PAUL I. MANDELL

THE RISE OF THE MODERN BRAZILIAN RICE INDUSTRY: DEMAND EXPANSION IN A DYNAMIC ECONOMY*

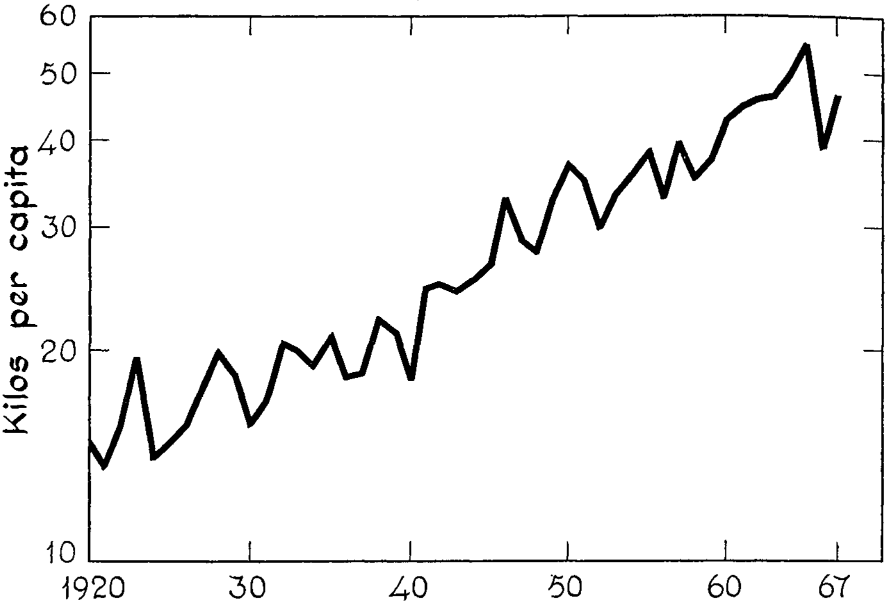
The ascent of rice to a preeminent position in the Brazilian diet began at some still mystery-enshrouded moment in the second half of the nineteenth century. We do know that since 1920, when the collection of pertinent statistics begins, rice consumption has risen more than threefold (Chart 1). Between 1920–24 and 1963–67, Brazilian rice production increased more than eightfold at a rate of 5.1 per cent per year, from an annual average of 775,000 to 6,500,000 metric tons. Over the same period, the population growth rate was slightly more than 2 per cent a year. According to our "balance sheet" estimate of rice consumption (see Appendix II), yearly per capita rice consumption rose from an average of 15.5 kilos in 1920–24 to 48.1 kilos in 1963–67 for an annual rate of increase of 2.7 per cent. This achievement involved a program of import substitution just after the turn of the century which successfully substituted domestic output for imported supply, the formation of Latin America's largest irrigated rice producing zone in Rio Grande do Sul, and the extension of commercial upland (unirrigated) rice production to vast areas in central and southern Brazil as an integral part of the advance of the Brazilian agricultural frontier.

This paper charts the rise of Brazilian rice consumption, relates a number of important episodes in the course of that rise, and analyzes the demand factors that accounted for it during the period 1947–67, when the availability of cross section and time series data makes such analysis possible. Curiously, though the growth of the Brazilian rice industry exhibits such exemplary traits as the economic dynamism of producers and middlemen and the cultural flexibility of consumers, it has suffered almost complete neglect. Both the intrinsic interest of this satisfactory but misunderstood chapter of Brazilian agricultural development, and the considerable light it casts upon the long-term process of agricultural modernization reward the effort to lift it from undeserved obscurity.

To place the rise of the rice industry in its historical context, particularly

* I wish to thank Valimohamed Jamal not only for his very able research assistance but also for suggestions and comments that helped to resolve problems that arose during the course of this research and assisted in the clarification of the final manuscript. Rosamond H. Peirce and Catherine S. Whittemore did yeoman service in the collection and tabulation of data. Suggestions and comments by William O. Jones, Benton F. Massell, Clark W. Reynolds, and David J. S. Rutledge saved me from innumerable errors and greatly improved the clarity of the final manuscript.

