt, it can very well be the case that the social planner drives the country to a long-run equilibrium in which all the resources of the economy are channeled to its creditors. (This will be the case if the planner's discount factor is always larger than the difference between interest rates and growth.) In such a long run, the ratio of the trade balance to GDP would converge toward one. Debt crises start far before such a point is reached: lenders usually worry about the creditworthiness of their client long before he drives himself to asymptotic starvation.

The Option to Repudiate Debt

Following Eaton and Gersovitz (1981) and Cohen and Sachs (1985), I now assume that a country has the option of repudiating its debt if the burden of its repayment becomes "too heavy." "Too heavy" means that the cost of servicing the debt (measured in terms of foregone utility) is larger than the cost that the country would bear if it were to default. This latter cost is extremely complex to

evaluate in practice, but it seems natural to represent it as some fraction of the country's income. This fraction will measure all the retaliatory devices that the lenders may inflict upon the defaulting debtor. In the analysis in appendix 1, the cost of default is not assumed to be a constant fraction of the country's income over time. It might very well be the case that most of the costs are up-front, being much higher just after default than ten years later.

Once the option to default is acknowledged, lenders will wish to ensure that the country will not be in a situation in which its postdefault real income is greater than if it were to service its debt. (As before, "service" the debt means to generate a sequence of trade balance surpluses with a discounted sum equal to the value of the debt.) This leads lenders to impose a credit ceiling. How can it be calculated? In the framework examined in appendix 1, I show that the country will not be willing to repay more than some fixed fraction b^* of its resources each period, the fraction depending only upon the costs of default. Therefore, once the cost of default has been established, the credit ceiling is readily obtained: it is this same fraction b^* applied to the wealth of the country (when the wealth is measured as the sum of all future resources discounted at the world rate of interest).

The credit ceiling amounts to a fixed upper bound to the "average" debt-over-resources ratio. In other words, a country that has reached its credit ceiling would be asked by its creditors to transfer abroad enough income so as to keep its debt-to-resources ratio from rising above the level it reached when the credit ceiling started to bind. In the framework analyzed in the appendix, this requirement will be exactly equivalent to asking the country at its credit ceiling to devote the fraction b^* of its income to its debt service every period. This fraction b^* will satisfy the two requirements: (1) it generates a sequence of trade balance surpluses with a discounted sum equal to the face value of the debt; and (2) it forces the country to forgo, for debt service, a stream of consumption no larger than it would expect to forgo by defaulting.

A Numerical Exercise and Some Economic Policy Implications

Accepting this framework as a benchmark, one sees that the first step in assessing whether a country would repudiate its debt rather than service it is to calculate the maximum fraction of its resources which should be devoted to debt service. In earlier work (Cohen 1985), I did exactly that, taking the exports of the country as a proxy for measuring its resources. I found that most countries should devote no more than 15 percent of their exports to debt service. This calculation was based upon pessimistic assumptions with regard to future interest rates and growth. In order to see the intuition behind this result, consider the case where the "average" difference between interest rates and growth is 5 percent in real terms. Then a country such as Brazil, which has net debt-to-exports ratio of 3, should devote 15 percent of its exports to external debt service. In other words (under these assumptions), 15 percent of the country's exports are sufficient: (1) to keep its debt-to-export ratio a constant on average; and (2) to

meet the solvency condition that the sum of the discounted flows of income transferred abroad is equal to the face value of the debt. If a country were to generate a surplus greater than or equal to 15 percent, rather than repudiating its debt, its debt-to-exports ratio would decline or be constant. Under the assumptions spelled out in appendix 1, the country will never repudiate its debt rather than service it according to the 15 percent rule.

The policy implications which stem from this analysis are clear. When designing the adjustment program of a country which is believed to have reached its credit ceiling, the World Bank or the International Monetary Fund (IMF) should not aim to reduce the debt-to-export ratio but rather should aim at stabilizing it. The idea that the debt-to-export ratio should be brought down to a point at which "voluntary lending" could resume is an invalid notion in the context of this analysis. If voluntary lending is to resume, it means that the debt-to-export ratio might rise again. It is hard to conceive of any optimizing framework which would prescribe a U-turn policy according to which the ratio should go down and then up.

II. WATCHING BOTH EXPORTS AND GDP

For external creditors, the resources that matter are those which can be channeled to the world markets and exchanged against "hard" currencies. From this aspect, total GDP is certainly too broad a measure and exports too narrow. Traditionally, the "tradeable" goods sector is regarded as an appropriate measure, but this is very much a short-run concept. In the long run, human and technological resources can be shifted from nontraded to other activities. From this point of view, using GDP is less inappropriate than it might at first seem. Yet even in the case when all resources can be inexpensively shifted from one sector to another, it would be a policy mistake to base one's lending strategy on GDP, for the borrowing country might be induced to overappreciate its currency so as to inflate the dollar value of its GDP artificially. Conversely, if bankers were to base their lending strategy upon exports only, they might induce the country to overvalue its currency, and again the measurement of wealth would be distorted. The two biases which are introduced by taking GDP or exports as a measure of a country's income are of opposite signs: one lending strategy induces too few resources to be channeled to the traded sector, the other too many.

A measure of wealth which is invariant with regard to the real rate of exchange is derived in appendix 2. Exports are positively related to a real depreciation of the currency; GDP negatively related. The invariant measure of wealth is that linear combination which fails to depend upon the real exchange rate. In the case of Brazil, this analysis yields the result that 10 percent of GDP plus 90 percent of exports is an invariant measure of Brazil's resources. Why is it that exports carry a much greater weight than GDP? First, it must be recalled that exports amount to 10 percent of GDP. Therefore, an increase of GDP by 1 percent counts almost as much, in the definition of the invariant measure of wealth, as a

1 percent increase of exports. Yet it is true that one more cruzado in the export sector counts much more than one more cruzado in the rest of the economy. Why is that? Think of a country the exports of which consist of raw materials only. If there is no substitutability between exports and the production of other goods, then the invariant measure of wealth should consist of exports only: it is the only source of foreign currency earnings (which is what matters for our purpose). Obviously, Brazil is not in this situation, and some substitution is possible. What our weighting indicates is that such substitution is costly, so that 1 percent of GDP counts as much as 1 percent of exports in the definition of the country's resources. Obviously this is an area where much more work is needed before we can reach a conclusive answer.

Figure 1 shows the ratio of Brazil's net debt to its exports, GDP, and "resources." Although the net debt-to-exports ratio has fallen significantly in recent years, the debt-to-GDP ratio decline has been much more modest. This is the result of the large real depreciation of the currency which was undertaken in 1983. The debt-to-resources ratio is a weighted average of the other two ratios.

Figure 1. *Brazil: Stock of Net Government Debt to Exports, GDP, and "Resources"*

Note: "Resources" are the sum of $GDP \times 0.10$ and $exports \times 0.90$.

Sources: World Bank estimates; International Monetary Fund, *International Financial Statistics*, various years.

III. IGNORING THE CREDITORS' CAPITAL LOSS

I have assumed so far that interest and growth rates can fluctuate, but along perfectly predicted paths. Let us now introduce uncertainty with regard to both rates. Uncertainty might be thought of as the sum of two components: a continuous component, which only creates smooth deviations around a deterministic path, and a discontinuous component, which allows for an abrupt swing of the overall trend. The first kind of uncertainty (say a stochastic diffusion process) would not yield substantially different results from those examined previously. Because unforeseen variations of this type take place continuously, the risk of default cannot take lenders by surprise, and the previous principles of debt management would continue to be valid. Lenders should impose a credit ceiling which is a function of the expected average difference between growth and interest rates, and the ceiling would be adjusted continuously to allow for stochastic deviations. In this section and in the following, I limit the analysis to the second kind of uncertainty, that which is associated with abrupt changes in the economic environment.

To simplify the analysis, first consider the case in which there are only two different states of nature. State 1 is a "good" state, characterized by low real interest rates and fast growth. State 2 is a "bad" state, characterized by high real interest rates and slow growth. In state 1, there is a probability p_1 of staying there and a probability $p_2 = 1 - p_1$ of going to state 2. Once in state 2, there is a probability q_1 of returning to state 1 and a probability $q_2 = 1 - q_1$ of staying in state 2. The variables p_1 and q_1 need not be equal. If p_1 and $1 - q_1$ are both close to one, the economy is likely to stay in the state it is in, whatever this state might be.

How can we characterize the lenders' strategy? In the previous deterministic setting there was no ambiguity. Lenders would provide any amount of lending below the credit ceiling at the riskless rate of interest. Provided that the credit ceiling was accurately calculated, the absence of uncertainty made the loans riskless. Furthermore, despite fluctuating growth rates, the country did not need any further insurance. It could spread out its consumption over time up to a credit ceiling. In the uncertainty case, the borrower would now like to insure itself against uncertainty regarding both the interest rate and the growth rate. As for the interest rate, it would rather borrow at a fixed rate and let the international lenders take the risk of fluctuations. As for the growth rate, the borrower would like to protect itself against an uncertain future and find some form of insurance against a drop in its income. Surprisingly, despite the obvious relevance of this problem for developing countries, very little risk diversification either on interest rates or on growth rates appears to have been undertaken.

Bank Lending under Uncertainty

I now assume that the borrowing country does not protect itself against fluctuating interest or growth rates. Assume also that the country starts to borrow in

the good state of nature, when interest rates are low and growth fast, and that during this state 1, interest rates are lower than growth rates. Then, as long as the world stays in state 1, any level of debt is sustainable: refinancing both the principal and interest falling due does not affect the solvency of the country. Its debt-to-resources ratio would still decline, even when the country makes no real transfer of resources to the rest of the world. Therefore, any credit ceiling imposed on the country can only be derived from the possibility of it moving to state 2. Lenders would seek to impose, in state 1, a credit ceiling such that the country would not default were the economy to shift abruptly to state 2. As before, the ceiling would be imposed as a maximum bound to the debt-to-resources ratio (see appendix 3). Once this ceiling has been reached, the country can keep borrowing net new amounts (in excess of principal and interest payments falling due) as long as the economy stays in state 1. This situation fits the happy state of affairs of the 1970s. Thus from 1977 to 1981, Brazil could keep its borrowings in excess of its debt service obligations and yet stabilize the debt-to-exports ratio at about 3. Now, assume that the state of nature shifts from state 1 to state 2 when the credit ceiling is already binding. In order to keep its debt-to-resources ratio at a constant level, the country must now generate a trade surplus. The principles which guide how this surplus should be determined are the same as in section 1, except that the future must be projected *as if* the economy were to stay forever in state 2. Relief will only come if state 1 returns.

What this analysis shows, at this point, is that one *cannot* argue that the large interest rate rise during the 1980s makes the debt-to-exports ratio of the 1970s unsustainable. Because interest rates were lower than growth rates during that decade, any ceiling on the debt-to-exports ratio imposed according to the principles of this article must have been imposed by reference to another state of nature.

*Banks' Misperceptions or Risk Sharing? A View of the
Discount on Developing Countries' Debt*

This two-states-of-nature view of the world fits well the process we have witnessed during these past years in many countries, including Brazil, except for one thing: since the crisis of 1982, and despite the country's outstanding success in generating trade surpluses, Brazil's debt has been trading at a substantial discount on the secondary markets. (In August 1986 the discount was 25 percent.) If only states 1 and 2 could occur, this should not be so. Once a country has shown that it would stabilize its debt-to-resources ratio rather than default, it reveals that the debt ceiling imposed in the 1970s was indeed safe enough to absorb the shock of the 1980s. Why then is the debt traded at a discount? Depending upon the optimism that one wishes to display with respect to the financial market, two answers might be given: risk sharing or risk misperceptions.

Let us start with the latter. Assume that lenders forecast only two possible states of affairs, but as the borrowing country moves from the good state 1 to the

bad state 2, lenders suddenly see that an ugly state 3 is also possible: a state where things would be even worse and in which the borrowing country would certainly default or have its debt partially written off. Given this risk, debt would then be traded at a discount on the secondary markets. Yet lenders cannot incorporate this risk into the rate charged to the borrower: if the country has indeed reached its credit ceiling, it would certainly default rather than pay a higher interest rate.

A more optimistic story might be told, however. Assume that the possibility of state 3 was indeed foreknown and that the transition from one state to another comes as follows: the economy can go from state 1 to state 2 or stay in state 1, but it cannot go directly from state 1 to state 3. Once it has moved from state 1 to state 2, however, there is now a positive probability of passing to either of the other two states. Let us assume that state 3 is so bad that any borrower would default rather than repay its debt. If banks decide to lend in state 1, they know that they face a positive probability of the debt being written down. If one assumes (as I have) that the banks are not ready to take a risk that they cannot diversify, this is only relevant if state 3 is confined to the country in question or a limited group of countries. A sudden and permanent fall of the country's terms of trade would be a good example of a state 3.

One can think of two polar ways in which to deal with this risk. In the first case, the banks could charge the riskless rate in state 1 and the risk-adjusted rate in state 2. As the economy goes from state 1 to state 2, they would not take a capital loss. However, the credit ceiling would have to be low enough to keep the country from defaulting in state 2, when it has to pay risk-adjusted interest rate on existing, as well as new, debt. Another way to deal with the state 3 problem is to charge the same spread in state 1 as in state 2. In this case, the spread measures the risk of default from a state 1 point of view: it is therefore relatively low because it measures the probability of going from state 1 to state 2 multiplied by the probability of going from state 2 on to state 3. Under this scheme, the credit ceiling is higher than before, for although the country must still be kept from defaulting in state 2, it is being charged a lower spread. If the borrowing country is risk averse, it will prefer this latter option.

What are the policy implications of this analysis? Whether it is a result of risk sharing or risk misperception makes little difference. Once the economy has moved into state 2, the lenders are faced with a capital loss on their assets. The outstanding debt will be quoted on the secondary market at a discount. The repayment scheme which should be undertaken is unambiguous. It is that which I set out in section I: the repayment should be stretched out so as to stabilize the debt-to-resources ratio. Again, this should be done under the assumption that the economy will stay in state 2. In other words, neither the possibility of going into state 3 nor that of returning to state 1 should be taken into account. The lenders' capital loss should be simply ignored. It is only when the state of nature has indeed shifted to state 3 that the debt should be written down: in state 3, the country would certainly default rather than service the face value of the debt,

contrary to what happens in state 2. (See Sachs 1986 on why an explicit write-off is superior to an implicit one.)

