

A TECHNIQUE FOR ESTIMATING INCOME TRENDS FROM CURRENCY DATA AND AN APPLICATION TO NINETEENTH-CENTURY BRAZIL

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This paper develops a method for estimating long-run trends in income growth from the data available on a country's currency stock. The method is applied to nineteenth-century Brazil. The results indicate that contrary to earlier beliefs, the country as a whole probably experienced only moderate growth in per-capita income during the nineteenth century. The approach may also be useful for other countries where data shortages preclude estimates of national income by conventional methods.

I

Analysis of the economic history of the less-developed countries has frequently been hampered by the absence of national income estimates before relatively recent dates, such as 1939 or 1920.¹ Moreover, the underlying data which would be required to construct such estimates, such as figures for labor force distribution and sectoral output, are in many cases also not available. As a result, studies of the economic history of the less-developed countries have generally not had an adequate basis for dealing with such fundamental questions as long-run income trends, and the demarcation of different sub-periods in terms of varying income growth.

As a number of authors have suggested, however, monetary data—which are usually collected on a systematic basis before production data—can be used to provide approximate answers to these questions.² The present paper is an application of this general approach based on the demand for real cash balances, with an additional algebraic manipulation to permit the estimation of long-term income trends from *currency* data. The analysis is applied to nineteenth-century Brazil: beginning in 1822 when, following Independence, the first data on the currency stock became available, and proceeding until 1913. Apart from providing an empirical basis for answering important substantive questions concerning income growth in nineteenth-century Brazil, the procedure applied may also be

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¹The only exceptions of which I know are Henry C. Aubrey's pioneering "National Income of Mexico," *Estadística*, 8 (July, 1950); Clark Reynolds, *The Mexican Economy: Twentieth Century Structure and Growth* (New Haven, 1970), Appendix B; Gisela Eisner's *Jamaica, 1830-1930* (Manchester, 1961); and M. Mukerji in V. B. Singh (ed.), *Economic History of India: 1857-1956* (Bombay, 1965).

²Milton Friedman, "Monetary Data and National Income Estimates," *Economic Development and Cultural Change* (April, 1961). See also Ernest Doblin, "The Ratio of Income to Money Supply: An International Survey," *Review of Economics and Statistics*, XXXIII, 3 (August, 1951).

methodologically relevant for the analysis of the economic history of other under-developed countries in the nineteenth century.

II

The procedure starts from the Quantity Theory, $MV = PY$. Dividing by P , $Y = (M/P)V$. In growth terms, $\dot{Y} = (\dot{M/P}) + \dot{V}$. Thus, in order to estimate trends in income, we require estimates of (M/P) and \dot{V} . In the present case, however, we lack data on the money supply, M , and we must go through an extra step to permit use of the currency supply figures which are available for nineteenth-century Brazil.³

We begin with identities on the income velocity of circulation, $V = Y/M$; and on the share of the currency stock in the total money supply, $Z = CS/M$. Writing these in logarithmic form,

$$(1) \quad \log V = \log Y - \log M$$

$$(2) \quad \log Z = \log CS - \log M.$$

Subtracting (2) from (1) and rearranging terms we have

$$(3) \quad \log Y = \log CS + \log V - \log Z.$$

Using dot notation and lower-case letters to denote annual percentage rates of change in the per-capita form of these variables,

$$(4) \quad \dot{y} = \dot{cs} + \dot{v} - \dot{z}.$$

In order to use expression (4) to draw conclusions from trends in the currency supply to long-term trends in income, we require knowledge concerning the magnitudes of \dot{v} and \dot{z} in nineteenth-century Brazil.

III

Cross-section and time series studies indicate that both Z and V are inversely related with Y .⁴ At higher levels of income, currency constitutes a smaller fraction of the total money supply; and countries also have a lower ratio of income to money supply.⁵ In addition, as Professor Gurley has demonstrated, larger population size (as an indicator of an increased number of decentralized decision-

³Sources for the data used in this paper are presented in Appendix II, below.

⁴Friedman, *op. cit.*; Doblin, *op. cit.*; J. M. Keynes, *A Treatise on Money*, Vol. I (New York, 1930), p. 31; John G. Gurley and E. S. Shaw, "Financial Structure and Economic Development," *Economic Development and Cultural Change*, 15 (April, 1967); Jacques Melitz and Hector Correa, "International Differences in Income Velocity," *The Review of Economics and Statistics*, LII (February, 1970); and especially John G. Gurley, "Repercusión del Desarrollo Económico en las Estructuras Financieras: Estudio de Cortes Transversales," in *Estructura Financiera y Desarrollo Económico* (Buenos Aires: Instituto Torquato di Tella, 1968). In addition, Daniel J. Khazoom has presented data showing a strong positive correlation between Z and V . See his "Covariations in the Currency Ratio and the Velocity of Money in Underdeveloped Countries," *Journal of Development Studies*, III (October, 1966).