CHART 1.—BRAZIL, PER CAPITA RICE CONSUMPTION, 1920–67*
(*Kilos*)



* Computation described as "First Series" in Appendix II.

as it bears upon our assessment of agriculture's role in Brazilian development, the paper begins with a review of the current consensus structuralist view of long-term Brazilian development and of the revisionist criticism of that view. The recounting of the rise of the rice industry that follows reveals telling exceptions to the generalizations of the conventional interpretation of Brazilian agricultural development and underscores the need for continued revision of our analysis of Brazilian agriculture.

Previous analysis of the Brazilian demand for rice shares the assumptions of the structuralist view of Brazilian agricultural development and along with it warrants reconsideration. Reviewing the important contributions of the Centro de Estudos Agrícolas of the Fundação Getúlio Vargas (hereafter, the FGV), summarized in the volume, *Projections of Supply and Demand for Agricultural Products of Brazil Through 1975* (*23*), we find that the FGV relied unduly upon cross section analysis for the interpretation of a historical phenomenon when a time series approach would have been more appropriate. Moreover, in fashioning an explanation consistent with structuralist orthodoxy from cross section data it commits serious logical and methodological errors. On the assumption that the entire difference between the actual increase in consumption and the increase projected on the basis of its cross section estimate of the income elasticity of rice was due to "substitution caused by limitation of supply" (*23*, pp. 8, 9), the FGV concluded that during the fifties and sixties about 80 per cent of increased rice consumption was the result of the substitution of rice for commodities that were in short supply. This implies that the price of rice fell relative to its substitutes. A review of available price data covering the period 1947–67 demonstrates that if there was any discernible price trend at all, it was against rather than in favor of rice consumption. The FGV hypothesis of supply rigidity induced substitution is therefore rejected.

The remainder of the paper is devoted to fashioning a more satisfactory explanation for the Brazilian population's robust demand for rice and to this end, two hypotheses are formulated and tested.

The first is that the income elasticity estimated by the FGV from family budget data systematically underestimates the true value as a result of the use of an inappropriate functional form and from the use of measured as opposed to expected income or some proxy for that concept. Rice consumption functions are fitted to some of the same data used by the FGV in order to test this hypothesis. On economic and statistical grounds the log-inverse function is shown to be superior to the double-log function used by the FGV and to imply a greater coefficient of income elasticity over the relevant income level. The direction and likely magnitude of the bias resulting from the use of measured income is investigated by comparing income elasticity coefficients estimated by fitting both income and expenditure data.

To complement the cross section analysis, an approach subject to inherent limitations when applied to historical phenomena, we next turn to the analysis of time series. While the results validate the upward revision of previous estimates of the income elasticity of rice, they also demonstrate that the evolution of rice consumption between 1947 and 1967 displayed a very marked upward trend over time. By the explicit inclusion of variables purporting to represent the processes of taste change and structural transformation (rural-urban and interregional migration, and the rapid spread of rice production among farmers) we show that, in some yet undetermined combination, they had a significant, possibly dominant, effect upon rice consumption.

The two hypotheses explaining the rise of Brazilian rice consumption that are formulated and validated by this paper are explanations of aggregate behavior. Underlying them are dramatic changes in the structure of tastes and household economies on which relatively little quantitative work has been done. Knowledge of the literature regarding Brazilian food consumption and familiarity with Brazilian life permits one to suggest some tentative ideas regarding these underlying changes. The penultimate section of this paper engages in some speculative rumination in this regard. A final section briefly considers the role of rice in Brazilian agricultural development.