A more troublesome question arises if an agency such as the World Bank or the IMF has some leverage to raise the country's efficiency and push the debt below the credit ceiling (while the economy is still in state 2). In this case, the lending banks will have an incentive to ask for faster repayment, and their aim would be to push the debt down to the point at which even the occurrence of state 3 would not induce default.

One sees from this analysis that a discrepancy between the market value and the face value of the debt should not necessarily imply that the debt should be written off. If the country is at its credit ceiling in state 2, it is the face value of the debt which must be rescheduled when it moves to state 3 so as to keep the debt-to-resources ratio a constant (on "average"). However, the discrepancy between the face and the market values does explain why the banks are so impatient to be repaid. And my analysis, thus far, suggests that they may indeed succeed in bringing to zero (if they want) the debt-to-exports ratio of a country which has "revealed" that it would bring the ratio down rather than default. I now argue, however, that this need not be so, once the domestic finance aspect of the external debt has been taken into account.

IV. WATCHING THE DOMESTIC DEFICIT

Domestic Finance with Distortionary Taxes

Until now, I have assumed that the government had at its free disposal all the country's economic resources. This is equivalent to assuming that an extremely efficient tax system could perform the desired transfer of resources underlying the design of the government's policy. Obviously, this assumption fits no country, developed or developing. In this section, I develop a framework in which the government faces a domestic financial problem in addition to the external one. I assume (as a first approximation) that only the government can borrow or lend abroad so that the private sector's only net financial wealth is the government's domestic debt. If taxes were not distortionary, this restriction would not modify my previous analysis, and the government would face the external debt ceiling as its only relevant constraint. Yet if taxes are distortionary, the government really faces two constraints: a domestic and an external one.

Consider a world economy with the two states of nature described in the previous section (see appendix 4 for details). Assume that the constraint on external debt is binding while the economy is in the good state, state 1. As long as the world economy stays in this state, the country can borrow a new net amount every period. This allows the government to maintain low domestic interest rates and low taxes. If the economy moves to state 2, all the bad news comes together. A trade surplus is required: this pushes the domestic interest rate up so that (distortionary) taxes must be raised to keep the domestic debt from exploding. This rise in domestic interest rates may be thought of as a version of

the transfer problem, the source of so many controversies. In the traditional literature, when a country that can affect its own terms of trade is forced to accomplish a transfer of income to the rest of the world, it must bear a terms of trade deterioration in order to obtain a trade surplus. This creates a secondary burden which adds to the primary burden of forgoing consumption at the pre-transfer relative prices. In the case we discuss, a government which is forced into a trade surplus incurs the secondary burden of repaying its own domestic debt at a higher interest cost, depending on the duration and terms of existing domestic debt. This analysis supports the IMF's emphasis on the necessity of domestic fiscal accommodation of an external adjustment. I now argue that, at least until 1986, this adjustment had not been undertaken by Brazil.

An Analysis of the Domestic Counterpart to Brazil's External Adjustment

Brazil's external surplus (excluding interest payments) reached more than \$10 billion in each of the three years 1984–86 as a result of a large cut in imports and a boost in exports following a large real depreciation. If one takes as a first approximation that all foreign debt is public debt, this surplus must have been reflected in a combination of: (1) money creation; (2) domestic debt increase; and (3) a government budget surplus. The arithmetic of this relationship is as follows. The increase in the sum of domestic and external debt is equal to the government budget deficit net of money creation. If only the government borrows abroad, then the decrease in the government's external debt is equal to the current account surplus. Therefore, the current account surplus is the sum of the increases in domestic government debt, the budget surplus, and money creation.

This relationship can be written as follows: Call $B(t)$ the domestic debt, $B^*(t)$ the foreign debt; $\rho_t B(t)$ the interest falling due domestically; $r_t B^*(t)$ the interest falling due abroad; $Z_0(t)$ the non-interest-payment government surplus; and $S(t)$ new real money creation (the seignorage tax). (The variable t represents either the situation at the end of period t or the flow in period t , as appropriate.) The total budget deficit of the government is the sum of the primary deficit and of interest payments, that is,

$$-Z_0(t) + r_t B^*(t-1) + \rho_t B(t-1).$$

It must be financed either by money creation or by an increase in domestic or external debt. Thus:

$$-Z_0(t) + r_t B^*(t-1) + \rho_t B(t-1) = B(t) - B(t-1) + B^*(t) - B^*(t-1) + S(t)$$

This equation can be rewritten as:

$$(1) -[B^*(t) - (1 + r_t)B^*(t-1)] = S(t) + Z_0(t) + B(t) - (1 + \rho_t)B(t-1)$$

The left-hand side is the non-interest-payment current account *surplus*; the right-hand side is the sum of seignorage tax, the government surplus (excluding interest payments), and new domestic debt. Even though the current account surplus might have been obtained by a real devaluation or a rationing of im-

ports, it must be reflected in one of the three latter items. Money creation is triggered when the government buys the dollars earned by exporters. (Recall the assumption that only the government holds foreign assets and liabilities.) If a (non-interest-payment) budget surplus can match the (non-interest-payment) external surplus, then this source of money creation can be offset. Alternatively, an open market operation might reduce the growth of the money supply brought by an external surplus.

How did Brazil manage its external surplus domestically? Figure 2 plots the non-interest-payment current account surplus, seigniorage due to money creation (in real terms), and the domestic debt increase. Except for the last quarter of 1983, domestic debt has been steadily increasing, following a pattern which is very similar to the current account surplus. As a result the real value of domestic debt increased by 84 percent between December 1982 and December 1985 (see figure 3). Not surprisingly, the soaring domestic debt put substantial pressure on domestic interest rates, as shown in figure 4.

Figure 2. *Brazil: Noninterest Current Account Counterparts*

Key: — change in domestic debt - - - noninterest current account — seigniorage

Note: "Seigniorage" is defined as the variation of central bank liabilities in real terms.

Sources: International Monetary Fund, *International Financial Statistics*, various years; Getulio Vargas Foundation; World Bank estimates; Central Bank of Brazil, *Brazil—Economic Program: Internal and External Adjustment*, various issues.

Figure 3. *Brazil: Stock of Quarterly Net Domestic Debt*

Source: Central Bank of Brazil, *Brazil—Economic Program: Internal and External Adjustment*, various issues.

Allowing for private capital transactions with foreigners, the contribution of each of these factors to the current account surplus is as follows:

$$(1') \quad TB(t) = S(t) + Z(t) + B(t) - (1 + \rho_t) B(t-1)$$

$TB(t)$ is the non-interest-payment current account surplus, $S(t)$ is the seignorage tax, and $B(t) - (1 + \rho_t) B(t-1)$ is the amount of net new resources channeled to the government through the issuance of domestic debt. $Z(t)$ is calculated as a residual. It measures the non-interest-payment government surplus (Z_0) plus the net external debt *decrease* of the private sector inclusive of capital flight. Z is likely to overstate the government surplus. TB , S and Z are shown in figure 5A; figure 5B plots TB and $S + Z$. If Z is taken as a proxy of the government non-interest-payment surplus, $S + Z$ measures its net income excluding interest payments but including seignorage from money creation. As figure 5B shows, the gap between TB and $Z + S$ has been substantial. To derive a quantitative measure of this discrepancy, we proceed as follows. We write (1') as:

$$(2) \quad \sum_{i=1}^T \frac{TB(t)}{\prod_{i=1}^t (1 + \rho_i)} = \sum_{i=1}^T \frac{S(t)}{\prod_{i=1}^t (1 + \rho_i)} + \sum_{i=1}^T \frac{Z(t)}{\prod_{i=1}^t (1 + \rho_i)}$$

Figure 4. *Brazil: Ex Ante and Ex Post Real Interest Rates*

Key: --- ex ante interest rate — ex post interest rate

Note: "Ex ante" rates refer to the indexation scheme ex ante premised to the buyer of government bonds. "Ex post" rates are actual rates of return.

Sources: World Bank estimates; Getulio Vargas Foundation.

$$+ B(0) - \frac{B(T)}{\prod_{i=1}^T (1 + \rho_i)}$$

(2) is simply (1') written in discounted terms (from a time zero point of view) and summed over time.

On the basis of this decomposition, the seignorage tax amounted to 57.5 percent of the current account surplus (excluding interest payments), the domestic debt increase amounted to 71.0 percent, and the variable Z to *minus* 28.6 percent. Taking $Z + S$ as a rough proxy of the government's net income, one sees that only 29 percent of the external surplus was really paid for by the government and that 71 percent was financed by domestic debt. In other words, one sees that the secondary burden of raising taxes in order to service the government's external debt has yet to be paid.

Figure 5. *Brazil: External and Domestic Surpluses*

Key: — noninterest government surplus (z) - - - noninterest current account - . - seigniorage

Key: - - - noninterest government surplus (z) plus seigniorage — noninterest current account

Note: "Seigniorage" is defined as the variation of central bank liabilities in real terms.

Sources: World Bank estimates; International Monetary Fund, *International Financial Statistics*, various years; Getulio Vargas Foundation; Central Bank of Brazil, *Brazil—Economic Program: Internal and External Adjustment*, various issues.

This decomposition also reveals the importance of the seignorage tax in total government revenue. In the balance of evils, inflation must be carefully weighed against rising domestic debt and rising real interest rates. Here, any use of the monetary approach to the balance of payments might be very harmful if it were to imply that monetary restraint is the appropriate tool for managing the external debt. (This argument is clearly an open economy version of the Sargent and Wallace [1981] "unpleasant monetarist arithmetic.")

One argument, however, against the seignorage tax is that it is becoming less and less efficient. As is well known, there is a maximum inflation rate above which increased money creation brings in less real income. Casual evidence seems to indicate that Brazil might have come near that point. The inflation rate doubled after the 1982 crisis and yet seignorage tax receipts rose by only 17 percent (see figure 6). Econometric evidence with regard to the elasticity of money demand vis-à-vis inflation seems to confirm this. By the beginning of 1986, more inflation did not necessarily mean more income to the government (see appendix 4, where it is also shown that the seignorage tax displays a low

Figure 6. *Brazil: Annualized Inflation and Seigniorage*

Key: ---seigniorage —inflation

Note: "Inflation" is defined as the December to December change in the consumer price index.

Source: International Monetary Fund, *International Financial Statistics*, various years.

covariance with the total government deficit). If this view is warranted, it would support the analysis by Kharas (1984), according to which a country's solvency must be judged both from its ability to generate a trade surplus and from the ability of its government to raise taxes. Roughly speaking, it is the minimum of the two bounds which should constrain the external debt. If the seignorage tax indeed reached an upper limit in 1986, it would make the repayment of external debt at the previous speed a dangerous exercise, one which might end by domestic default.

On the basis of this analysis, one might want to conclude that although Brazil's external adjustment has been successful, its internal adjustment has not. Yet, based on the analysis in section I, one might also want to argue that the external adjustment was *too* successful. In order to illustrate this point, I calculate what would have been the level of the domestic debt by the end of 1985 if the trade surplus has been held to the level implied by the analysis in section I, 15 percent of exports. The answer is that the domestic debt would have risen by 22 percent (in real terms) above its December 1982 level. Econometric estimates (shown in appendix 4) indicate this might have reduced 1985 real interest rates by 5 percentage points.

To conclude, we see that the Brazilian adjustment has not been completed. From the government's viewpoint, domestic debt has replaced external debt. Yet the former is dearer than the latter. In these circumstances, pushing the external debt-to-exports ratio down further would seriously damage the Brazilian economy and need not be in the creditors' self-interest. What would be preferable for Brazil is a relaxation of the scheme for servicing its external debt¹ and a tougher fiscal stance.

V. CONCLUSION

I have argued in this article that a country which was believed to have reached its credit ceiling should not be asked to bring down its debt-to-resources ratio but instead should be asked to stabilize it. I have indicated that a trade surplus equal to roughly 15 percent of its exports should achieve that purpose. This analysis was shown to be valid even for cases in which the current market value of the debt does not coincide with its face value. Furthermore, I have indicated why the same ceiling to the debt-to-exports ratio might be applied both in the 1970s and in the 1980s. Because interest rates were lower than growth rates in the 1970s (and as it is the difference between the two rates that matters), it must

1. Obtaining a trade surplus is a slow and painful process, and it would certainly not be wise to try to reduce it blindly. However, all that is needed to take the pressure off the domestic debt is a reduction in the speed of repayment of the external debt. This would allow the government to reduce its domestic debt. Indirectly, it would exchange its external debt against its domestic debt, selling dollars to buy cruzados and selling cruzados to rebuy its domestic debt (leaving the money supply unchanged).

have been the case that the ceiling imposed during the 1970s was aimed at absorbing some shock such as that which occurred during the 1980s.

Conversely, I have indicated that the ability of a country to stabilize its debt should apply both to its external and to its domestic debt. Yet in the case of Brazil, domestic debt rose as a result of foreign debt payments. If continued, this process may seriously damage the working of Brazil's financial system. Under these circumstances, a slowdown of external debt payments coupled with a tougher fiscal policy stance might yield a superior outcome for both the debtor and the creditors.

APPENDIX 1

Assume that the resources of the country can be unambiguously measured by a good Ω_t with which the country is exogenously endowed according to a law of motion (a dot superscript means a time derivative):

$$(A1-1) \quad \dot{\Omega}_t = n_t \Omega_t$$

The country has access to a world market on which this good is traded. A world financial market, whose rates of interest are r_t , $t \geq 0$, allows the country to spread its consumption intertemporally. Assume that the country's representative consumer (or its social planner) has the objective:

$$(A1-2) \quad \text{maximize } \int_0^{\infty} e^{-\delta t} \log C_t dt$$

in which C_t is consumption (of the numeraire) at time t and δ is the rate of time preference.