⁵Apart from the possibility that, particularly at low income levels, cash balances may be a luxury good, among the reasons usually adduced for the lower V are (1) the growing differentiation in the structure of the economy which interrupts the synchronization of production and requires growing cash balances, (2) relative decline in the share of production devoted to direct use by producers, for example, in agriculture, (3) disproportionate growth in purely financial transactions, (4) change in payment patterns, e.g., from daily to weekly payments.

makers who must hold cash balances to carry out their transactions) is also associated with a lower V .⁶ Consequently, even without rising per-capita income, growth in the scale of the economy and in the number of economic units would lead to a fall in velocity.

In the first decades of the nineteenth century, Brazil was not well developed financially.⁷ Hence it is reasonable to suppose that Z was close to its upper limit of 1. In 1913, Z was 0.41. If we assume that in 1822, Z was equal to 0.9, this would imply $\dot{z} = -0.9$ percent. Choosing the initial value of Z close to its upper limit, of course, increases the magnitude of \dot{z} , and in accordance with (4), to this extent, may bias upward our estimate for y .

Observations for 1920 and 1925 indicate that in those years, V averaged 3.4 in Brazil. Data for the earlier years are not available, but statistics from other countries suggest possible lower-bound, upper-bound, and intermediate figures for V in Brazil in 1822. In the first half of the nineteenth century, V averaged approximately 10 in the United States.⁸ This is probably an extreme lower limit for V_{1822} in Brazil. First, all indications are that in 1822, per-capita income was lower in Brazil than in the United States. In addition, Brazil had a proportionately larger slave labor-force, which did not require the holding of cash balances for wage payments. Since the slaves were concentrated in many of the economy's highest productivity activities, the demand for money in a relatively large percentage of the economy's transactions was relatively low. Brazil also had a much larger quasi-subsistence sector than the United States.⁹ Moreover, the population was overwhelmingly rural—as late as 1890, only 9 percent of the population resided in the urban areas, the counties of the national capital and of the state capitals. As mentioned, the banking system seems to have been extremely primitive. Finally, the share of the export sector in aggregate output in 1822 was much smaller than has commonly been assumed.¹⁰ All of these conditions would lower the demand for money in Brazil, and lead to a V_{1822} higher than in the United States during the first half of the nineteenth century.

Data from other countries suggest 20 as an upper-bound assumption for V_{1822} in Brazil; and 15 an intermediate figure.¹¹ (Alternative assumptions concerning V_{1822} which the reader may find more plausible can of course readily be

⁶John G. Gurley, "Repercusión del Desarrollo Económico," especially pp. 138–143, 150.

⁷For material on the Brazilian banking system in this period, see J. Pandá Calógeras, *A Política Monetária do Brasil* (São Paulo, 1960) (trans. by Thomaz Newlands Neto from the 1910 edition of *La Politique Monétaire de Brésil*), Chapters II and III.

⁸I owe this information to a personal communication from Professor Raymond Goldsmith. He bears no responsibility for the present discussion.

⁹See Nathaniel H. Leff, "Economic Retardation in Nineteenth-Century Brazil," *The Economic History Review*, Aug., 1972.

¹⁰Nathaniel H. Leff, "Tropical Exports and Development in the Nineteenth Century: The Brazilian Case," *The Journal of Political Economy*, forthcoming.

¹¹In Mexico during the years 1895–1897, V averaged 17. See Leopoldo Solís, "La Evolución Económica de México a Partir de la Revolución de 1910," *Demografía y Economía*, III, 1 (1969), Cuadro 2. More generally, see the estimates presented in Gurley, "Repercusión del Desarrollo Económico," pp. 124–127. The following considerations, however, lead me to select 20 as an upper-bound for V_{1822} even though this is higher than the figures computed by Gurley for (contemporary) underdeveloped countries. As noted below, as late as 1920–1925, per-capita income in Brazil was only 98 dollars. Consequently, the observations of V most relevant in Gurley's data are those for the countries with per-capita income below 100 dollars. Within this sub-set of countries, because of the association (demonstrated by Gurley) of large population

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incorporated with the data provided in the paper to permit his own conclusions on the rate of income growth.) The annual figures for \dot{v} which these upper-bound, intermediate, and lower-bound assumptions imply are, respectively: -2.2 , -1.8 , and -1.1 percent.¹² As these figures indicate, large differences in the initial V are associated with less than proportionate variations in \dot{v} . Consequently, the final estimates of \dot{v} are not as sensitive as might have been expected to the assumptions concerning V_{1822} .

We cannot, however, use these materials and equation (4) to estimate upper-bound, lower-bound, and intermediate rates of income growth without a price deflator for the nominal Brazilian currency stock. This is considered in the next section. Before we proceed to that discussion, however, we should note at the outset that even the data on the nominal currency stock do not suggest a rapid increase in Brazilian per-capita income during this period.