BRAZILIAN AGRICULTURAL DEVELOPMENT

Analysis of modern Brazilian economic and agricultural development is currently in a state of flux. For the past two decades the structuralist interpretation of Brazilian development has been widely influential. Recent research reveals a movement toward the revision of its principal tenets. These are that the critical events of Brazilian economic modernization were the disruption of international trade during the Depression and the Second World War and the postwar government directed import substitution campaign, and that the agricultural sector was the continuing cause of Brazilian backwardness.[1]

[1] The most widely read exposition of the structuralist or Economic Commission for Latin America (ECLA) interpretation of Brazilian economic history is Celso Furtado's *The Economic Growth of Brazil* (*20*). Werner Baer, though far less sanguine in his evaluation of the Brazilian program of import substitution and deficit financed investment in infrastructure, nevertheless implicitly accepts the structuralist interpretation of long-run Brazilian development by stressing recent events to the almost complete exclusion of the past (*2*). The revisionist position has not yet received a broad one-volume treatment, but has gradually taken form in successive articles appearing in the periodical literature.

Donald Huddle argues that the cost in reduced exports of the exchange controls used to restrict imports outweighed the gains that accrued to the industrial sector (*28*). Carlos Pelaez disputes Furtado's thesis that the breakdown of the export sector during the Great Depression propelled the Brazilian economy into economic takeoff (*45*). A later article by Pelaez, who appears to have taken the role of structuralism's empirical *bête noire*, "Acerca da Política Governamental, da Grande Depressão e da Industrialização do Brasil," criticizes Furtado's thesis that anticyclical policy during the Depression produced increased rates of investment and growth (*44*). In a recent article, Nathaniel Leff broadened the assault when he observed that "in fact, Brazil experienced substantial industrial development and import substitution earlier, and under different conditions than has sometimes been appreciated" (*35*, p. 474).

The characterization of Brazilian agriculture as stagnant, needlessly wasting soil and forest resources with its "hollow frontier," and performing very badly the function of supplying food to a growing and increasingly urban population is widely accepted. Examples of this view are found in CIDA and Celso Furtado (*32*, p. 24; *20*, pp. 250, 257, 268–69). Ruy Miller Paiva attempts to provide a theoretical explanation for the "hollow frontier" (*42*, pp. 122–25).

Revisionist criticism of this evaluation of the performance of Brazilian agriculture has been slow in appearing but is finding a respectable place in the literature. William H. Nicholls offers the

Revisionism's positive contribution is its renewed recognition of the continuity of modern Brazilian economic development and of the decisive role played by the coffee economy in its foundation. Thus Leff generalizes upon his criticism as follows (*35*, p. 490):

> Brazil experienced substantial industrialization earlier than has sometimes been assumed. Far from being the creation of the import difficulties during World War II, the Depression, or World War I, Brazilian industrialization had proceeded extensively and at rapid rates before these events. More generally, industrial development occurred in complementarity with favorable foreign trade conditions rather than as an "alternative" to export-based growth. On the whole, Brazilian industrialization seems to have taken place under conditions similar to those of other regions of recent settlement: in conjunction with rapid expansion of foreign trade and with strong government support in the form of tariff protection.

The rapid expansion of foreign trade referred to by Leff was, of course, the result of the coffee boom by which Brazil came to dominate international coffee trade. Like most celebrated economic booms, the rise of the coffee economy was both more gradual and prosaic than is ordinarily assumed. Production and export of coffee increased slowly during the first three quarters of the nineteenth century. The physical and human resources that were later to enable Brazil to take advantage of the sharply increased demand for coffee as competition weakened were accumulated and trained during the preceding decades. By the end of the century export revenues began to grow very rapidly.[2]

In 1892, Santos exported about $40 million worth of goods. In 1912 the value of coffee exports had reached $170 million. The state of São Paulo's population increased almost threefold between 1872 and 1900, from 837,000 to 2,283,000. The capital, a small town of 31,000 in 1872, had grown to a metropolis of 580,000 by 1920. The enlargement of the banking system and the supply of credit, successful replacement of a slave system with Southern European immigrants, early industrialization, construction of an extensive railroad network, investment in electric power generation, telecommunications and urban transport, and the formation of a class of energetic entrepreneurs, were directly related to the coffee economy. These are the well known consequences of its formation. Its impact upon the domestic agricultural economy was equally important but has received less attention. Nevertheless, in it we may find the sources of much of the transformation that has overtaken Brazilian agriculture.