Following the work by Eaton and Gersovitz (1981) and my own research with J. Sachs, assume that a country may repudiate its debt if the cost of repaying it becomes "excessive." The threshold with which this "excessive" burden is compared is an "autarkic" utility level which measures the capital to which the country has access after it has defaulted on its debt. (This is autarky with regard to trade in capital but not trade in goods.) The autarky utility threshold is defined as follows. Take a country which defaults at time t^* . Assume that its resources are reduced by a factor λ_{s-t^*} at time s , and that it is forced to financial autarky after time t^* . In other words, a country defaulting at time t^* only receives the endowments $[1 - \lambda_{s-t^*}] \Omega_s$ at time s and cannot spread out its pattern of consumption. A defaulting country, therefore, necessarily consumes:

$$(A1-3) \quad C_{t^*+s}^a = (1 - \lambda_s) \Omega_{s+t^*}, s \geq 0$$

The variable λ_s , $s \geq 0$, measures the cost of debt repudiation, which need not be a constant—for instance, we could assume that it is a decreasing function of time. Lenders will then limit their exposure to the country so that repayment never becomes so heavy as to make debt repudiation a superior alternative. Associated with this equilibrium lending strategy, the borrower can reach a

utility level, which we can write $U(D_t, \Omega_t, F_t)$ in which D_t = external borrowing and $F_t = \{r_s, n_s\}$, $s \geq t$ measures the prospects of a future strategy such that the country never finds it profitable to repudiate its debt. Call $U_a(\Omega_t, F_t)$ the autarky utility level.

Lenders will seek to lend so that the country will never find that

$$(A1-4) \quad U(D, \Omega, F) < U_a(\Omega, F)$$

that is, that it will never prefer autarky to repaying the debt. To design this strategy, we first show:

Proposition: On any interval of time during which the constraint A1-4 is binding, the country repays its creditors a fixed fraction of its resources.

The proof is obtained by time differentiating the equation $U = U_a$. Variable b is shown to be a scalar which solves:

$$\log(1 - b) = \delta \int_0^\infty \log(1 - \lambda_s) e^{-\delta s} ds$$

In the simple case where λ_s is a constant λ , b equals λ . In that case, the interpretation of the above proposition is straightforward: lenders restrict their lending so that the country reaches a trade surplus which drives the country's consumption to its default level. What the proposition tells is that there exists a fixed scalar b such that the country must obtain a trade surplus equal to $b\Omega_t$ whenever A1-4 is binding.

From this proposition, one may define the supply of credit. To simplify, assume that the constraint on the debt, once it binds, keeps binding. Maximum lending is defined by the inequality:

$$D_t \leq b \int_t^\infty (\exp - \int_t^s r_u du) \Omega_s ds$$

Call h_t^* the maximum debt-to-resources ratio. From this inequality, we can write:

$$(A1-5) \quad h_t^* = b \left[\int_t^\infty \exp - \int_t^s (r_u - n_u) ds \right]$$

The term in parentheses may be interpreted as an "average" difference between interest and growth rates. Call this average difference θ_t^* , where

$$(A1-6) \quad \theta_t^* \equiv \int_t^\infty \exp \left[- \int_t^s (r_u - n_u) du \right] ds$$

One can show that the maximum debt-to-resources ratio h_t^* follows a law of motion:

$$(A1-7) \quad \frac{\dot{h}^*(t)}{h^*(t)} = (r_t - n_t) - \theta_t^*$$

Equation A1-7 shows that the maximum value of the debt-to-resources ratio may increase, decrease, or stay constant depending upon whether the difference between interest and growth rate is above, below, or equal to its average value. In a stationary environment, the debt-to-resources ratio is constant when the

constraint starts binding. Otherwise, when $r_t - n_t$ oscillates, the maximum debt-to-resources ratio may be allowed to oscillate countercyclically.

APPENDIX 2

In appendix 1 resources of the country are measured by a numeraire, Ω_t . Assume now that Ω_t is not observable, but exports and GDP are. Assume that the country produces two goods: a home good (1) and an export good (2). Whereas residents consume only the home good, imports are required to produce it, so exports are required.

Let $Q_1 = M^{1-\alpha} \Omega_1^\alpha$, $Q_2 = \Omega_2$, and $\Omega_1 + \Omega_2 \leq \Omega$.

Variable Ω is the endowment of the country, and M is the imports which enter into the production of good 1. Imports are the numeraire. Let P_2 be the terms of trade so that: $M = P_2 Q_2 - P$, where P is the trade balance. Assume that the cost of default is a penalty λ_s imposed on exports. A country choosing to default would therefore import $M_{t+s} = P_2 (1 - \lambda_s) Q_{2t+s}$ in exchange for its exports Q_{2t+s} , the cost of default being the worsening of the terms of trade. Lenders will lend so that $U(D, \Omega, F) \geq U_a(\Omega, F)$, and as before we can check that $U(zD, z\Omega, F) \geq U_a(z\Omega, F)$ holds for all z whenever $U(D, \Omega, F) \geq U_a(\Omega, F)$ holds.

The optimal borrowing strategy should therefore be set as previously:

$$(A2-1) \quad \frac{D_t}{\Omega_t} \leq h_t^*$$

As Ω_t is not observable, which of GDP and exports, X , should proxy the resources of the country in equation (A2-1)? Assume that the pricing mechanism is efficient. Then:

$$\begin{aligned} P_1 &= \frac{1}{\alpha^\alpha (1-\alpha)^{1-\alpha}} P_2^\alpha \quad \text{and} \\ \text{GDP} &= P_1 Q_1 + P_2 Q_2 - M = P_2 \bar{\Omega} \\ X &= P_2 (1-\alpha) \bar{\Omega} + \alpha P \end{aligned}$$

We see that GDP provides a direct measure of $\bar{\Omega}$ and X an indirect one.

An invariant measure of resources is now devised. Assume that the country adopts a rationing or a subsidy scheme on imports or on exports, respectively, which we shall measure by the shadow price, γ , of imports. When $\gamma = 1$, imports are priced at their world level, and we are back to the equilibrium pricing case examined above. When $\gamma > 1$, imports are rationed and their shadow price (the black market premium) is above world price. When $\gamma < 1$, however, exports are subsidized above their world level. Given this measurement of price distortion, GDP and exports become

$$\begin{aligned} \text{GDP} &= \frac{1}{1+\alpha(\gamma-1)} [\gamma P_2 \bar{\Omega} - (1-\alpha)(\gamma-1)P] \\ X &= \frac{1}{1+\alpha(\gamma-1)} [(1-\alpha)P_2 \bar{\Omega} + \alpha \gamma P] \end{aligned}$$

GDP increases and exports decrease with γ . Now consider the following alternative measure of a country's wealth, W_t .

$$W_t = \frac{\alpha}{1+\alpha} \text{GDP}_t + \frac{1}{1+\alpha} X_t$$

W_t is designed so as to be independent of γ . Because of our various "Cobb-Douglas linearities," the definition of W_t is simple. Curvature of the production possibility frontiers would change the coefficient α , however. For instance, assume that the resource constraint is written as $\Omega_1 + \phi (\Omega_2/\Omega_1) \Omega_2 \leq \bar{\Omega}$, in which ϕ is a decreasing function which measures the cost of shifting resources from sector 1 to sector 2. Now the coefficient α should be changed to $\alpha^1 = \alpha/\rho$, in which $\rho \geq 1$ is a measure of the curvature of the production possibility frontier. In the extreme case when $\rho = \infty$, ($\phi = 1$ if $\Omega_2/\Omega_1 = \infty$, 0 otherwise) exports become the sole measure of wealth. Otherwise, the more difficult it is to shift resources, the more weight will be given to exports in the measurement of wealth.

In a numerical application of the above to Brazil, for an explicit estimate of the invariant measure of wealth we need to find a scalar κ such that $W_t = \kappa \text{GDP}_t + (1 - \kappa) X_t$ fails to depend upon the real exchange rate. For Brazil, exports are shown to depend upon the real exchange rate as follows:

$$\log X(t) = 5.75 + 0.08 \text{ time} + 0.88 \log z(t-1) \\ (4.6) \quad (11.9) \quad (2.6)$$

$$R^2 = 0.97 \quad DW = 1.3 \quad (t\text{-statistics in parentheses})$$

with $z(t-1)$ the lagged value of the real exchange rate and $X(t)$ the constant dollar value of exports. Exports respond significantly to real depreciation, the volume elasticity being 0.88. The constant dollar value of GDP_t depends upon the real exchange rate:

$$\log \text{GDP}_t = 14.6 + 0.06 \text{ time} - 0.78 \log z(t-1) \\ (11.5) \quad (9.9) \quad (-2.3)$$

$$R^2 = 0.93 \quad DW = 0.97$$

The real exchange rate and the dollar value of GDP are negatively related. We then look for a value κ which makes $\log W_t = \log [\kappa \text{GDP}_t + (1 - \kappa) X(t)]$ independent of $z(t-1)$. The sign of the relationship between $\log W_t$ and $\log z(t-1)$ changes for values of κ between 0.095 and 0.1. Therefore, for Brazil, $W(t) = 0.1 \text{GDP}_t + 0.9 X(t)$.

APPENDIX 3

A Two-State Uncertainty Model

Assume there are two possible states of nature i ($i = 1, 2$), in which the world real interest rate is r_i , and the rate of growth of the country's economy is n_i .

As in appendix 1, assume that the resource can be unambiguously identified with GDP. In state 1, the economy faces a probability p_1 of staying there and $p_2 = 1 - p_1$ of moving to state 2. In state 2, the probability of moving to state 1 is q_1 , that of remaining in state 2 is $q_2 = 1 - q_1$. Contrary to the structure in appendix 1, I now assume a discrete time economy. The subjective discount factor of the social planner is $\beta = 1/(1 + \delta)$ and δ is the rate of time preference. The objective is to maximize the expected value of $J = E_o \sum_t \beta^t \log C_t$. The social planner's welfare function can be written as $J_1(D, Q)$ in which Q = GDP and D is the debt accumulated by the country at the beginning of the period.

When the economy is in state i , GDP during that period is $Q(1 + n_i)$ and the debt at the end of the period is $D_i = (1 + r_i)D + C - Q(1 + n_i)$, where C is the consumption during that period. I assume that the decision to consume is made after the country has learned which state of nature it is in. J_1 and J_2 are the solutions to the following system:

$$\begin{aligned} \text{(A3-1)} \quad J_1(D, Q) &= \max_c \{ \log C + \beta p_1 J_1 [(1 + r_1)D + C - Q(1 + n_1), Q(1 + n_1)] \\ &\quad + \beta (1 - p_1) J_2 [(1 + r_1)D + C - Q(1 + n_1)] \\ J_2(D, Q) &= \max_c \{ \log C + \beta q_1 J_1 [(1 + r_2)D + C - Q(1 + n_2), Q(1 + n_2)] \\ &\quad + \beta q_2 J_2 [(1 + r_2)D + C - Q(1 + n_2), Q(1 + n_2)] \} \end{aligned}$$

To prevent default, lenders must ensure that $J_1(D, Q) \geq J_{d,1}$ and $J_2(D, Q) \geq J_{d,2}$ when $J_{d,i}$ is the expected postdefault utility in state i . Now, given the assumption that

$$\text{(A3-2)} \quad r_1 \leq n_1 \text{ and } r_2 \geq n_2$$

it is clear that $J_2(D, Q) \geq J_{d,2}$ is the only inequality to watch. Following the same argument as in appendix 1, this inequality yields a credit ceiling for both states:

$$\text{(A3-3)} \quad D/Q \leq h^*$$

As in appendix 1, the country's decision to borrow will depend on $[\delta, r_1, r_2, n_1, n_2]$. Assume $\delta \geq r_2 - n_2$; even in state 2 the country would still like to borrow. Under this hypothesis, the country will borrow until the credit ceiling (A3-3) binds, but even then the country will borrow if it is in state 1. In effect assume that the country's initial debt and endowment satisfy $D = h^*Q$. If it is in state 1, it can still borrow net new debt (over and above all debt service payments): $C - Q_1 = (n_1 - r_1)D$. Its end-of-period debt is then $D_1 = (1 + r_1)D + (n_1 - r_1)D = (1 + n_1)D$ so that its end-of-period debt-to-GDP ratio D_1/Q_1 is

indeed unchanged. However, if it is in state 2, it must pay $Q_2 - C = (r_2 - n_2)D$ so as to keep its debt-to-GDP ratio unchanged.

A Three-State Uncertainty Model

Assume now that a third state of nature might arise once the economy has moved to state 2. As before, P_1 and $P_2 = 1 - P_1$ are the probabilities of staying in state 1 and passing to state 2, respectively. But now let $(q_1, q_2, q_3 = 1 - q_1 - q_2)$ be the probabilities of passing from state 2 to state 1, remaining in state 2 or passing into state 3, respectively. Assume that state 3 is a state that one cannot leave. It is characterized by (r_3, n_3) such that $r_3 - n_3$ is very large. Let $J_3(D, Q)$ be the welfare that is obtained by the country when it is (forever) in state 3, assuming that it services its debt. The condition for obtaining $J_3(D, Q) \geq J_{3,a}$ yields a very low debt ceiling $D \leq h_3^* Q$ (with h_3^* much less than h_2^*). If the lenders want to take no risk of debt repudiation at all, it is this ceiling which they should impose. Now assume that state 3 is a state of nature which is idiosyncratic to the debtor country; for instance, assume that $r_3 = r_2$ but n_3 is much less than n_2 . Contrary to states 1 and 2, which were worldwide phenomena, the risk of state 3 can now be diversified away by the lenders. In other words, we may assume that they will act as risk-neutral lenders with respect to all stochastic shocks related to the occurrence of state 3.