Between 1822 and 1913, the nominal Brazilian currency stock increased at annual trend rate of 3.8 percent.¹³ On a per-capita basis, however, the growth in the currency supply was more modest, 2.0 percent. Much of this increase in the currency supply went to sustain increased demand for cash balances due to increased monetization of the economy (as reflected in *any* of our assumptions for \dot{v}). In terms of equation (4), the figure for \dot{z} and the intermediate \dot{v} , for example, the ratio y/cs declined at an annual trend rate of 0.6 percent, absorbing almost a third of the increase in the nominal per-capita currency stock. Nevertheless, the increase, such as it was, in the per-capita currency stock was sufficient to generate chronic inflation.¹⁴ As an indication of this inflation, despite generally favorable movements in the country's terms of trade, Brazil's exchange rate, which was free to float during most of this period, depreciated at an annual trend rate of 1.4 percent between 1822 and 1913, in a movement which was closely correlated with the annual changes in the currency stock.¹⁵ The existence of sustained size with low V , the figures for V which are most applicable for Brazil in 1822 are those for the countries with a relatively small population. In 1822, the population of Brazil was only 4.7 million. By increasing the costs of holding cash balances, Brazil's price inflation at the beginning of this period would also have led to a relatively high value for V_{1822} . Finally, Gurley's observations relate to non-slave economies, a condition which, as noted in the text, would lead to a lower V than for an economy in which slaves were a substantial portion of the labor force.

¹²It has sometimes been suggested that the abolition, in 1888, of slavery in Brazil led to an abrupt shift in velocity, due to the sudden need to hold cash balances to pay wages to the labor force. In fact, however, the percentage of slaves in the Brazilian population declined steadily during the century, and by the time Emancipation came, the slaves constituted only some 4 percent of the population.

¹³All trend rates of growth cited were computed by regressing the logarithm of the series against a trend variable, the latter specified with mean zero. Unless otherwise stated, the trend rates cited in the paper were all statistically significant at the 5 percent level or above.

¹⁴See Oliver Onody, *A Inflação Brasileira, 1822-1958* (Rio de Janeiro, 1960).

¹⁵Annual observations of the logarithm of the exchange rate were regressed against annual observations of the logarithm of the nominal Brazilian currency stock for the years 1822-1913. Because of the presence of strong time trends in both series, a trend term, r , was also specified. The regression coefficient of the currency stock term in this specification shows the correlation between annual deviations of the exchange rate and the currency stock from their trend values. The estimated equation, with t -ratios in parenthesis, is:

$$\log ER_t = -2.02 + 0.82 \log CS_t - 0.017r \quad \bar{R}^2 = 0.76$$

(2.5) (5.6) (3.1)

The coefficient of the $\log CS_t$ term indicates an elasticity not too far from unity for the deviations, while the t -ratio shows this to be significant above the 1-percent level.

inflation, despite the relatively modest rate of growth of the per-capita currency stock and the great increase in the monetization of the economy, suggests that the level of real transactions per capita cannot have been rising at a very high rate.

IV

A Brazilian price index to deflate the annual observations of the currency stock is not available. However, following a purchasing-power-parity hypothesis, the Brazilian exchange rate may be used to help give a rough indication of the long-term relative movement of Brazilian prices.¹⁶ The exchange rate was free to float during most of this period, and its movements were, as seen, closely correlated with changes in the Brazilian currency stock. In support of a *PPP* approach, we should note that most of Brazilian GNP was generated within agriculture, and all exports were agricultural commodities. Hence, given the possibilities for shifting resources within agriculture, price movements within the economy as a whole would be reflected in the export sector.

We begin, then, with the "relative-movement" version of the *PPP* hypothesis.¹⁷ Thus, changes in the ratio of *milreis* prices to prices in the United Kingdom, Brazil's principal foreign supplier, would be approximately equal to changes in the *milreis*-sterling exchange rate.

$$\dot{ER} \cong (P_{\text{Brazil}}/P_{\text{UK}})$$

Rearranging terms,

$$\dot{P}_{\text{Brazil}} \cong \dot{ER} + \dot{P}_{\text{UK}}$$

That is, changes in the Brazilian price level would be roughly equal to the change in the *milreis*/sterling exchange rate plus the change in United Kingdom prices.¹⁸ Following this reasoning, a series for deflating the annual observations of the Brazilian currency stock was constructed by forming the product of the annual

¹⁶Data from other countries in fact support the *PPP* theory's suggestion of a correspondence between long-term changes in prices and in exchange rates. See H. J. Gailliot, "Purchasing Power Parity as an Explanation of Long-term Changes in Exchange Rates," *Journal of Money, Credit and Banking*, 2 (3), August, 1970.

¹⁷See Bela Balassa, "The Purchasing-Power-Parity Doctrine: A Reappraisal," *Journal of Political Economy* (December, 1964). The ratio of the exchange rate to the *PPP* ratio might of course change over time due to shifts in the demand and supply curves for foreign exchange in the course of the economy's expansion. In nineteenth-century Brazil, such shifts were at least partly offsetting. Demand may have been biased toward import goods. At the same time, however, the expansion path of supply was heavily biased toward exports. On the latter point, see my "Tropical Exports and Development in the Nineteenth Century: The Brazilian Case" forthcoming, *The Journal of Political Economy*.