São Paulo, the growing cities to its west, and the specialized coffee producing areas in its hinterland no longer supplied themselves with all of their own food

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fullest statement of a conflicting view that I have yet seen (*41*). With considerable ingenuity Matthew Edel fashions an operational definition of "satisfactory agricultural performance" and applies it to seven Latin American nations, including Brazil. He concludes that "food output in . . . Brazil . . . outpaced . . . or at least approximately equalled requirements" (*15*, p. 34). Elsewhere I have raised theoretical and empirical objections to the "hollow frontier" hypothesis, and have also analyzed the means by which Brazilian agricultural output has increased (*38*, pp. 12–59).

The tendency of a number of studies written after the coup of 1964 to return to structuralist fundamentals by identifying the domestic agricultural sector as the principal bottleneck in Brazilian development promises to heat up the debate.

[2] This exposition of the rise of the coffee economy leans very heavily upon Warren Dean's study (*14*).

requirements and had increased their purchases from more distant regions then entering the initial phases of agricultural commercialization. The effect of the coffee boom spread outwards from São Paulo in a concentric pattern of waves penetrating ever more distant parts of the isolated, economically fragmented rural economy, borne along on the bright new track of railroads that were financed by burgeoning agricultural revenues. Coffee gave rise to new settlements and breathed renewed vitality into old cattle towns and rural county seats long dormant in the isolation of the *sertão*.[3] The first tentative steps toward the modernization and commercialization of the livestock industry and the rapid expansion of commercial rice production were the earliest results of the impetus given to domestic agriculture by coffee export.

When economic historians finally write the definitive account of modern Brazilian agricultural development, the chapter on the rice industry should occupy a place of prominence in their narrative. In terms of the value of sales on the domestic market, the rice industry is the most prominent manifestation of such important features of Brazilian agriculture as (1) the ability to expand the supply of most commodities (with the important exception of meat and livestock products), (2) the growth of demand, (3) the increased production achieved by modest increments of labor combined with proportionally greater increases of land and physical capital, (4) the westward expansion of the agricultural frontier, (5) the emergence of a surprisingly effective marketing and distribution system largely articulated by the motor truck, and (6) the intimate association and complementarity of cereal production and stockraising.

RICE IN BRAZIL

Throughout the colonial period (1502–1821) and the Empire (1821–1889), manioc, corn, beans, yams, and rice were the principal staple foods consumed by the Brazilian population.[4] Manioc was preeminent in the north and northeast while south of Bahia and Minas Gerais corn had a relatively larger role in the diet. Yams were the main staple in a few areas in the northeast and possibly in Espírito Santo. Rice appears to have been consumed in large quantities only in Maranhão where it was produced for export but was considered an inferior foodstuff consumed in large quantities only under the threat of starvation.[5] Many households did not consume rice at all.

Although the exact date of introduction is unknown, mid-eighteenth century accounts report rice cultivation in various parts of Brazil. Later in that century, rice rose to prominence as an export crop in Maranhão, Pará, Bahia, Rio de Janeiro, and São Paulo, and continued to occupy a high place on their lists of

[3] A generic term which has been variously translated as the backlands, the frontier, the interior, and the backwoods.

[4] Caio Prado, Jr. gives a good summary of primary and secondary sources on the Colonial Brazilian diet in *46*, pp. 180–94.

[5] Quantitative data do not exist and any characterization of nineteenth century diets is, of necessity, entirely qualitative. This qualitative evidence is strongly negative regarding rice consumption in either the northeast or central Brazil. In extended and lovingly detailed accounts of traditional foods and recipes, Gilberto Freyre, that connoisseur of northeastern cooking, mentions rice but once. The bulk of calories in the cuisine he describes derive from manioc, corn, sugar, and yams (*17*, pp. 44–48, 57–61, 125–35). Charles Boxer's lengthy discussions of colonial food supply include no reference to rice; manioc and sugar appear in his index, rice does not (*8*).

exports through the first several decades of the next century (*46*, pp. 70–80). About the middle of the nineteenth century rice exports gradually began to decline and by the last decades of the century, Brazil had lost its role as an exporter and had begun to import rice in increasing quantities. Imports reached a peak early in the twentieth century. This change in role from exporter to importer coincided with a slight increase in the rate of population growth, the formation of the São Paulo coffee economy, bringing a large supply of foreign exchange to Brazil, increased interregional migration, and the arrival of growing numbers of Italian, German, and Portuguese immigrants.