Let us assume that the country starts borrowing in state 1. A continuum of loans can be offered to the debtor. At one extreme, consider the following: all loans offered in state 1 are priced at the riskless rate. Yet as the economy moves to state 2, the lenders offer a risk-adjusted interest rate whenever $D \geq h_3^* Q$ so as to reflect the probability of going to state 3 and having the debt defaulted upon. In this case, as soon as $D \geq h_3^* Q$, the law of motion of the country's welfare can be written as:

$$(A3-4) \quad J_1, \text{ as in equation A3-1}$$

$$(A3-5) \quad J_2, \text{ which solves:}$$

$$\begin{aligned} J_2(D, Q) = \max \{ & \log C + \beta q_1 J_1 \left[\left(\frac{1 + r_2}{q_1 + q_2} \right) D + C - Q(1 + n_2), Q(1 + n_2) \right] \\ & + \beta q_2 J_2 \left[\left(\frac{1 + r_2}{q_1 + q_2} \right) D + C - Q(1 + n_2), Q(1 + n_2) \right] \\ & + \beta q_3 J_{3d} [Q(1 + n_2)] \} \end{aligned}$$

In order to prevent default in state 2, lenders impose $J_1(D, Q) \geq J_{2d}(Q)$ which is equivalent to a new credit ceiling $D \leq h_2^* Q$, the same credit ceiling that applied in both states 1 and 2.

Now there is another lending strategy available. The lenders charge a risk premium ϵ in both state 1 and state 2. But this risk premium now reflects the probability of default from a state 1 point of view, that is $\epsilon = (1 - p_1) q_3$. If $q_3 = 20$ percent and $(1 - p_1) = 5$ percent, then ϵ is 1 percent. Under this new lending

strategy, the borrower pays a spread in state 1 as well as in state 2, but the new credit ceiling is larger since, in state 2, the debt is rolled over at the rate $1+r_2/1-(1-p_1)q_3$. The lender is indifferent between the two schemes, but the borrower will certainly take the latter (if $1-p_1$ is low enough). As indicated in the text, in state 2 the debt will be traded at a discount and the lenders will take a capital loss on the debt. Yet the same simple maxim for servicing the debt should apply: keep the debt-to-resources ratio at its ceiling.

APPENDIX 4

Theory

Again assume two possible states for the world economy, but assume now that the government is distinct from the private sector and that only the government has access to the rest of the world's financial market.

Assume for simplicity that the government's only action is to transfer payments to or collect taxes from the private sector. Call B^* the foreign debt. The law of motion of external debt is given by:

$$(A4-1) \quad B_i^*(t) = (1 + r_i) B^*(t-1) + C - Q(1 + n_i) \quad i = 1, 2$$

Depending upon which state of nature prevails, domestic debt $B(t)$ follows the law of motion:

$$(A4-2) \quad B(t) = (1 + \rho_i) B(t-1) + Q(1 + n_i) - C - T \quad i = 1, 2$$

where T is the budget surplus and ρ_i is the domestic rate of interest in each of the two states.

It can be seen by checking that equations A4-1 plus A4-2 yield the result that the government deficit ($-T$) is financed by domestic and foreign debt.

Empirical Estimates of Money Demand and Real Interest in Brazil

Decreasing returns to money creation. Two estimates of the following money demand equation have been made where M is money demand and $\pi(t)$ is the inflation rate:

$$\log \frac{M(t)}{\text{GDP}(t)} = a - \mu \pi(t).$$

Estimation on a yearly basis for 1971-85 yields $a = -2.39$ ($t = -46.6$), $\mu = 0.765$ ($t = 10.1$) ($R^2 = 0.886$, $DW = 1.4$). Thus the maximum seignorage tax is obtained for a monthly inflation rate $\pi^* = 10.9$ percent (in logarithm; 11.5 percent in rate of growth).

Estimating the same equation on a quarterly basis over the subsample 1983-85 yields $\mu = 3.6$ ($t = 9.3$) and implies a maximum monthly inflation rate π^* of 9.2 percent, very much in line with the previous result. In 1985, the inflation rate has reached 10.0 percent per month on average, leaving little doubt that Brazil has nearly exhausted its capability to expand its seignorage tax receipts.

Other evidence of this can be obtained by analyzing the covariance of the government's financial need, U , with government debt increase and seignorage tax s . We write $U = TB - Z$ and $U = S + \nabla B$, in which TB is the non-interest payment current account, Z is non-interest government surplus, and $\nabla B = B_t - (1 + \rho_t) B_{t-1}$ measures the net new resources from bond holders. It must be matched either by money creation or an increase in domestic debt. We write this relation as follows:

$$1 = \frac{\text{cov}(S, U)}{\text{var } U} + \frac{\text{cov}(\nabla B, U)}{\text{var } U}$$

We find that the two terms on the right-hand side are 10 percent and 90 percent, respectively. This supports other evidence showing the low responsiveness of the seignorage tax to government needs.

Domestic interest rate. The influence of mounting domestic debt upon real interest rates has been estimated on a quarterly basis from 1983 to 1985 in the form $r_t = \alpha + \beta \log B(t)$, in which $B(t)$ is the real value of domestic debt. The results are $\alpha = -0.707$ ($t = -2.04$), $\beta = 0.118$ ($t = 1.98$) ($R^2 = 0.28$, $DW = 1.15$). Even though it is not a very satisfactory relationship, it does support the responsiveness of interest rates to domestic debt. Furthermore, the estimate of β seems consistent with that which results from a larger-sample analysis. [On a yearly basis, 1971–85, we find $\beta = 0.178$ ($t = 1.17$); this is a hint (only) that the past three years were not abnormal.]

Finally, consider the exercise presented in the text. If the repayment of external debt had followed the scheme described at the beginning of the article (pay 15 percent of Brazil's exports to its creditors), domestic debt would have increased by 22 percent instead of the 84 percent rise which has been observed. If one trusts the first relationship obtained above, our proposed repayment scheme would have reduced real interest rates by 5 percentage points. This would have amounted to a reduction of 1.8 percent of GDP for the government deficit (in 1985 the overall government deficit, after monetary correction, was 3 percent of GDP).

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External Shocks and the Demand for Adjustment Finance

Ricardo Martin and Marcelo Selowsky

When a country experiences a long-term adverse external shock, resulting in a balance of payments deficit unsustainable in the medium term, how quickly should it adjust? Because time is required for movement of productive factors and consumption patterns, the short-term effect of the shock will be a large increase in the value of foreign exchange. It then pays to borrow abroad during the first years of the transition against those years when full resource and demand reallocations have taken place. To allow this adjustment path, the market exchange rate should follow the shadow exchange rate. This article uses a simple traded/nontraded sector model with lagged responses and optimal borrowing theory to derive a quantitative relationship between the magnitude of the shock and the optimal amount of borrowing, the speed at which the original shortfall of foreign currency should be closed, and the required currency depreciation during the borrowing and repayment period.

The appropriate mix of instruments and the speed at which to close an unsustainable deficit in the balance of payments has recently received considerable attention. These questions become more important when that deficit results from an external shock that is expected to last for several years or even reflect a new medium-term external scenario for the country in question. The adjustment calls for a substantial medium- or long-run restructuring or reallocation of resources in the economy.

To a large extent, discussions of these issues have centered on the appropriateness of present adjustment programs, particularly those faced by developing countries as a result of a worsening external scenario during the 1980-85 period. Balassa (1986), for example, compares the size of shocks and the way countries responded to them, and Kharas and Shishido (1985) assess alternative borrowing strategies followed by Thailand as a reaction to the external shocks of the late 1970s. Implicit in these discussions is the notion that some of these programs might have entailed an excessive welfare cost and that less costly transition paths might exist to reach a sustainable equilibrium compatible with the new medium-term external conditions.

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A specific hypothesis is that a more gradual adjustment program to close the deficit, which relies less on strong short-term expenditure contraction and expenditure switching policies but requires extra external borrowing, might have benefits that more than compensate for the cost of this extra credit. The real issue is whether this demand for adjustment funds is high enough to be justified at a nonconcessionary cost of credit. If countries are willing to pay, let us say, 10 percent real interest to finance these programs, but because of risk perceptions they have credit constraints from commercial sources of finance, this demand for adjustment finance could be interpreted as a case for the type of new lending programs of multilateral institutions such as the Structural Adjustment Lending Program of the World Bank.

The purpose of this article is to explore such a case. We develop a simple traded/nontraded sector model with lagged elasticity response plus an application of optimal borrowing theory to derive a quantitative relationship between the magnitude of the external shock and the optimal amount of external borrowing.

When faced with a permanent external shock, a country can choose different speeds at which to close the resulting balance of payments gap. It can attempt to close it rather quickly with strong short-term contractionary and rapid exchange rate devaluation policies. If the elasticity response of the traded sector is low in the short run, most of the adjustment will have to come from contractionary policies that lower the consumption of exportables and importables. If these policies call for a decline in the nominal prices of nontraded goods and these prices are inflexible, and it takes time for resources in these sectors to move toward the traded sectors, some unemployment of resources will occur in the nontraded sector. Alternately, the possibilities of achieving strong *real* devaluations in the short run might be limited by the behavior of nominal wages. Increases in nominal wages must be kept below increases in the nominal exchange rate if a real devaluation is the goal. If workers' consumption basket consists largely of traded goods, nominal wages will tend to follow the nominal exchange rate. Downward pressures on the nominal wage will emerge only when the labor market begins to adjust in the face of unemployment, and this might also take time.

The model to be developed here will only capture part of the forces described earlier that may call for a slower adjustment path. The analysis focuses on the effect of the time it takes for resources to move from the nontraded to the traded sector; the long-run elasticity response of the traded sector might be substantially larger than the sector's short-term response. In the first years after the shock the scarcity (shadow) price of foreign exchange might be substantially higher than in the medium and long terms, as resources begin to move from the traded to the nontraded sector. It then pays for the country to borrow during these first years, when foreign exchange is scarce, against the medium term when the adjustment to the new external situation has taken place. It is this differential

scarcity of foreign exchange that determines the rationale for borrowing; adding the cost of the short-term unemployment described earlier might be an added argument for borrowing, not being considered here.

With or without borrowing, the new shadow or scarcity price of foreign exchange will be higher in the long run than the pre-shock equilibrium level. What is important for this exercise is that the market exchange rate is allowed to move: no *additional* tariffs or import restrictions are used in lieu of the market exchange rate in order to close the balance of payments. Only in this way will resources be pulled into the traded sectors.

The article is organized as follows. Section I defines the features of the economy in question; section II discusses the determinants of optimal external borrowing; section III analyzes the effect of the external shock on borrowing; section IV presents empirical results and a sensitivity analysis; and section V summarizes the main conclusions. The appendix presents the formal model used to derive the quantitative results.

I. THE GENERAL FRAMEWORK

The economy is small in relation to international markets, and has two types of traded goods, "importables" and "exportables," and one nontraded sector. The only distortion in the economy is a tariff on imports. Consequently, that tariff generates a wedge between the market exchange rate and the shadow exchange rate. These tariffs are kept constant throughout the analysis.

By selecting units so that the international prices of exportables and importables are equal to one, we define three domestic relative prices, of which only one is endogenous (in these definitions the subindexes N , X , and I are used to denote goods as nontraded, exportables, and importables, respectively):

$$(1) \quad \frac{P_X}{P_N} = P,$$

which is endogenous and equal to the *real* market exchange rate.

$$(2) \quad \frac{P_I}{P_X} = (1 + T),$$

where T is the import tariff. On the basis of equations 1 and 2, we obtain:

$$(3) \quad \frac{P_I}{P_N} = P(1 + T).$$

Thus having determined P , the other relative prices are automatically determined.

Market equilibrium in the nontraded market is defined as:

$$(4) \quad E_N(P, y) = 0$$

where E_N is the excess demand for nontraded goods and y is real income. Balance of payments equilibrium is written as:

$$(5) \quad E_I(P, y) + E_X(P, y) = F - Z$$

where E_I and E_X are the excess demand functions of importables and exportables, F is the planned borrowing under the pre-shock situation, and Z is the unpredicted gap (shock) in the balance of payments.

The effect of the shock can be obtained by differentiation of equations 4 and 5. The endogenous variables are P , the exchange rate, and y , real income. The policy variable is F , which will be revised as a result of the shock.

II. OPTIMAL EXTERNAL BORROWING

It is assumed that the economy was on an optimal borrowing path prior to the reform. We can evaluate the effect of the external shock on that path.

On an optimal borrowing path, there cannot be any unexploited opportunity for intertemporal arbitrage in terms of traded goods. Borrowing will take place up to the point at which the marginal utility of a unit of foreign exchange borrowed today is equal to the discounted value of the utility forgone when that unit is repaid in any future period t . Thus we must have:

$$(6) \quad \lambda_0 P_0^* = \lambda_t P_t^* \left(\frac{\rho}{\delta} \right)^t \text{ for all } t,$$

where λ is the marginal utility of income, P^* is the scarcity (shadow) relative price of traded goods, ρ is equal to one plus the cost of borrowing, and δ is one plus the pure rate of time preference. This equality depends on the assumption that ρ is exogenous, that is, that the country does not face a quantitative ceiling on its external borrowing, at least in the relevant range.

Note that because of the tariff, T , the *market* real exchange rate, P , entering equations 4 and 5 is different from the *shadow* exchange rate, P^* , which is the relevant price entering equation 6 and thus determining the optimal borrowing plan. The relation between the two rates is described in the appendix and can be written as:

$$(7) \quad P_t^* = \frac{e_{XX}}{e_{XX} + e_{II}} P_t + \frac{e_{II}}{e_{XX} + e_{II}} P_t (1 + T_t)$$

where e_{II} is the own-price elasticity of the excess demand for importables (the demand for imports) and e_{XX} the own-price elasticity of the supply of exports (the excess demand for exportables). This expression assumes that the cross-price elasticity of the excess demand of exportables with respect to importables is zero. Where tariffs are always fully rebated to consumers, as in our model, the real income of the private sector remains constant. Consequently these elasticities refer to *compensated* demands. For mathematical purposes, both elasticities

are defined positive (see Dornbusch 1974 and van Wijnbergen 1984 for a discussion of the shadow exchange rate in this type of model).

Equation 7 shows that the shadow exchange rate is equal to a weighted average of the relative prices of exportables, P , and importables, $P(1 + T)$, where the weights are proportional to e_{XX} and e_{II} . This can be more intuitively discussed with the help of figure 1.