¹⁸One might expect that the *PPP* rate would also be affected by changes in Brazil's terms of trade (which generally improved during the century) and by the balance of trade (which was usually small but negative). In order to estimate a model which would indicate the exact effects of these variables on the exchange market, a series for Brazilian national income would be required. This is not available. However, on *a priori* grounds, the effects of improving terms of trade and of a negative trade balance on the *PPP* rate might be expected to be in opposite directions and hence at least partially offsetting. The *PPP* hypothesis, which is in any case only a crude approximation, is used only to provide a rough order of magnitude for the long-term movement of Brazilian prices.

milreis-sterling exchange rate and the British wholesale price index.¹⁹ Trend rates of growth were then computed from the series for the deflated currency stock.

This procedure gives 1.0 percent per annum as the implicit rate of long-term price inflation between 1822 and 1913. This estimate may appear very low in light of Brazil's reputation as an inflationary country during the nineteenth century. Still, an increase of 1.0 per cent per annum over 92 years implies a rise from a base of 100 to an index of 260. The rising trend of Brazil's prices may have appeared especially noteworthy to contemporary observers since it occurred against a background of world prices which were *falling* during much of the century. In addition, Brazil may have gained notoriety because of two spectacular episodes of very high rates of inflation which occurred in the 1860's (during the Paraguayan War) and in the 1890's (during the "*encilhamento*"). In any case, in the framework used here, the rate of real income growth is equal to the rate of monetary expansion plus the change in velocity minus the rate of price inflation. Consequently, if the long-term rate of inflation was higher than our estimate, the principal consequence in the present context is that the rate of real income growth was even lower than the figures presented below.

V

The deflated Brazilian currency stock grew at an annual trend rate of 2.8 percent between 1822 and 1913. On a per-capita basis, the annual trend rate of growth was 1.0 percent. Applying equation (4), the figure for \dot{z} and the alternative assumptions for V_{1822} and \dot{v} , we obtain the upper-bound, intermediate and lower-bound estimates for the long-term rate of growth of monetized per-capita income in Brazil between 1822 and 1913. Considering the rough nature of the model used, the approximate nature of these estimates must be stressed, though the bounding procedure applied to \dot{v} reduces the probability of gross error. (Also, as noted earlier, if anything, the upper limit selected for Z_{1822} imparts an upward bias to our estimates for \dot{y} .) In any case, it is reassuring to see that the estimates for \dot{y}

TABLE 1

ALTERNATIVE PROJECTIONS FOR THE ANNUAL LONG-TERM RATE OF GROWTH OF MONETIZED PER-CAPITA INCOME IN BRAZIL, 1822-1913

$\dot{y} = 1.0\% + \dot{v} + 0.9\%$		
Assumed Value for V , 1822	Implied Value for \dot{v}	Implied Rate of Growth of Monetized Per-Capita Income
20	-1.8%	0.1%
15	-1.5%	0.4%
10	-1.1%	0.8%

¹⁹Another possibility would be to use the British export price index. This index was not used because the *PPP* hypothesis has usually been formulated in terms of the ratios of general price levels, which is better approximated by the wholesale price index. If, however, the British export price index is used in the deflator, the estimates, presented below, for \dot{y} in Brazil are raised by 0.4 percent. The time-series for the nominal and deflated currency stock are presented in Appendix III of this paper.

are well within the bounds of, say ± 2 percent, which might have been set on purely *a priori* considerations.

The picture indicated by the intermediate figure of Table 1, which is in the most likely range of estimates, is one of relatively moderate growth in Brazilian per-capita income during the nineteenth century. That is, although output was able to exceed the high rate of population increase—1.8 percent per annum—per-capita income does not seem to have grown at a high rate. In particular, Brazil seems to have offered a notable contrast with the United States, where per-capita income is estimated to have grown at an annual long-term rate of approximately 1.5 percent during the nineteenth century.²⁰ Over 92 years, a 1.5 percent annual rate of growth leads to an almost fourfold increase in the level of per-capita income. By contrast, a 0.4 percent annual growth rate, for example, cumulates to a total increase of only 44 percent.

As noted below, this view of the nineteenth century as being one of only slow growth for Brazil goes counter to earlier discussions of the subject. The existence of a long period of sustained rapid growth, however, would not be consistent with the low income levels observed in the country toward the end of this period. In 1920–1925, the years for which the first national income estimates are available for Brazil, per-capita income averaged only 98 dollars (1950 prices). In addition, as discussed in Appendix I of this paper, the results of Table 1 are closely supported by estimates of Brazilian income growth which were derived using another economic indicator, the data on exports. Finally, the figures of Table 1 may even over-state the rate of growth of per-capita income in nineteenth-century Brazil. The estimates of Table 1 relate only to monetized per-capita income. Non-monetized per-capita income grew at a lower rate during the century.²¹ Consequently, the rate of growth of total real product per capita in the economy was even lower than the estimates of Table 1.²² In light of these

²⁰Robert E. Gallman, "Gross National Product in the United States, 1834–1909," in *Output, Employment, and Productivity in the United States After 1800*, National Bureau of Economic Research (New York, 1966), pp. 9–10; and Paul A. David, "The Growth of Real Product in the United States before 1840: Some Controlled Conjectures," *The Journal of Economic History*, XXVII (June, 1967), p. 155. It may be objected that declines in Brazil's velocity of the magnitude assumed in Table 1 are not consistent with a low rate of per-capita income growth. As Gurley has demonstrated, however, a large increase in the *scale* of an economy would in itself lead to a substantial rise in the demand for cash balances and a fall in velocity. Such an increase in scale did occur in nineteenth-century Brazil, where the population increased fourfold, from approximately 4.7 millions in 1822 to some 23.7 millions in 1913.