As the demand for marketed foodstuffs rose rapidly under the impact of urbanization and the growth of population and income in the late nineteenth century, output that had formerly been exported was diverted to domestic markets. When domestic commercial supply failed to satisfy demand, imports increased to meet the deficit. When they rose to alarming levels, government intervened to stem the flood and secure domestic substitutes.

Immediately after the fall of the Empire, Brazilian leaders carried on an intense debate over development policy. On one side were arrayed urban professionals, progressive positivists, and intellectuals advocating a tariff, tax, and exchange policy designed to promote import substitution and finance infrastructure investment. On the other side were agrarian interests, particularly coffee planters supporting free trade, a sound currency, and a balanced budget. The former viewed agricultural imports as an especially perverse and aggravating manifestation of backwardness. The sound money men carried the day, but they apparently gave way on the taxation of agricultural imports, no doubt because the interests of both sides coincided on this point (*14*, pp. 70–72). Imposition of import taxes upon rice had far-reaching effects upon the rice industry.

In 1896, the Brazilian government doubled the tariff on rice from 30 to 60 réis a kilo. The tariff had little effect on imports. The rate was again doubled in 1903 and raised by 33 per cent in 1906 to 160 réis a kilo, or about 40 per cent of the retail price (400 réis a kilo). To this basic rate was added a 50 per cent surcharge (in gold) raising the effective rate to 215 réis, or more than 50 per cent of the wholesale price. This time the repercussions were immediate. Imports fell sharply in 1903 and 1904 and drastically in 1906 and 1907 (Table 1). Thereafter they remained at the low level of 1908 (*50*). (A rise in world rice prices in 1906 also contributed to their decline.)

The initial effects of the tariff were to reduce imports and to raise the domestic price of rice (Table 1). Rice consumption must have suffered a temporary setback even as domestic producers were attracted by the higher price and moved into the vacuum left by the disappearance of imports. However, the long-term effects upon consumption and domestic production were salutary. Rice production for the domestic market became a major source of farm revenue and a force of specialized rice farmers, merchants, millers, middlemen, and wholesalers came into being. The combined effect of the tariff, the short world supply of rice during World War I, growing domestic demand, and the expanding transport network induced a great expansion in the volume, area, geographical dispersion, and degree of commercialization of Brazilian rice production. Irrigated agricultural zones, most notably Rio Grande do Sul, made an important contribution to in-

TABLE 1.—BRAZILIAN RICE IMPORTS 1901–9*

Year	Volume (*1,000 kilos*)	Value (*1,000 milréis*)[a]	Unit value (*milréis/ton*)
1901	89,375	16,755	187.5
1902	100,985	18,509	183.3
1903	73,589	14,508	198.2
1904	60,801	12,143	199.7
1905	58,701	8,825	150.3
1906	40,289	7,052	175.0
1907	11,581	2,633	227.3
1908	6,768	1,657	244.8
1909	10,802	2,367	219.1

* Data from Álvaro Ornellas de Souza, "O Arroz no Rio Grande do Sul," *Lavoura Arrozeira*, January 1955, p. 18.

[a] Until November 1, 1942 the milréis (1$000) was the Brazilian monetary unit. One milréis equalled one thousand réis. It was then renamed the cruzeiro (Cr$1.00). By 1967 inflation had made the use of the cruzeiro impractical and it was replaced by the new cruzeiro (NC$1.00) equal to one thousand old cruzeiros. Wherever cruzeiros are used in this paper they refer to old, pre-1967 cruzeiros.

creased rice production between 1900 and 1920. In later years, Rio Grande do Sul was to remain the principal producer of irrigated rice in Brazil. Almost everywhere else it was to be upland rice production which contributed to growing output and which, along with livestock production, gave the rural economy an increasingly commercial character. In its earliest phase of commercial development the expansion of upland rice production was most rapid in São Paulo. Later it advanced to the north and to the west and took hold in Minas Gerais. Still later Goiás, Mato Grosso, and Maranhão became major upland producers.