Figure 1 illustrates the effect of the import tariff on the supply of and demand for foreign exchange, the relation between the shadow market and real market exchange rates, and the impact of foreign borrowing. The domestic demand for imports is represented by the curve D . The curve $\hat{D}$ shows, for any level of import demand, the price that is actually paid to the foreign exporter—that is, the vertical difference between the two curves is the amount of import tariff. In the absence of any capital flows, equilibrium occurs at the intersection of the S curve, which shows the supply of foreign exchange, and the $\hat{D}$ curve, for here the demand for and supply of foreign currency are equal. (Recall the assumption that units of imports and exports are defined so that their prices in foreign exchange are unity.) At this equilibrium, P_0 is the price of exports and the real market exchange rate and $P_0(1 + T)$ the internal price of imports and hence the marginal valuation of importables.

When an amount, Δ , of additional foreign exchange becomes available through borrowing, the supply of foreign currency curve moves to $S + \Delta$ with a new equilibrium price of P_1 . Demand for imports increases by b , whereas the supply of imports falls by a . The shaded area is the valuation of the additional

Figure 1. *Foreign Exchange Markets, Borrowing, and the Shadow Exchange Rate*

imports; the dotted area is the value of resources released from exports that are now available for domestic demand. The total benefit of the additional foreign exchange is the sum of the two areas: when divided by Δ , the amount of the increase, this yields the additional benefit of a unit, that is, the shadow price of foreign exchange. When Δ is small, this is a weighted average of P_0 and $P_1(1 + T)$, where the weights are functions of the relative elasticities of demand for and supply of foreign exchange (or the elasticities of excess supply of importables and demand for importables).

III. THE EFFECT OF THE EXTERNAL SHOCK

We assume the country was originally on an optimal borrowing path prior to the shock. The issue is to what extent the shock calls for a reformulation of that plan, or whether the new time path of the *shadow* exchange rate might call for extra borrowing. As we illustrate below, that time path will crucially depend on the *speed* at which the economy's resources move as a result of changes in the new level of the real *market* exchange rate.

Figure 2 shows again the market for foreign exchange. P_0 is the market equilibrium exchange rate, given the structure of tariffs, that would have prevailed without the shock Z . That equilibrium incorporated positive borrowing out of the original optimal borrowing plan. P_0^* is the optimal shadow exchange rate associated with P_0 and the structure of tariffs.

Figure 2. *Behavior of the Exchange Rate under the External Shock and Before Extra Borrowing*

S_0 and D_0 reflect the short-run supply and demand for foreign exchange immediately after the shock. If the excess demand for foreign exchange, Z , were to be immediately closed, the new market exchange rate would be $\hat{P}_0$. As resources begin to move toward the traded sector in response to the new (higher) real market exchange rate, both supply and demand increase their elasticity response; that is, they gradually rotate around the original level of the market exchange rate. Thus in period 1 the required real market exchange rate becomes P_1 ; as time passes and further resources move, the new required level becomes P_2 . If it takes three periods to complete the adjustment, and S_3 and D_3 would represent the long-run supply and demand schedules, and the new real market rate for the economy which will result is P_3 . The shadow rate follows the same behavior as the market rate given that the structure of tariffs remains invariant.¹

If the economy were instantaneously to adjust to the new equilibrium values P_3 and P_3^* , no justification for extra borrowing would exist. An immediate new and constant scarcity price of foreign exchange does not disturb the optimal borrowing condition 7 and thus does not call for extra borrowing. However, if it takes time for the market and shadow rates to converge to their new values, equation 7 will indeed be disturbed; it will then pay to borrow during the first years after the shock, against the period when the scarcity price of foreign exchange is lower. The rationale for borrowing is not the shock per se, but the fact that it takes time for the economy to adjust to the new external conditions.

A key assumption in this analysis is that changes in the elasticities of the exportable and importable sectors are exogenous and only a function of time. In other words, the short-term schedules converge toward the long-run ones only over time, independently of other variables in the economy. For example, when the extra borrowing evens out the path of the *market* real exchange rate, we assume this "smoothing" does not affect the speed at which the short-run values converge to the long-run ones; that is, the increase in elasticity response is independent of the path of prices or incentives. What matters is for the market real exchange rate in any single year after the shock to be higher than the pre-shock equilibrium level.

IV. SIMULATION RESULTS

Parameter Values and Assumptions: Base Case

Table 1 shows the parameter values used in the base case in order to obtain estimates of the extra optimal borrowing induced by the external shock. It is assumed that both the excess demands for both importables and exportables have short-run elasticities of 0.2 and long-run elasticities of 0.6. The speed of adjustment coefficient of 0.4 means that, in each period, the short-term elasticities

1. The proportionality between the shadow and market exchange rates, P_t^* and P_t , will only change because of changes in the *differential* elasticity response between imports and exports as time passes. In this case the weights attached to P_t in equation 7 will change.

Table 1. *Parameter Values: Base Case*

<i>Parameter</i>	<i>Value</i>
Elasticity of excess demand importables	
Short-run	0.2
Long-run	0.6
Elasticity of excess demand exportables	
Short-run	0.2
Long-run	0.6
Cross-elasticity between exportables and importables	0
Speed of adjustment	0.4
Elasticity of the marginal utility of income	-1.0
Income elasticity of nontraded goods	1.0
Income elasticity of importables	1.0
Interest rate on borrowing	0.1
Import tariff	0.2
Production	
Share of nontraded in GNP	0.5
Share of exportables in GNP	0.4
Share of importables in GNP	0.1
Expenditure	
Expenditure share on importables	0.4
Share of imports in GNP	0.3

ties increase by a fraction 0.4 of the difference between the long-run and present value, that is, approach asymptotically their long-run values. Two values for the elasticity of the marginal utility of income are used, 0 and -1; the latter is used for the base case.²

The base case assumes a zero cross-price elasticity between exportables and importables; this implies that both commodities are independent in consumption (a change in the price of one commodity does not affect the demand for the other commodity) and that both sectors do not compete for the same primary inputs. This case represents best an economy where tariffs are concentrated on manu-

2. Positive present savings can be expected if the discounted utility of one dollar saved is larger than the utility of consuming it today. Denoting r the rate of return and d the pure rate of time preference, this will be true of:

$$(1') \quad \left(\frac{1+r}{1+d} \right) \lambda_1 > \lambda_0 \quad \text{or} \quad \left(\frac{1+r}{1+d} \right) \frac{\lambda_1}{\lambda_0} > 1$$

where λ_t is the marginal utility of consumption in period t . Denoting ϕ as the elasticity of the marginal utility of income (consumption) and g as the annual growth rate of consumption, then (1') can be rewritten as:

$$(2') \quad \left(\frac{1+r}{1+d} \right) (1 - \phi g) > 1$$

$$(3') \quad r > (d + \phi g),$$

where $(d + \phi g)$ can be called the consumption discount rate. If $\phi = 0$, savings behavior will be independent of the expected growth of consumption. Some large values of d can also be ruled out. If $\phi > 2$, $g = 0.03$, and $r = 0.10$, no savings are expected unless the rate of time preference is below 0.04.

factures and where exports are agricultural goods. Cross-price elasticities of zero will always hold if the country does not consume the exportable good and does not produce the importable good. However, the results did not appear to be particularly sensitive to this assumption of zero cross-elasticities.

The production and expenditure values used in the base case characterize a rather small, open type of economy that is sensitive to external factors. Traded goods are a high proportion of total output and exports and imports represent a high fraction of gross national product (GNP). Movements in terms of trade are translated into large shocks as a fraction of GNP.

The borrowing to be derived from the optimal rule 6 must obey a budget constraint relating future repayment flows to the amount borrowed and the interest rate (equation A-11 in appendix). This requires specifying a horizon or repayment period over which this constraint holds—the period over which the present discounted value of the extra borrowing and its repayment becomes zero.

Results

Table 2 shows values for optimal yearly borrowing as a percentage of the extra gap in the balance of payments due to the external shock. The positive figures indicate borrowing, the negative ones indicate the resulting repayment flows.

The effect of alternative assumptions regarding the difference between short-

Table 2. *Optimal Annual Borrowing as a Percentage of the External Shock*

<i>Parameters varied</i>	<i>Borrowing and repayment periods (years)</i>									
	1	2	3	4	5	6	7	8	9	10
Difference in short-run and long-run supply and demand elasticities ^a										
Base case: 0.2, 0.6	32	2	-10	-16	-20					
Small difference: 0.5, 1.0	14	1	-4	-7	-9					
Large difference: 0.2, 1.0	42	0	-14	20	-23					
Inelastic marginal utility of income (= 0) ^b	50	10	-14	-29	-37					
Speed of convergence from short- to long-run elasticities										
Moderate (= 0.4 a year)										
3-year repayment	25	-8	-21							
5-year repayment	32	2	-10	-16	-20					
10-year repayment	37	10	1	-7	-10	-12	-13	-13	-14	-14
Low (= 0.2 a year)										
3-year repayment	17	-3	-16							
5-year repayment	24	6	-6	-14	-20					
10-year repayment	31	15	4	-3	-8	-12	-15	-17	-19	-20

Note: positive values indicate borrowing; negative values indicate repayment.

a. Supply and demand elasticities are assumed to be the same; we allow the short and long run to vary.

b. Assumed to be equal to -1.0 in the base and other cases.

and long-run elasticities are first explored. For the base case, the optimal borrowing during the first year is 32 percent of the balance of payment gap, that is, 68 percent of the gap must be closed during the first year through a real devaluation. If the permanent gap were equal to \$300 million, the optimal strategy would be for the country to borrow \$96 million during the first year, \$6 million during the second year, and start repaying it by the third year. As shown, the results are quite sensitive to the differences between the short- and long-run elasticities. When the long-run elasticity is 1.0 instead of 0.6, the optimal borrowing during the first year increases from 32 to 42 percent of the shock.

Table 2 also indicates the effect of changing the value of elasticity of the marginal utility of income from 1.0 to 0. When this value is zero, there is no benefit to be obtained by equalizing incomes over time, and no penalties associated with an increase in intertemporal income inequality. In this case, borrowing only responds to intertemporal differences in the scarcity price of foreign exchange; no penalty is attached to the fact that borrowing transfers income from the future to the present, thus creating an intertemporal inequality in income. The effect of this condition is a large level of borrowing. In this case, the increase in borrowing is substantial, equal to 50 percent of the shock during the first year.

Different speeds of convergence of the short-run to the long-run elasticity will also affect optimal borrowing strategies. A slower coefficient of convergence (equal to 0.2) makes the level of borrowing quite sensitive to the limit of the period of repayment. Although the long-run elasticity of supply and demand is still the same, it takes longer to achieve that long-run level, and the effective response to the foreign exchange gap during the borrowing-repayment period is much smaller. Given the low convergence rate, as the repayment period increases from 3 to 10 years, the borrowing during the first year increases from 17 to 31 percent of the shock.

Behavior of the exchange rate

Table 3 and figure 3 show the behavior of the market and shadow real exchange rate with and without the additional external borrowing. We assume

Table 3. *Response of the Market and Shadow Exchange Rates to an External Shock*
(market rate in the base period = 100)

Period	Without borrowing		With borrowing		Borrowing as a percentage of GNP
	Market	Shadow	Market	Shadow	
0 (pre-shock)	100	109	100	109	
1	130	142	119	129	1.6
2	115	125	114	125	0.1
3	111	121	112	123	-0.5
4	110	120	111	122	-0.8
5	109	119	111	121	-1.0

Note: Parameter values are as in the base case (see table 1). The shock creates a gap or shortage of foreign exchange at current exchange rates equal to 5 percent of GNP.

Figure 3. *Response of the Market and Shadow Exchange Rates to an External Shock*

base case parameter values (table 1) and a five-year repayment period. It is assumed that the external shock amounts to 5 percent of the country's GNP.

The immediate effect of the shock is to increase the market and shadow real exchange rate by about 30 percent. As elasticities increase, both rates decline and converge toward a value 9 percent higher than the pre-shock values. The effect of borrowing is to smooth out that path; by borrowing in the first period, both exchanges only go up by about 19 percent during the first year after the shock. With borrowing, however, both exchange rates increase toward a value 11 percent higher than the pre-shock values. The fact that with borrowing, both exchange rates converge toward a higher value than without borrowing, reflects the fact that a surplus has to be generated in order to repay the original borrowing.

Sensitivity to the real interest rate

The earlier results showed the extra borrowing at a 10 percent interest rate, which is the same rate that is in effect while the pre-shock long-run borrowing

Table 4. *Sensitivity of First-Year Borrowing to the Marginal Interest Rate*

<i>Spread between new and previous average interest rate (percentage points)</i>	<i>Borrowing as a percentage of shock</i>
+3	15
+2	20
+1	26
0	32
-1	38
-2	44
-3	51

strategy is observed; the marginal rate for "adjustment borrowing" is equal to the previous interest rate.

How elastic is this extra borrowing to a marginal interest rate that differs from the previous rate? Table 4 shows such a sensitivity. The marginal rates are expressed as percentage point spreads from the previous average rate, so the results are not sensitive to the level of the previous rate.

The demand for "adjustment" borrowing is shown to be quite elastic to the marginal rate. A marginal rate 3 points higher than the previous one cuts borrowing by half from 32 percent of the shock (table 2) to 15 percent (table 4). A negative (or "concessionary") spread of 3 percentage points increases borrowing from 32 to 51 percent of the shock.

This high elasticity for adjustment finance reflects the potential for important benefits out of policies or international initiatives that reduce interest spreads from commercial sources of credit, particularly when a country is facing an adverse external shock. It is precisely in those situations that these spreads tend to increase: external credit tends to be procyclical. Simultaneously, this high elasticity also suggests the large benefits that may accrue out of multilateral lending that finances these programs at interest rates below the marginal rates charged by private sources.

V. CONCLUSIONS

The main purpose of this article is to develop a framework under which a quantitative relationship could be derived between the magnitude of an external shock, a lagged elasticity response, and the behavior of the market and shadow real exchange rates. An optimal borrowing rule determines the amount of extra borrowing induced by the shock.