²¹The percentage of the Brazilian labor force in the monetized sector increased during the nineteenth century. This shift in the allocation of the labor force would imply that the value of per-capita output was growing at a higher rate in the monetized sector than in the non-monetized sector of the economy. The estimates of Table 1 relate only to the growth of monetized income, excluding the growth of income in the non-monetized and subsistence part of the economy. Consequently, the discussion that follows in the text and in the next footnote is necessary to clarify the relation between the rate of growth of total income in the economy and that of the monetized sector. The Brazilian national income estimates cited above for 1920–25 do not include the subsistence sector.

²²Writing Y for income and N for population, and using subscripts 1 and 2 to denote the monetized and non-monetized sectors, respectively, the rate of growth for per-capita income in the economy as a whole can be written as

$$(5) \quad \left(\frac{\dot{Y}}{N}\right) = \left(\frac{Y_1 + Y_2}{N_1 + N_2}\right) = \left(\frac{\dot{Y}_1}{N_1 + N_2}\right) + \left(\frac{\dot{Y}_2}{N_1 + N_2}\right).$$

[continued at foot of next page]

considerations, the general conclusion that Brazil experienced only moderate growth of per-capita incomes during this period seems warranted. As noted earlier, this conclusion is reinforced to the extent that the price deflation technique used here understates the actual rate of price inflation in nineteenth-century Brazil.

It should be emphasized, however, that our estimates relate to per-capita income for the economy considered as a whole. As such, the aggregate estimates reflect the different experiences of the economy's various sectors and regions. There is evidence that these fared very differently over the century. The South-eastern coffee region did experience considerable economic progress.²³ The large North-east region, however, did poorly and may even have had a decline in per-capita income levels.²⁴ And in the domestic agricultural sector, which employed a large portion of the country's labor force, the value of per-capita output was probably stagnant until the beginning of large-scale railroad construction toward the turn of the century.²⁵

VI

The figures of Table 1 can also be extrapolated backward to form a range of estimates for the *level* of monetized Brazilian per-capita income in 1822. Although the index-number problems inherent in such an exercise preclude welfare comparisons, it may be of interest to see in rough terms how monetized Brazilian per-capita income stood in relation with that of the United States. In 1822, per-capita income in the United States was approximately 253 dollars (1950 prices).²⁶ By contrast, taken together with the estimate of 98 dollars per-capita in 1920–1925, the upper-bound, intermediate, and lower-bound growth estimates for nineteenth-century Brazil imply 44, 66, and 89 dollars (1950 prices), respectively, for the level of monetized per-capita income in the country in

The numbers given in Table 1 for the growth of monetized per-capita income relate to $[Y_1/(N_1 + N_2)]$. This is less than (Y_1/N_1) because, due to reallocation effects over the century, population in the monetized sector was growing at a rate higher than total population. The usual expectation for subsistence agriculture is of stagnant per-capita output; i.e., $(Y_2/N_2) \approx 0$. Because of the shift in population, population in the non-monetized sector was increasing at a rate lower than total population. That is, $(\dot{N}_2) < (N_1 + N_2)$, and therefore, $[Y_2/(N_1 + N_2)] < (Y_2/N_2)$. Consequently, the last term on the right-hand side of (5) is negative. Thus the rate of growth of per-capita income in the economy as a whole is even less than the figures presented in Table 1, which relate only to monetized income.

²³Within the Southeast, however, there were important intra-regional shifts. The effects on aggregate income growth of the new producing areas such as São Paulo were partly offset by the decline of the older coffee areas within the Southeast. On this decline, see Stanley J. Stein, *Vassouras: A Brazilian Coffee County, 1850–1890* (Cambridge, Mass., 1957), pp. 213–249.

²⁴See Nathaniel H. Leff, "Development and Regional Inequality in Brazil," *The Quarterly Journal of Economics*, LXXXVI, 2; May, 1972, pp. 243–262. In light of the very different economic growth experience of the Southeast and of the Northeast during the nineteenth century, the estimates of Table 1 could be cited as an example of the irrelevance of aggregate economic growth, or of the country as a unit of study. Still, from the viewpoint of some important issues in economic development, per-capita income growth in the country as a whole is an important question, and it is in that context that those estimates are presented.

²⁵See "Economic Retardation," section VII.

²⁶Computed from data in Simon Kuznets, *Economic Growth and Structure* (New York, 1965), p. 305, and David, *op. cit.*

1822.²⁷ Thus as early as that date a sizeable gap in monetized per-capita income seems to have existed as between Brazil and the United States. In addition, the picture conveyed by these backward extrapolations is also relevant for views concerning the level and growth of Brazilian income during the eighteenth century.