In the first decade of this century, upland rice cultivation in São Paulo was associated with the coffee economy near Ribeirão Prêto (the center of the coffee frontier at that time) and with the formation of new pasture in the immediate hinterland of Barretos (the great cattle entrepôt of the day) located just beyond the coffee frontier. Later the phenomenal development of upland rice production in the Triângulo Mineiro and Goiás in the forties made them the principal Brazilian commercial rice producing areas. There the opening of new pasture and the cultivation of rice were closely intertwined. Upland rice production became the activity par excellence for the opening of the central Brazilian agricultural frontier (*39*, p. 144).

Conditions were favorable for the emergence and expansion of the rice industry. Rice grows relatively well upon the acid and infertile soils of the central plateaus. It requires modest amounts of labor (except at harvest) when compared to other staples. The practice of opening new land with several crops of rice before converting land to pasture also made rice farming complementary to cattle raising. Rice's high value relative to its weight, the fact that it stores well, the early establishment of well-defined varieties and a widely accepted system of quality classification, and its smaller processing requirements relative to corn and manioc also made the development of an efficient marketing system less difficult for rice than for other commodities (*49*, pp. 107–26). Consumers were attracted to rice because it takes less time to prepare than dishes based upon manioc or corn and is easy to store in the household; rice eating had also acquired social status among urban consumers.

The dynamism of rice in Brazil, manifested in the adoption of a new crop, the rapid expansion of production, and the modification of century-old consumption habits, is inconsistent with the prevailing tone of lamentation and pessimism in much that has been written about Brazilian agriculture. Brazilian structuralists, advocates of what Matthew Edel has called "the inelastic supply hypothesis," have consequently found it necessary to dismiss this apparent dynamism as illusory. (*15*, pp. 1–15). They say that Brazilian farmers regularly adopt new crops but systematically scorn improved technology; land intensive output expansion along the agricultural frontier has created a wasteful "hollow frontier"; increased rice consumption has come about not by choice but by the enforced necessity of substituting rice for other commodities in short supply.

The real problems of agricultural development are so serious and are often so resistant to remedy that we need have little patience with imagined ones. If increased rice consumption involved the substitution of an inferior food for more desirable commodities whose supply was inadequate, then Brazilian cereal production is indeed in a sad state. If not we should quickly pass on to more serious matters.

PREVIOUS WORK ON THE DEMAND FOR RICE IN BRAZIL

In 1961 the Brazilian Institute of Economics of the Fundação Getúlio Vargas contracted with the United States Department of Agriculture to "prepare projections of the supply and demand for agricultural products up to 1975 in order to give evidence of potential insufficiencies or surpluses for eighteen of the main agricultural products in Brazil" (*23*, p. 1). A necessary step for the completion of the FGV investigation was the collection of family budget data from a representative sample of urban and rural areas. Part of the actual field research was done directly under the FGV's supervision, part subcontracted to the Departamento de Estudos Econômicos of the Banco do Nordeste do Brasil, S.A. (hereafter ETENE). With these data, the coefficients derived from them, the output of demographic and macroeconomic models, and supply functions fitted to original farm survey data, the FGV could project the demand, supply, and potential deficits or surpluses of the principal agricultural commodities for 1965, 1970, and 1975. The original family budget data it collected constitutes the largest, most representative, and most reliable body of consumption data from Brazil.[6]

Though the FGV study was oriented toward the future, its projects are necessarily rooted in its analysis of the past evolution of the consumption of agricultural commodities and of current consumption behavior as embodied in the family budget data it collected. The crux of its analysis was the identification and

[6] The most complete summary of the results of the studies carried out by both these organizations reports on the results of the FGV's own family budget studies as well as those of the ETENE (*23*). A separate summary of the research of ETENE appears in *5*. For more detailed data from the family budget studies made by the ETENE in the northeast, see *3*; *4*; *6*; *7*. During this research two detailed reports of FGV family budget data were used (*21*; *22*). The FGV and ETENE computed the income elasticities of demand for both rural and urban populations of the various Brazilian regions for all of the important Brazilian agricultural commodities. The ETENE research also includes estimates of the price elasticity of demand for several commodities.

measurement of the effects of rising income, rural-urban migration, and changes in relative prices upon the consumption of various agricultural commodities. Let us follow the FGV analysis of rice consumption in detail.