The main assumption of the model is exogeneity in the movement of elasticities; they are only a function of time and of the fact that at each moment the market real exchange rate is above the pre-shock equilibrium level. A smoother path of the real exchange rate resulting from additional foreign borrowing does not affect the time path of these elasticities. If the movements of these elasticities were to depend on the size of the price change brought about by the shock, the estimated increase in borrowing would be somewhat smaller. Borrowing reduces

the initial increase in the value of foreign exchange, so that benefits from bringing foreign exchange from the future toward the present are reduced.

It is important to realize that associated with the optimal borrowing path there is an optimal capital accumulation and investment plan. This plan might be reformulated with the shock and have an effect on external borrowing. This effect is not incorporated into the present analysis. The bias introduced by this omission depends primarily on how changes in the level of investment affect the demand for foreign exchange, because the main rationale for additional borrowing in the present analysis is to reduce variations of the real exchange rate over time. This impact, in turn, depends on the relative "traded goods intensity" of investment and other expenditures. If investment and consumption use traded and nontraded goods in similar proportions, changes in the investment rate will not affect the net demand for foreign exchange. In this case, the present estimates of the model do not have a bias. If investment is more "traded-goods intensive," changes in investment are a substitute for external borrowing in smoothing foreign exchange availability over time. In this case, the present model overestimates the magnitude of external borrowing induced by the shock.

The main reason for borrowing in the model is the change in the time path of the real exchange rate induced by the shock. The model is frictionless; it does not incorporate the effect of probable short-term losses of income during the process of adjustment. These losses might be particularly important under price and wage inflexibility. Incorporating these factors might increase the amount of additional borrowing. In addition to evening out the availability of foreign exchange, external finance could smooth intertemporal income changes induced by short-term unemployment. In this respect, the present results, which do not account for this factor, would tend to underestimate the amount of optimal "adjustment" borrowing.

The fact that a large share of demand for adjustment borrowing is derived at nonconcessionary interest rates suggests that private credit can play an important role in this respect. Nevertheless, although the demand is large, it is quite elastic. Thus, incorporating any "excessive risk" in the private supply of credit to offset creditors' inability to influence and monitor the policies of a borrowing country can have an important welfare cost. The joint involvement of the World Bank and the International Monetary Fund, however, can reduce that risk perception and bring down the cost of that credit. The impact of these lower costs on the quantity of adjustment finance demand can be substantial.

The high responsiveness of borrowing to the marginal rate of interest implies also a large demand for adjustment finance from such organizations as the World Bank, which may be able to provide credit at rates below those of commercial creditors. If the Bank is able to provide that credit at 2 percentage points below the original average rate, following a shock, for example, optimal borrowing increases by more than 35 percent during the first year in our model. Long-term lending also has an important impact on the amount of borrowing, when the speed of convergence of the short-run elasticities to the long-term rates is slow. We find that the possibility of repaying a loan in ten years instead of five in-

creates an optimal total loan from an amount equal to 30 percent of the shock, to 50 percent of the shock.

It is important to realize that the model assumes that no new distortions are introduced as a result of the shock; neither quantitative restrictions nor new tariffs are adopted to close the balance of payments gap. Only the exchange rate and a neutral aggregate demand policy maintaining full employment are used. The new real exchange rate determines the new system of incentives and thus the reallocation of resources. In this case it is shown that, as a first approximation, the market exchange rate follows a path quite similar to the shadow rate. This means that under perfect foresight and full access of the private sector to world capital markets, the optimal borrowing derived earlier could automatically be carried out by the private sector. In this case, the present analysis would be basically a predictive one. The normative implications for public policy would appear if the earlier conditions do not hold.

APPENDIX: THE OPTIMAL BORROWING PROBLEM

This appendix describes the formal model used to derive the optimality conditions and numerical simulation results presented in the text. The optimal borrowing problem is defined as one of maximizing the discounted value of real income, subject to market clearing conditions for traded and nontraded goods, and repayment of everything borrowed.

We ignore investment and capital accumulation, so that foreign borrowing is the only instrument available for intertemporal arbitrage after the shock. We also assume a stationary social welfare function, $W(U)$, and constant rates for time preference, δ , and the cost of borrowing, ρ .

Let E_N , E_X , and E_I be the excess demand functions for nontraded goods, exportables, and importables. We will use double subindexes to indicate the derivatives of these functions with respect to specific prices, P_j , and real income U for example, $E_{NX} = \partial E_N / \partial P_X$, $E_{IU} = \partial E_I / \partial U$. Later on, we will use $\bullet e_{ij}$ to indicate the elasticity of E_i with respect to P_j . Nontraded goods are the numeraire and traded goods are measured in units that make their (given) international prices equal to one. Thus $P_N = 1$, $P_X = P$, and $P_I = (1 + T)P$, where T is the tariff rate on imports, and P is the real exchange rate, defined as the price of traded goods (foreign exchange) in terms of nontraded goods.

The optimal borrowing problem is:

$$\max \sum_{t=1}^H W(U_t) \delta^{-t}$$

subject to:

$$(A-1) \quad E_N = 0 \quad t = 0, 1, \dots, H \quad (\lambda_t)$$

$$(A-2) \quad E_I + E_X = B_t - Z_t \quad t = 0, 1, \dots, H \quad (\lambda_t P_t^*)$$

$$(A-3) \quad \sum_{t=0}^H B_t \rho^{-t} = 0 \quad (\Psi).$$

B_t is net foreign borrowing in period t and Z_t represents a (negative) external shock in that period, so that equation A-2 simply requires that net financing cover the cost of the excess of imports over exports. Equation 3 is the repayment constraint.

The symbols in parentheses beside the equations are the Lagrange multipliers associated with the $(2H + 1)$ constraints. Thus, λ_t is the social value of one additional unit of nontraded goods available in period t ; $\lambda_t P_t^*$ is the social value of traded goods in t , so that P_t^* is their value in terms of nontradables, that is, the *shadow* real exchange rate. The constant Ψ is the present value of relaxing the repayment constraint, which is equivalent to the value of foreign exchange in period 0.

The optimality conditions are:

$$(A-4) \quad E_{NN} + P_t^*(E_{XN} + E_{IN}) = 0$$

$$(A-5) \quad \lambda_t P_t^* = \Psi \rho^{-t}$$

$$(A-6) \quad dW/dU_t \delta^{-t} = \lambda_t (E_{NU} + P_t^* E_{XU} + P_t^* E_{IU}).$$

Equation A-4 defines the shadow real exchange rate P_t^* . By using the homogeneity condition, $E_{NN} + P E_{XN} + P(1 + T) E_{IN} = 0$, it can be transformed to show that P^* is a weighted average of the real exchange rate as received by exporters (P) and paid by importers ($P + PT$), with weights proportional to the price responsiveness of exports and imports, respectively.

$$(A-7) \quad P^* = P \frac{[E_{XN} + (1 + T)E_{IN}]}{E_{XN} + E_{IN}}.$$

If the cross-elasticity between imports and exports is zero, $E_{XN} = -E_{XX}$ and $E_{IN} = -E_{II}$, so that equation A-7 above reduces to equation 7 in the text. In addition to $E_{XI} = 0$, equation 7 in the text assumes that initially $E_X + E_I = 0$, so that equation 7 can be directly interpreted in terms of elasticities.

Condition A-5 states that the present value of traded goods must decline at the rate of interest paid on foreign loans; otherwise there would be obvious opportunities for gains through arbitrage between the present and the future, via borrowing-repaying. The value of traded goods has two components: the shadow real exchange rate, P^* , and the value of income in terms of nontraded goods, λ_t .

We can rewrite condition A-6 as:

$$(A-6') \quad \lambda_t = \frac{\delta^{-t} dW/dU_t}{E_{NU} + P_t^* E_{XU} + P_t^* E_{IU}}$$

so there are three elements determining the evolution of λ_t : the social rate of time preference, δ ; the marginal value of real income, dW/dU_t (which tends to reduce λ_t when real income is large and increase it when society is poorer); and the denominator in this expression, which is what allows us to go back from the real income numeraire of $W(U)$ to units of expenditure in terms of nontraded goods. Note that in the absence of tariffs the denominator would simply be $-E_U = \partial E / \partial U$, the change in expenditures needed to obtain one more unit of real income.

For the analysis of the next section, it is convenient to substitute λ_t and P_t^* from equations A-4 and A-5 to obtain:

$$(A-8) \quad dW/dU_t = \Psi (\delta/\rho)^t E_U \left[1 + J \left(\frac{m_N e_{NI}}{e_{NN} - m_I} \right) \right]$$

where m_N and m_I are the marginal propensities to consume nontraded and importable goods, ($m_I = P_t E_W/E_U$); $J = T/(1 + T)$, which is the proportional tariff rate, and e_{NI} = elasticity of E_N with respect to P_i , for $i = N, I$.

Effect of external shocks

We assume now that after the economy has settled on an optimal borrowing plan, as defined by equations A-1 through A-6, there is an increase in Z_t , disturbing the equilibrium. The problem is to determine how the path for B_t should change as a result of the shock. The answer is obtained by differentiating the conditions defining the equilibrium with respect to Z_t .

Let p_t and u_t indicate the proportional changes in P_t , U_t , and b_t ; z_t will denote the change in B_t and Z_t as a proportion of total expenditures in the period. Then from equations A-1 and A-2:

$$(A-9) \quad e_{NN} \cdot p_t + e_{NU} \cdot u_t = 0$$

$$(A-10) \quad (1 - J \cdot m_I) u_t - J \theta_I e_{IN} p_t = b_t - z_t$$

where θ_I = share of imports in total expenditures and e_{NU} = income elasticity of nontraded goods.

The repayment condition in terms of additional borrowing is:

$$(A-11) \quad \sum_{t=1}^H b_t \left(\frac{g}{p} \right)^t = 0$$

with g = growth in GNP (this is necessary by the normalization of changes in B_t by the size of the economy).

Differentiation of the optimal borrowing conditions is less straightforward because they are defined in terms of derivatives of the excess demand functions, so that explicit assumptions about "higher order" behavior of these functions is required. It is assumed that within each period the marginal propensities to consume and excess demand elasticities are constant. Then from equation A-8:

$$(A-12) \quad \frac{d\Psi}{\Psi} = \phi u_t + m_N p_t$$

where ϕ = elasticity of the marginal utility of real income, dW/dU_t , with respect to U_t .

This system, equations 9 through 12, can readily be solved for p_t , u_t , and b_t as a function of z_t . The results are reported in the text.

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Personal Income Taxes in Developing Countries

Gerardo P. Sicat and Arvind Virmani

Comparative work on income taxes in developing countries has commonly looked at average tax rates. These rates are often constructed by dividing revenue collections by some measure of private or personal income. Recent controversies have, however, focused on the incentive effects of marginal tax rates. This article develops and applies a simple methodology to compare marginal official tax rates across a sample of fifty developing countries. As would be expected given differences in fiscal capacity, the poorest and the lower-middle-income countries impose relatively low marginal rates, and the rates for the upper-middle-income and developed countries are higher. Conversely, several low- and lower-middle-income countries' tax thresholds start at income levels which are low relative to their mean income when compared with those of developed countries. The results warn against trying to derive information on the disincentive effect of a country's tax schedule from the highest marginal rate; our data show that this is not an accurate indicator of overall disincentive effects.

Governments have adopted income tax systems which vary in both scope and scale. This article presents information on marginal tax rates in a detailed cross-country comparison of the structure of personal income taxes in which an estimated "average" of family income is used to suggest the scale and breadth of coverage. Attention is focused on developing countries.

In many past studies, the scale of different taxes has been evaluated by comparing the ratio of total tax revenues with gross domestic product (GDP). A further refinement to measuring the relative size of income tax revenues is to define a base other than GDP and to calculate an average tax rate relative to this base (Tait, Gratz, and Eichengreen 1979; Chelliah, Baas, and Kelly 1975). The scope or breadth of coverage of the income tax can be assessed by comparing the share of total revenues accruing from households at different income levels.

Past studies do not, however, effectively address the central issue of the distorting consequences of the tax system. The income tax is the most commonly used tax instrument for income redistribution and has been at the center of discussions on the distorting effect of high marginal rates of taxation (Feldstein

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1986; Fullerton 1982; Cantor and others 1983). Tax evasion and behavior changes may incur real resource costs, as the rent-seeking literature reminds us. Tanzi (1987) shows that personal income tax revenues are 11 percent of the total revenues of the eighty-two countries covered by his study, a ratio significantly smaller than that of developed countries because of the extent of evasion and the high level of exemptions.

Any analysis of the distortions caused by the tax system requires information on the effective marginal tax rates faced by different taxpayers. In the absence of such information, attention has often been focused on the highest marginal rate. In this article it is shown how misleading the arbitrary selection of one nominal marginal rate, such as the highest one, can be in assessing the overall disincentives created by the tax system of a country.

The information presented below indicates the relative incentive to evade taxes or to change economic behavior that is created by the different tax rates at increasing income brackets, if tax collection is effective. This study can form the basis for preliminary discussion of income tax reform to alleviate the costs of evasion and economic disincentives. It can be seen as one in a series of steps designed to evaluate differing tax schedules. In order to simplify and thus allow cross-country comparison, the article does not incorporate differences in family size, number of income earners per household, income distribution, or the relative strictness of enforcement. This type of detail should be added for any discussion of income tax policy reform for a single country.

I. THE METHODOLOGY

The typical income tax system can be thought of at the simplest level as consisting of three elements: the deductions which can be netted out of gross income to yield net taxable income; the income tax rate schedule which applies to net income; and the credits deductible from the resultant tax liability. Deductions and credits vary in general with the income source (salary, interest, dividends, perquisites); with the purpose of the deduction or credit (life or medical insurance premiums, mortgage interest, losses from theft or natural calamities); and with personal circumstances (number of dependents, working status of spouse). These deductions vary not only with gross income but also for different taxpayers with the same gross income.