VII

The data on the currency stock can also be used to derive some impressions concerning the existence of distinct periods in nineteenth-century Brazilian income growth.

Not surprisingly, the trend equation for the Brazilian currency stock in constant prices during the years 1822–1913 showed large residuals in individual years. Moreover, these residuals were distributed above or below the trend line in fairly discrete patterns, indicating that in those sub-periods conditions were present which led to growth of the Brazilian currency stock at a rate above or below the long-term trend value. This suggests a possible approach to the question of the periodization of Brazilian income growth in the century before 1913. After inspection of the pattern of the residuals, trend equations were fitted for different sub-periods, in an effort to identify relatively homogeneous sub-periods. Too much emphasis cannot be put on such variations in the rate of growth. Still, if the demand for real balances varied substantially in distinct periods which are sufficiently long for the short-term objections to the *PPP* deflation procedure to be mitigated, this fact should be mentioned. Material which would not be worth noting for a well-charted terrain is of interest as a suggestion for further investigation in what is now virtually a *terra incognita*.

Table 2 shows the statistical results for the sub-period equations which after experimentation, gave the best fits. The annual trend rate of growth of the deflated currency stock is denoted by g_1 ; and the growth of the per-capita deflated currency stock, by g_2 .

Table 2 suggests a relatively high rate of growth between 1895 and 1913. This is consistent with the data on exports, central-government expenditure,

TABLE 2
ANNUAL PERCENTAGE TREND RATE OF GROWTH OF THE DEFLATED CURRENCY SUPPLY
IN BRAZIL BETWEEN 1822 AND 1913, SELECTED PERIODS
(*t*-ratios for the trend coefficients are in parentheses)

Period	g_1	\bar{r}^2 of Trend Equation	g_2	\bar{r}^2 of Trend Equation
1822–1869	2.7 (20.1)	0.90	1.2 (8.4)	0.60
1870–1894	2.1 (4.5)	0.44	0.3 (0.6)	–0.03
1895–1913	4.3 (7.7)	0.77	2.2 (3.9)	0.43

²⁷Total per-capita income, including the non-monetized sector, was higher than these figures. Using the notation of footnote 22, above, $(Y/N)_{1822} = [Y_1/(N_1 + N_2)] + [Y_2/(N_1 + N_2)]$. The second term on the right-hand side would raise the total figure.

and foreign investment, all of which show a sudden spurt around the turn of the century. Data on energy consumption between 1901 and 1920 also indicate rapid growth during this period.²⁸ The data on the rate of growth of the per-capita, currency stock also suggest a period of perceptible growth between 1822 and 1869. A noteworthy feature of Table 2, however, is the quarter century between 1870 and 1894 during which the per-capita currency stock shows no statistically significant trend. Again, this aggregate picture probably reflects the poor experience of the large Northeast region, which suffered from the decline of the sugar industry and from a number of catastrophic droughts. Further research is clearly needed, however, to substantiate this suggested periodization, and to analyze the causes of the Brazilian economy's relatively modest growth performance during much of the nineteenth century.

VIII

As emphasized above, this periodization and the range of estimates implied for the growth of per-capita income during the century can only be considered as tentative and rough approximates. We should note, however, that the picture which they suggest of nineteenth-century Brazilian growth differs considerably from the earlier view, frequently cited in the literature, which has its origin in the pioneering work of Celso Furtado.²⁹ Furtado estimated that from 1850 to the end of the nineteenth century, per-capita income in Brazil increased at an annual rate of approximately 1.5 percent.³⁰ The methodology underlying Furtado's estimate is not completely clear. Moreover, he seems to have used the export statistics as a macroeconomic indicator without taking account of the changing share of exports in Brazilian national product during the nineteenth century.³¹ The latter shift is apparent when one considers the export statistics in conjunction with the data on the currency stock, which reflect conditions in the domestic sector of the economy as well. Consequently, even considering the rough nature of the estimates presented in Tables 1 and 2, they suggest the need for an entirely new view of income growth in nineteenth-century Brazil. At the least, the evidence from both the nominal and the "real" currency stock is inconsistent

²⁸See "Economic Retardation in Nineteenth-Century Brazil," and Nathaniel H. Leff, "Long-Term Brazilian Economic Development," *Journal of Economic History* (September, 1969), p. 488, n. 44.

²⁹See, e.g., references to Furtado's estimates in William H. Nicholls, "The Transformation of Agriculture In a Semi-Industrialized Country: The Case of Brazil," esp. pp. 319-320, in Erik Thorbecke (ed.), *The Role of Agriculture in Economic Development*, National Bureau of Economic Research (New York, 1969). Furtado's estimates have sometimes been cited in the form of the levels of per-capita income which his growth figures, extrapolated backward, imply for 1850. See, for example, William P. McGreevy, "Recent Research on the Economic History of Latin America," *Latin American Research Review* III (Spring 1968), p. 98, Table II.

³⁰Celso Furtado, "Brazil" in A. Pepelasis, L. Mears, and I. Adelman (eds.), *Economic Development, Analysis and Case Studies* (New York, 1961), pp. 257-259. Furtado's methodology is presented in his *Formação Econômica do Brasil* (5th ed., Rio, 1963), Chap. XXV, esp. pp. 175-176. The periodization suggested in Table 2 also differs from that proposed by Furtado. He suggested that until 1850 the nineteenth-century Brazilian economy experienced stagnation in per-capita incomes, while after 1850, it showed sustained growth at the 1.5 percent annual rate cited.

³¹"Tropical Exports and Development," section VII, and Appendix I, below.

with the alternative picture of Brazil experiencing substantial growth in per-capita income during the last half of the nineteenth century. Thus, if only as a corrective to macroeconomic impressions given by partial indicators, the technique used in this paper may be useful in the study of the economic history of the less-developed countries.

IX

This paper has used a model based on the demand for real cash balances to derive a range of estimates for the rate of income growth in nineteenth-century Brazil. Because of the limitations of the data available, the principal conclusion of this "quantitative" analysis of Brazilian economic history is "qualitative": namely, that Brazil did not experience a substantial increase in aggregate per-capita income during the nineteenth century. No other conclusion is consistent with the rate of growth of the country's currency stock, either nominal or deflated. In its slow rate of aggregate per-capita income growth during most of the nineteenth century, Brazil's experience seems to have been similar to that of some other tropical countries, which also seem to have experienced only modest progress during this period.³² Finally, because this conclusion concerning Brazil contrasts sharply with earlier views, it suggests the need for a new perspective in research on the country's economic history in the nineteenth century. One's general attitude and the questions to be answered are clearly different for an economy in which per-capita income was growing at a very low rate as compared with an economy whose per-capita income is believed to have been growing for half a century at an annual rate of 1.5 percent.

Brazil's slow aggregate growth during most of the nineteenth century also sheds light on the origins of the income gap which now separates Brazil from the economically advanced countries. As we have seen, as early as 1822 there was a substantial difference in monetized per-capita income levels as between Brazil and the United States. Even if Brazil had grown at the same rate as the United States during the nineteenth century, the absolute difference would have increased. As it was, the rate of income growth in the United States was much greater than in Brazil, so that the size of the income gap increased considerably. During the twentieth century, the long-term rate of per-capita income growth in Brazil has not been below that of the United States and the other more developed countries.³³ However, the long period in the nineteenth century when Brazilian per-capita income grew at a rate markedly lower than that of the United States led to the widening of the income gap. Consequently, Brazil began its modern economic growth with a substantial difference in income levels.³⁴

³²See the estimates presented in the sources cited in footnote 1, above, and Simon Kuznets' summarizing statement in *Modern Economic Growth* (New Haven, 1966), pp. 390-392.

³³See "Long-Term Brazilian Economic Development," pp. 485-489.

³⁴Cf. Furtado, *loc. cit.*, for a similar view of the source of Brazil's income gap. The material presented above, which suggests that sustained Brazilian growth began approximately half a century later than proposed by Furtado, however, increases the poignancy of the opportunities missed during the nineteenth century.

APPENDIX I: THE EVIDENCE FROM EXPORTS ON INCOME GROWTH IN BRAZIL: 1822–1913

We begin with the identity

$$(5) \quad X/Y \equiv X/CS \cdot CS/Y.$$

Using dot notation and lower-case letters to denote the annual percentage rates of change in the per-capita form of these variables:

$$(6) \quad \dot{x} - \dot{y} = (\dot{x}/cs) + (cs/\dot{y})$$

$$(7) \quad \dot{y} = \dot{x} - (\dot{x}/cs) - (cs/\dot{y}).$$

The data on the (nominal) per-capita *milreis* value of exports show \dot{x} and (\dot{x}/cs) to have been 2.5 and 0.5 percent, respectively. Using the value for \dot{z} and the intermediate value for \dot{v} , as discussed in section III above, $(cs/\dot{y}) = 0.6$ percent. Hence, in nominal *milreis*,

$$(8) \quad \dot{y} = 2.5 - 0.5 - 0.6 = 1.4\%$$

Since the annual trend rate of growth of the PPP price deflator discussed in Section IV was 1.0 percent, equation (8) implies that aggregate “real” per-capita income grew at an annual trend rate of 0.4 percent over the period as a whole. This is the same as the estimate of 0.4 percent which in section V was derived from the currency stock, using, as with the present procedure, the intermediate figure for \dot{v} .