Several studies of countries in the Organisation for Economic Co-operation and Development (OECD) have solved this problem by selecting a typical taxpayer. These studies compare the tax rate faced by the average production worker heading a hypothetical family of four (see, for example, OECD 1980, 1983). Such an approach is not very useful, however, in comparing our large sample of highly diverse developing countries. Because complete information on the typical worker is not available for all fifty countries in the sample, the income tax base can vary so widely that many poor countries may not even tax the "typical worker," and tax structures are much less homogeneous compared

with those of the OECD countries, comparison is much less informative and could even be quite misleading.

A choice must therefore be made between accounting for all these deductions and credits in a few countries or taking account of only the standard deductions and credits so as to compare a larger number of countries. The second approach is adopted in this article.¹ We focus on wage and salary earners only, to avoid the complexities of capital taxation. The variations in household and family structure across countries are avoided (as in the OECD study) by focusing on married couples with one income earner and three children, the average family size in developing countries (World Bank 1985). Further, only standardized deductions and credits related to the family or linked to wage and salary income are subtracted from gross income to obtain taxable income.

The effective marginal tax rate at any gross income level is obtained by applying the countries' tax rate at that income level to the taxable income. As income tax schedules are almost universally piecewise linear, the nominal marginal rates obtained rise in steps. Figure 1 shows hypothetical (smoothed out) marginal tax schedules for a low-income and a developed country. Even if the two countries had similar per capita income levels, the schedules could cross. In countries with widely different per capita income levels, a crossing such as that depicted in figure 1 is likely.

For purposes of comparison, gross family income is measured relative to each country's mean family income, which is defined for our hypothetical single taxpayer family of five people as five times per capita GDP. GDP is the most reliable and current number available for comparison across such a large group of developing countries. Though this measure is likely to overestimate mean family income, the bias is not likely to distort the overall comparison. A more important potential source of bias for the few developed countries included in our sample is the assumed family size. As the developed countries typically have families of less than five, this will tend to overstate their average and marginal tax rates relative to those of the developing countries.

The income threshold at which a positive tax payment must be made, or the maximum of the zero tax bracket (Y^*), will just equal the sum of standard deductions and the basic exemption. Y^* is also measured relative to per family GDP (FGDP). Because allowable deductions, the zero bracket, and tax credits have been accounted for in determining Y^* , the ratio of the threshold income level over "average" family income (Y^*/FGDP) defines a comparative *tax threshold index*. If the index is zero, all income is subject to the tax. If the value is 0.5, families with an income of less than half FGDP are not subject to any tax, whereas families with income equal to FGDP pay a tax on half their income. The larger the deductions, credits, and zero bracket, the greater this index value and the smaller the tax base.

1. Readers interested in further detail for each country are referred to the appendix in Sicat and Virmani (1987).

Figure 1. *Marginal Tax Schedule for Two Diverse Countries*

The income level at which the tax rate reaches the highest marginal rate is similarly measured relative to FGDP. This provides a basis for judging the proportion of taxpayers to which the highest rate may apply. The comparative analysis is based on this, the threshold income level defined above, and four other income levels (which are $\frac{3}{4}$ of mean FGDP, mean FGDP, 2 times FGDP and 3 times FGDP). Summary marginal effective tax schedules for each country are thus defined in terms of family income at these six levels.²

II. THE INCOME TAX BASE

In developing countries an important and often legitimate reason for limiting the size of the income tax base is administrative feasibility. The existence of a large informal sector makes it difficult to categorize and collect taxes. Thus smallholders in agriculture, small retail services, and small industrial establishments are often exempted from many types of taxes. In poor countries the

2. A single measure of the mean marginal tax rate or the mean average tax rate for all taxpayers in a country requires information on either the general or the taxpayer income distribution. As these are readily available for relatively few countries, such a measure is beyond the scope of the current study (see Virmani 1986, which studies the case of India).

proportion of people facing absolute poverty may be larger, and this also restricts the base. Administrative costs may also be used, however, as an excuse for giving special exemptions to favored taxpayers and political pressure groups. The present calculations do not account, however, for "special" elements of the base such as excluded income sources and exceptional deductions and credits.

The tax threshold index (Y^*) for all countries is shown in table 1, whereas table 2 groups countries by ranges of this index. Under the low income countries category, it is surprising to find five countries with an almost universal income tax base. According to this index, the low-income countries with an index close to zero are Burkina Faso, Chad, Ghana, Madagascar, Malawi, and Somalia, whereas among the lower-middle-income countries, Côte D'Ivoire, Liberia, Morocco, and Nigeria also have a zero index; all are in Africa.

For a substantial range of incomes, many of the countries with a relatively broad base also have fairly low tax rates (see table 1). Among the low-income countries, Madagascar has a marginal tax rate of less than 10 percent up to an income level equal to 3 times FGDP. Malawi's marginal rate does not reach 10 percent till it reaches an income level equal to 2 times FGDP, whereas that of Burkina is less than 10 percent at the FGDP level. Among the lower-middle-income countries, the Côte D'Ivoire has a rate of 2 percent even at 3 times FGDP. The case of Côte D'Ivoire is particularly interesting because it has fairly low, almost uniform rates for much of its population. The simple rate structure probably makes it easier to administer a universal tax. The tradeoff between simplicity and administration costs needs to be investigated further.

All the countries with a zero index appear to have a broader base than the three developed countries included for comparison, which have indexes falling in the 0.11–0.2 range (table 2). Thirty-five of the countries, however, have a narrower base than these developed countries. Table 2 shows that thirteen countries have an index between 0.1 and 0.2 and that twelve countries have an index between 0.2 and 0.5. These form the broad midrange of countries within which the base appears to be reasonable.

Countries with a high threshold level of taxable income, which suggests a relatively narrow base, seem more consistent with expectations. The low-income countries with the highest indexes, Bangladesh and India, are both relatively large, poor countries. Within the low-income group, Niger and Pakistan also appear to have a relatively narrow base. Niger has a very narrow base given its rather small population.

Among the lower-middle-income countries, exceptionally high index values (greater than two standard deviations from the group average) are found for Indonesia and Guatemala. Indonesia fits the pattern of a large, populous country that has potentially high administration costs and thus an expectedly lower tax base. Guatemala's tax base appears to be even narrower for its size than Niger's. Among the upper-middle-income countries, Argentina has an exceptionally narrow base, which seems to be too extreme to be explained by its large size alone.

Table 1. *Marginal Tax Rates and Tax Threshold Index, 1984-85*

Number	Within-group number		Tax threshold index (Y*/FGDP) (1)	Marginal tax rate on first bracket (percent) (2)	Marginal tax rate on 3/4 FGDP (percent) (3)	Marginal tax rate on FGDP (percent) (4)	Marginal tax rate on 2 FGDP (percent) (5)	Marginal tax rate on 3 FGDP (percent) (6)	Marginal tax rate on highest bracket (percent) (7)	Ratio of highest bracket to FGDP (8)
<i>Low-income countries</i>										
1	1	Ethiopia	0.42	10.0	10.0	10.0	10.0	13.0	85.0	31.22
2	2	Bangladesh	1.56++	2.5	0.0	0.0	10.0	20.0	65.0	15.05
3	3	Mali	0.34	10.0	10.0	18.0	25.0	35.0	70.0	4.94
4	4	Zaire	0.75	4.0	10.0	12.0	18.0	22.0	60.0	9.11
5	5	Burkina Faso	0.00	2.0	5.0	8.6	16.3	16.3	30.0	9.71
6	6	Burma	0.65	4.0	4.0	4.0	7.0	10.0	75.0	43.11
7	7	Malawi	0.00	3.0	—	3.0	10.0	20.0	50.0	19.00
8	8	Niger	0.92	2.0	0.0	1.8	5.4	5.4	72.0	41.58
9	9	Tanzania	0.69	20.0	20.0	20.0	25.0	30.0	95.0	19.93
10	10	Somalia	0.00	5.0	21.0	36.2	56.1	56.1	56.1	1.57
11	11	India	1.56++	33.0	0.0	0.0	28.0	39.1	62.0	7.79
12	12	Benin	0.23	4.5	10.2	10.2	16.6	20.1	66.0	12.00
13	13	Ghana	0.02	5.0	60.0	60.0	60.0	60.0	60.0	0.18
14	14	Madagascar	0.00	na	3.1	3.5	6.7	9.7	60.0	36.27
15	15	Sierra Leone	0.13	2.4	21.5	27.0	51.0	57.5	70.0	6.28
16	16	Sri Lanka	0.30	9.3	17.5	28.5	55.0	55.0	61.5	1.66
17	17	Kenya	0.86	10.0	0.0	10.0	15.0	25.0	65.0	11.50
18	18	Pakistan	0.88	15.0	0.0	—	35.0	50.0	60.0	5.76
19	19	Sudan	0.18	5.0	15.0	20.0	30.0	40.0	60.0	4.51
20	20	Chad	0.00	16.0	15.4	15.4	15.4	21.6	65.0	46.78
<i>Lower-middle-income countries</i>										
21	1	Senegal	0.49	5.0	9.3	9.3	9.3	19.4	65.0	70.97
22	2	Liberia	0.00—	12.0	12.0	15.5	24.5	31.5	73.0	37.59
23	3	Yemen A.R.	0.17	3.0	12.0	15.0	15.0	15.0	15.0	0.85
24	4	Indonesia	1.29++	15.0	0.0	0.0	15.0	15.0	35.0	22.43
25	5	Zambia	0.75	5.0	5.0	5.0	20.0	20.0	80.0	7.41
26	6	Egypt A.R.	0.33	2.0	16.3	23.0	31.0	32.9	73.0	76.80

27	7	Côte d'Ivoire	0.00–	2.5	1.2	2.2	2.2	2.2	72.5	239.61
28	8	Zimbabwe	0.33	12.0	2.0	2.0	28.8	30.0	63.0	9.33
29	9	Morocco	0.00–	0.3	11.9	13.1	18.6	34.0	80.2	33.33
30	10	Philippines	0.44	1.0	7.0	11.0	15.0	19.0	35.0	13.65
31	11	Nigeria	0.00–	10.0	1.0	10.0	15.0	20.0	70.0	11.72
32	12	Thailand	0.47	7.0	7.0	7.0	17.0	22.0	65.0	21.35
33	13	Peru	0.82	2.0	0.0	4.0	18.0	34.0	65.0	14.24
34	14	Guatemala	1.26++	5.0	0.0	0.0	6.8	9.5	48.0	87.33
35	15	Turkey	0.06	36.0	36.0	40.0	40.0	48.0	65.0	20.72
36	16	Tunisia	0.19	5.3	24.7	42.6	63.3	67.3	89.3	25.07
37	17	Jamaica	0.45	30.0	45.0	57.5	57.5	57.5	57.5	0.94
38	18	Ecuador	0.35	8.0	20.0	20.0	26.0	29.0	46.0	9.99
39	19	Colombia	0.06	7.0	20.0	24.0	39.0	44.0	49.0	12.14
<i>Upper-middle-income countries</i>										
40	1	Jordan	0.51	5.0	3.8	5.0	15.0	20.0	45.0	10.60
41	2	Malaysia	0.47	6.0	15.0	20.0	40.0	45.0	55.0	4.41
42	3	Chile	0.95	8.0	0.0	8.0	13.0	18.0	54.0	11.15
43	4	Brazil	0.59	5.0	10.0	15.0	35.0	45.0	60.0	7.36
44	5	Korea, Rep.	0.39	7.1	10.6	14.0	31.0	44.6	70.1	8.06
45	6	Argentina	1.16++	6.4	0.0	0.0	16.0	22.8	54.0	7.90
46	7	Portugal	0.20	5.5	29.5	39.5	67.5	95.5	95.5	2.21
47	8	Mexico	0.14–	3.1	20.5	24.2	34.0	40.0	55.0	11.16
48	9	Greece	0.54	12.1	48.3	52.9	62.1	66.7	69.0	3.41
49	10	Hong Kong	0.37	5.0	25.0	25.0	17.0	17.0	25.0	0.21
50	11	Singapore	0.08–	3.6	22.5	27.0	32.0	36.0	40.5	10.66
<i>Industrial countries</i>										
		Ireland	0.16	35.0	60.0	66.0	66.0	66.0	66.0	0.72
		Japan	0.11	14.5	44.0	50.0	71.0	77.0	84.0	6.93
		United States	0.12	11.0	38.0	42.0	49.0	50.0	50.0	2.34

n.a. Not available.

Note: Y* = threshold income or maximum nontaxable income level; FGDP = family per capita GDP (five times GDP per capita).

+, – stand for number of standard deviations above (+), and below (–) the mean of the income group. For instance India's index is between 2 and 3 standard deviations above the mean for the low-income countries.

Source: Derived from tax information mainly from the Bureau of International Fiscal Documentation. For details, see Sicat and Virmani (1986).

Table 2. *Countries Grouped by Range of Tax Base Index*

<i>Range of tax base index (Y*/FGDP)</i>	<i>Countries in the range</i>
0.00	Low-income: Burkina Faso, Malawi, Somalia, Madagascar, Chad Lower-middle-income: Liberia, Côte d'Ivoire, Morocco, Nigeria
0.01–0.20	Low-income: Ghana, Sierra Leone, Sudan Lower-middle-income: Colombia, Turkey, Yemen A.R., Tunisia Upper-middle-income: Singapore, Portugal, Mexico Industrial: Ireland, Japan, United States
0.21–0.50	Low-income: Benin, Sri Lanka, Mali, Ethiopia Lower-middle-income: Egypt A.R., Zimbabwe, Ecuador, Senegal, Philippines, Thailand, Jamaica Upper-middle-income: Malaysia
0.51–0.80	Low-income: Burma, Tanzania, Zaire Lower-middle-income: Zambia Upper-middle-income: Greece
0.81–1.00	Low-income: Kenya, Pakistan, Niger Lower-middle-income: Peru Upper-middle-income: Chile
1.01–1.40	Lower-middle-income: Indonesia, Guatemala Upper-middle-income: Argentina
1.41–1.60	Low-income: Bangladesh, India

Note: Y* = threshold income or maximum nontaxable income level; FGDP = family per capita GDP (five times GDP per capita).

Source: Derived from table 1.