APPENDIX II: DATA SOURCES

Data on the Brazilian exchange rate, and on the sterling value of imports and exports are from Instituto Brasileiro de Geografia e Estatística, *Anuário Estatístico* 1939/40 (Rio, 1941). Data on the currency stock are also from this source; J. Pándia Calógeras, *A Política Monetária do Brasil* (trans. by Thomaz Newlands Neto from the 1910 edition of *La Politique Monétaire du Bresil*) (São Paulo, 1960), pp. 80, 88, and 89; and from Dorival Teixeira, “A Evolução do Sistema Monetário Brasileiro,” *Revista de Administração* (June, 1947), pp. 310–311. I am grateful to Laura Randall for bringing this last reference to my attention. Estimates for Brazilian GNP in 1920–1925 were computed from data in Fundação Getúlio Vargas, *Estrutura do Comercio Exterior do Brasil, 1920–64*, Vol. II (mimeo., 1969), and from *Contas Nacionais do Brasil 1939, 1947/1967*, Vol. II (mimeo., 1969). Data on demand deposits in 1920 and 1925 are from Victor Viana, *O Banco do Brasil* (Rio, 1926), p. 50. The figure for Z in 1913 was computed from Raymond Goldsmith, *Financial Structure and Development* (New Haven, 1969), Table D-4. Data on Brazil’s net barter terms of trade are from Nathaniel H. Leff, “Tropical Trade and Development in the Nineteenth Century: The Brazilian Experience” *The Journal of Political Economy*, forthcoming. A population series was constructed by interpolation from the population censuses and estimates available for the nineteenth century. The data are in Ministerio de Planejamento, *Demografia* (Rio, 1966), pp. 38–39; Roberto C. Simonsen, *História Econômica do Brasil* (4th edition, Sao Paulo, 1962), p. 271;

A Economia Brasileiro e Suas Perspectivas (Rio: APEC, 1962), p. 4; and G. Mortara, "The Development and Structure of Brazil's Population" in Joseph J. Spengler and Otis D. Duncan (eds.), *Demographic Analysis* (Glencoe, Ill., 1956), p. 653. Data on British export prices are from Albert H. Imlah's *Economic Elements in the Pax Britannica* (Cambridge, Mass., 1958), pp. 94-98. The British wholesale price index is the Rousseaux series, available in B. R. Mitchell and Phyllis Deane, *Abstract of British Historical Statistics* (Cambridge, 1962), pp. 472-473.

APPENDIX III: THE NOMINAL AND DEFLATED AGGREGATE BRAZILIAN CURRENCY STOCK, 1822-1913

Year	Nominal Currency Stock (millions of <i>milreis</i>)	Deflated Currency Stock (thousands of <i>milreis</i>)	Year	Nominal Currency Stock (millions of <i>milreis</i>)	Deflated Currency Stock (thousands of <i>milreis</i>)
1822	33.45	58.83	1859	185.55	167.80
1823	34.95	62.04	1860	179.85	161.86
1824	37.65	61.72	1861	175.05	161.35
1825	39.45	64.37	1862	173.15	158.72
1826	42.25	72.22	1863	176.85	166.62
1827	51.85	65.14	1864	196.15	182.96
1828	54.25	62.00	1865	199.95	177.73
1829	56.45	52.86	1866	215.85	181.67
1830	59.25	51.64	1867	221.15	174.30
1831	60.25	55.95	1868	229.85	141.91
1832	60.95	82.20	1869	288.85	210.56
1833	61.05	59.34	1870	298.55	249.70
1834	61.15	87.90	1871	298.85	259.87
1835	71.55	104.77	1872	296.45	240.87
1836	71.65	93.79	1873	293.15	251.60
1837	71.65	74.69	1874	291.55	260.23
1838	80.45	78.42	1875	290.75	283.29
1839	80.45	81.69	1876	288.45	263.37
1840	80.45	81.71	1877	288.75	267.75
1841	81.45	85.49	1878	318.55	299.63
1842	84.95	84.95	1879	326.85	296.83
1843	87.75	90.26	1880	325.95	293.99
1844	89.55	87.06	1881	322.85	296.76
1845	92.15	88.80	1882	323.15	281.56
1846	92.75	95.30	1883	322.35	287.24
1847	91.65	92.45	1884	321.35	290.91
1848	90.85	94.48	1885	320.15	283.77
1849	90.45	102.83	1886	326.65	306.97
1850	90.95	114.88	1887	317.85	231.52
1851	97.75	131.05	1888	323.15	196.20
1852	108.55	132.80	1889	330.55	432.86
1853	115.75	122.98	1890	418.95	452.66
1854	128.05	117.81	1891	570.95	411.61
1855	141.65	130.32	1892	647.35	394.72
1856	165.85	153.81	1893	755.95	442.51
1857	180.65	157.89	1894	837.15	475.15
1858	180.55	172.42	1895	803.95	457.80

Year	Nominal Currency Stock (millions of <i>milreis</i>)	Deflated Currency Stock (thousands of <i>milreis</i>)	Year	Nominal Currency Stock (millions of <i>milreis</i>)	Deflated Currency Stock (thousands of <i>milreis</i>)
1896	839.65	425.58	1905	799.85	604.54
1897	909.05	380.82	1906	833.55	591.55
1898	909.85	349.94	1907	883.05	573.53
1899	864.15	318.91	1908	869.25	629.46
1900	829.95	355.69	1909	999.85	692.20
1901	810.85	443.14	1910	1,074.85	742.42
1902	805.85	468.52	1911	1,138.45	747.80
1903	805.35	458.86	1912	1,163.75	749.72
1904	804.05	494.05	1913	1,060.25	599.00