III. HIGHEST BRACKET AND MARGINAL RATES

Impressionistic statements about comparative tax rates sometimes single out the highest marginal tax rate. The highest tax rate is a measure which has some value in comparing countries with similar income levels and a measurable fraction of income earners in this bracket. But in some of the poorer developing countries, such rates may apply only to a handful of individuals. In many countries, few earners will actually pay these rates because of tax evasion. This provides a measure of the incentive for evasion and corruption (see, for example, Virmani 1983). The income (relative to FGDP) at which this highest rate applies is an important element in judging the importance of this rate within the entire tax schedule.

The importance of the tax bracket level can be seen from the following illustrative calculation. Under the assumption that income is distributed log normally, the National Council of Applied Economic Research survey of India for 1975–76 is used to calculate the mean and variance of the income distribution. Using tables for the normal distribution, we find that only 0.05 percent of the population has an income greater than 5 times mean per capita income. If every family had the same number of members and only one income earner, this also

implies that only 0.05 percent of families have income greater than 5 times FGDP. That is, if the same distribution applied to a country of 50 million people with 10 million families, only 5,000 families (taxpayers) would have an income greater than 5 times mean FGDP. The number would fall to insignificant levels at 20 to 30 times mean income.

Table 1 presents the high tax bracket income level relative to FGDP (column 8) along with the highest marginal tax rates (column 7). Among the low-income countries, Burma, Ethiopia, Niger, and Tanzania have the highest marginal rates, ranging from 95 to 72 percent. For all these countries the income level at which these rates apply is 20 or more times FGDP. In the case of Burma, a marginal tax rate of 75 percent becomes applicable at an income level equal to 43 times FGDP. The number of people with this level of income can probably be counted on one hand, and it seems highly unlikely that anyone officially declares incomes at these levels. Similar arguments apply to Ethiopia and Niger, and the high rates appear quite meaningless for a realistic discussion of incentive effects. In the latter three countries marginal tax rates are a relatively low 5–13 percent at 3 times FGDP.

Tanzania has a 30 percent marginal rate at 3 times FGDP and a 95 percent rate at 20 times FGDP. Though only a small fraction of the population is likely to have income levels of 20 times FGDP, high marginal rates come in at relatively low income levels in Tanzania. Similarly, Mali and Sierra Leone also have high rates at relatively low income levels: though the highest rate is only 70 percent in both, it applies at 6 and 5 times FGDP, respectively.

Among the lower-middle-income countries, the highest bracket marginal tax rate of six countries is greater than 70 percent. Of these, five countries have the highest tax rate applying at incomes which are more than 25 times FGDP. For four of these countries, Côte D'Ivoire, Egypt, Liberia, and Morocco, the high rates of 73 to 80 percent seem quite irrelevant. For example, in the case of Côte D'Ivoire, the 73 percent rate becomes applicable at 240 times FGDP! The fifth country, Tunisia, has the highest marginal rate in the group, 89 percent. The fact that it applies at income levels of 25 times FGDP seems to indicate that this too is never applied. But even at 3 times FGDP, Tunisia has a marginal tax rate of 67 percent, the highest rate at this level for the lower-middle-income countries. This indicates that high marginal rates may have significant incentive effects in Tunisia. Portugal has the highest marginal rate in the entire set of countries. This rate applies at an income level less than 3 times FGDP and thus is likely to be important for incentives.

In some countries the extremely high marginal tax rates on a very small number of taxpayers raise questions about the intent of the tax schedule. In economic terms, if there is no individual with a present or potential income at which the rate applies, the rate is irrelevant. It could therefore be reduced to zero without having any economic effect. The question is why countries have such high rates on mythical income. The answer may be a mix of sociopolitical pressures and a wild hope that somebody will pay these high rates.

IV. EFFECTIVE MARGINAL TAX RATES

As discussed in section I, the four income levels we use to define a summary effective marginal tax schedule for each country, assuming taxpayer compliance, are the four multiples of FGDP ($3/4$, 1, 2, and 3). These are also shown in table 1. In the absence of detailed earner information either from the returns of all tax filers or from an income distribution survey, we can only illustrate the applicability of these rates by using the previously mentioned data on India. Given the assumption of log normal income distribution, these data suggest that 25–50 percent of families have income above the FGDP, 6.5 percent of families have income greater than 2 times FGDP, and 1 percent of families have income greater than 3 times FGDP. Given that only 0.05 percent of families have income greater than 5 times FGDP, we conclude that a majority of taxpayers have income less than 4 times FGDP. For most developing countries, the bulk of tax revenues are also likely to accrue from those with income greater than FGDP. In a more detailed study, Virmani (1986) finds that fewer than 3.5 percent of earners in India were liable for a positive tax in a single year.

A ranking of countries by marginal tax rates provides a useful frame of reference for determining which income levels have a more representative tax structure than others. The Spearman's rank correlation coefficient of the ranking at different multiples of FGDP is a useful index for this purpose. We find that the correlation coefficient is 0.96 for the ranks at $3/4$ FGDP and FGDP, and for 2 times FGDP and 3 times FGDP. The same pattern of relatively high correlations is found for countries ranked within the income groups. The rank correlation coefficient between the ranks at 1 and 2 times FGDP, however, is much lower at 0.8. The pattern of rank correlation coefficients suggests that the structure of taxes changes most significantly between 1 and 2 times FGDP in many countries. These two income levels together are therefore reasonably representative for cross-country comparison of marginal tax rates.

Table 3 summarizes the mean and standard deviation of the marginal rates for the low-, lower-middle- and upper-middle-income countries. For the low-income countries as a whole, the mean marginal tax rate rises from 11 percent at $3/4$ FGDP to 30 percent at 3 times FGDP. As we would expect, the increasing marginal rate pattern is found for each group of countries. As shown in figure 2, the marginal rate rises most rapidly between 2 and 3 times FGDP, after which the rate of increase slows down somewhat. The schedule for the lower-middle-income countries is remarkably similar to that of the low-income countries. In contrast, for the upper-middle-income countries the mean marginal rate increases at virtually the same rate between 1 and 3 times FGDP. For the few developed countries considered here, the mean rate increases most rapidly between 1 and 2 times FGDP but less rapidly than for the developing countries between 2 and 3 times FGDP. The difference in pattern between the upper-middle and the high-income countries could be caused by the fact that the former have a greater proportion of potential taxpayers with incomes between 2 and 3 times FGDP.

Table 3. Means and Standard Deviations of Marginal Tax Rates over Various Country Groups

Countries and group	Multiple of FGDP			
	3/4	1	2	3
<i>Low-income</i>				
Mean (unweighted)	11.1	15.2	24.8	30.3
Standard deviation	13.5	14.5	17.3	17.2
Coefficient of variation	1.22	0.95	0.70	0.57
<i>Lower-middle-income</i>				
Mean (unweighted)	12.1	15.9	24.3	29.0
Standard deviation	12.2	15.4	15.7	15.9
Coefficient of variation	1.01	0.97	0.65	0.55
<i>Upper-middle-income</i>				
Mean (unweighted)	16.8	21.0	33.0	41.0
Standard deviation	13.8	14.7	17.5	22.5
Coefficient of variation	0.82	0.70	0.53	0.55
<i>All developing</i>				
Mean (unweighted)	12.8	16.7	26.4	32.1
Standard deviation	13.3	15.1	17.1	18.7
Coefficient of variation	1.04	0.90	0.65	0.58
<i>All</i>				
Mean (unweighted)	14.7	18.8	28.4	34
Standard deviation	15.3	17.0	18.7	19.8
Coefficient of variation	1.04	0.90	0.66	0.58

Note: FGDP = family per capita GDP (five times GDP per capita).

Source: Derived from table 1.

Though the mean marginal schedules for the low- and lower-middle-income countries are virtually identical, that for the upper-middle-income countries lies well above these two (figure 2). One can speculate that a structural change occurs in the economy between these per capita income levels. The most plausible candidate for this change is an increase in the proportion of labor employed by modern organized entities (corporate, government). This may be associated with a relative decline of the agricultural sector and a rise in the urban middle class. The schedule for the developing countries lies even further above that of the upper-middle income countries, perhaps because of an acceleration of this trend.

In figure 3, for any multiple of FGDP, the curve traces out the increase in the mean marginal rate as we move from the low-income to the developed countries. As shown in table 3, for instance, at 2 times FGDP, the mean marginal rate goes from about 24.8 percent for the low-income countries to 33 percent for the upper-middle-income countries. The rate is about 60 percent for the developed countries in the sample. As family GDP increases from about \$4,000 to about \$14,000 (or per capita income rises from around \$800 to \$2,800), the marginal rate increases most rapidly at the 3-times-FGDP level. The mean marginal tax rate falls slightly, however, for the early family GDP range of \$2,000 to \$4,000, at 3 times FGDP. Subsequently the increase is relatively more rapid at the FGDP level.

Figure 2. Mean Marginal Tax Rates by "Family GDP"

Key: — Low-income countries   - - - Lower-middle-income countries   - . - Upper-middle-income countries
 — Developed countries

The mean values of the marginal rate for a group of developing countries obscures the variability within the group as shown in table 3. The coefficient of variation (cv) for all developing countries shows that the variability is greatest at $3/4$ FGDP ($cv = 1$) and declines with increases in family income (to $cv = 0.6$ at 3 times FGDP). The same pattern is observed within each of the developing country groups. As the diversity in rates is reduced much more rapidly in the low-income countries, the coefficient of variation is almost identical (at 0.55) for all three groups at 3 times FGDP.

The low-income and lower-middle income countries have similar variability in marginal rates, except at $3/4$ FGDP. There is considerably more diversity in the marginal tax rates of the low-income countries ($cv = 1.2$) than in the lower-middle-income countries ($cv = 1$). This is largely caused by differences in the tax threshold index. Many more low-income than lower-middle-income countries have a zero tax rate at $3/4$ FGDP, with the index lying between $3/4$ FGDP and FGDP.

The diversity in rates also tends to decline as we move from the low-income to the upper-middle-income countries at each family income level. For instance, at a family income of 2 times FGDP the cv is 0.7 for low-income, 0.65 for the lower-middle-income and only 0.53 for the upper-middle-income countries. This sug-

Figure 3. Mean Marginal Tax Rates by Country Income Category

Key: — $3/4$ FGDP — FGDP — $2 \times$ FGDP — $3 \times$ FGDP

gests that as the importance of the income tax in total revenues increases, countries apply a more systematic approach to it. At low-income levels the tax seems more idiosyncratic and much more dependent on noneconomic factors or on factors not usually considered in traditional economic analysis, such as administration costs and evasion.

Table 4 indicates which countries deviate most widely from the mean for each country group. On the low side, whereas 14 countries fall more than 1 standard deviation below the mean, there is no country with marginal rates more than 2 standard deviations below the mean. Only one country, Ghana, differs from its group mean by more than 3 standard deviations. Focusing on the 2- and 3-times-FGDP income levels, we find that among the low-income countries, Ghana, Sierra Leone, Somalia, and Sri Lanka have the highest marginal rates. Other countries with relatively high rates are Jamaica, Portugal, and Tunisia.

V. CONCLUSION

This study has produced a comparative view of the structure of personal income taxes in developing countries, based on a simple methodology which takes account of standard deductions and relative family incomes, on the basis of per capita GDP measurements. The marginal tax rates for the poorest develop-

Table 4. *Countries with Relatively High or Low Marginal Tax Rates at Different Income Levels*

Standard deviation from mean marginal tax rate	Income level of 3/4 FGDP			Income level of FGDP			Income level of 2 × FGDP			Income level of 3 × FGDP		
	Low- income	Lower- middle- income	Upper- middle- income	Low- income	Lower- middle- income	Upper- middle- income	Low- income	Lower- middle- income	Upper- middle- income	Low- income	Lower- middle- income	Upper- middle- income
+4												
+3		Ghana										
		Jamaica	Greece	Ghana	Jamaica	Greece	Ghana	Tunisia Jamaica			Tunisia	Portugal
+2		Turkey Tunisia		Somalia	Turkey Tunisia	Portugal	Somalia Sierra Leone Sri Lanka	Turkey	Portugal Greece	Somalia Ghana Sierra Leone Sri Lanka Pakistan	Turkey Jamaica	Greece
+1												
MEAN AND STANDARD DEVIATION OF MARGINAL TAX RATES (PERCENT)	11.1 13.5	12.1 12.2	16.8 13.8	15.2 14.5	15.9 15.4	21.0 14.7	24.8 17.3	24.3 15.7	33.0 17.5	30.3 17.2	29.0 15.9	41.0 22.5
-1			Chile Argentina	Bangladesh India Pakistan	Indonesia Guatemala	Jordan Argentina	Burma Niger Madagascar	Côte d'Ivoire Guatemala	Jordan Chile	Ethiopia Burma Niger Madagascar	Côte d'Ivoire Guatemala	Chile Hong Kong
-2												

Source: Derived from table 1.

ing countries were substantially lower than those for the upper-middle-income countries and were not found to be significantly different from that of the lower-middle-income countries. The marginal rates for the upper-middle-income countries were, in turn, substantially lower than for the developed countries included as comparators.

The naive view that high income tax rates are positively related to per capita income across countries can be decisively rejected. A related approach which uses the highest marginal rate as an indicator of overall marginal tax rates was shown to be equally erroneous. Among the countries with very high marginal rates at the highest bracket, there were many in which the highest bracket started at an extremely high income level, at which level no taxpayers are likely to be subject to the tax. Conversely, there were several countries with relatively low rates for the highest bracket but in which the highest bracket was at a relatively low income level. They therefore had relatively high marginal rates over an important range of incomes.

The tax base is an important component of tax reform discussions in developing countries. The tax threshold index we used suggests that a number of poor developing countries had a narrow base, as expected. Somewhat surprisingly, there were a number of low- and lower-middle-income countries which had a broader income tax base than the developed countries with which they were compared. The lower-middle-income countries had a somewhat broader base than other developing countries. In interpreting these results, however, the incomplete nature of this index should be kept in mind. It is proposed as one stage in a continuing analysis of income tax systems.

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