Statistical backwardness and underdevelopment are constant companions. The FGV study group had to choose between a theoretically superior model for which only relatively unreliable data were available and an acknowledgedly inferior model which could be applied to the better data it had collected by family budget survey. It opted for the latter. Time series analysis, generally regarded as the method of choice for the prediction and retrospective analysis of a historical series (27, p. 7), requires, for its application, historical series of consumption, price, income, and demographic statistics. These data are often lacking and those that are available contain an unmeasured but, presumably, high degree of error. Cross section analysis, subject to well known limitations when applied to historical phenomena, can be carried out with highly reliable family budget data.

The FGV collected family budget data from urban and rural areas selected as representative of the diverse socio-economic and ecological conditions presented by Brazil. Sample areas represent major regions including the north, northeast, east, and south. Omission of the central west was justified on the grounds that it would have an insignificant effect upon the aggregate results.

These data are the point of departure of the FGV analysis. From them it derives estimates of the per capita consumption of rice normalized to 1960, the base year. Cross section consumption functions were fitted to the budget data and provide estimates of the income elasticity of rice.

The function used was invariably of the form

$$\log Y = a + b \log X$$

where Y is per capita consumption in physical terms and X per capita income. This functional form was selected for two reasons: it has a constant elasticity at every point and fits all levels of consumption about equally well; the income elasticity, η, is the fitted parameter b, thus simplifying calculations, particularly weighting and aggregation. These considerations are relatively trivial and should ordinarily be subordinated to statistical and economic considerations in the selection of the functional form. We return to this critical aspect of the FGV's estimates later.

Since the sample consumption and income data are reported as group averages it was necessary to fit weighted regressions to achieve consistent estimates. To secure representative regional elasticity coefficients, the elasticity estimates derived from individual samples were weighted by aggregate regional consumption and these regional elasticities further aggregated to secure weighted rural and urban elasticities.

Table 2 summarizes the results for rice. There is a rough inverse correlation between the income elasticity of the demand for rice and regional levels of per capita income; the smallest elasticities are in the urban-industrial south and east, the largest in the east and the backward northeast. Analogously, rural values are greater than urban values. Incidentally, the inverse correlation of income and income elasticity *across states* might have suggested to the FGV study group that its assumption of the constancy of the income elasticity of rice *within states* rests upon dubious grounds.

TABLE 2.—THE RESULTS OF THE FGV FAMILY BUDGET STUDIES: WEIGHTED REGIONAL CROSS SECTION ELASTICITIES, AND REGIONAL AVERAGE PER CAPITA RICE CONSUMPTION, 1960*

	North and Northeast	East	South	Brazil
Cross section income elasticity of rice[a]				
Urban	.53	.19	.14	.21
Rural	.53	.30	.21	.33
Total	—	—	—	.28
Annual per capita income (*thousand cruzeiros*)	22.9	45.1	52.1	40.3
Annual per capita rice consumption (*kilos*)				
Urban	15.6	44.3	60.6	38.4
Rural	15.8	32.8	48.5	40.3
Total	15.8	38.2	55.1	39.4

* Data from Fundação Getúlio Vargas, Instituto Brasileiro de Economia, Centro de Estudos Agrícolas, *Pesquisa Agrícola no Estado da Guanabara, Orçamentos Familiares* (Rio de Janeiro, September 1967, mimeo.), pp. 44, 47–48; and for regional estimates of per capita rice consumption from Brazil, Ministry of Agriculture and United States Agency for International Development, Escritório Técnico de Agricultura, Weitz-Hettelsater Engineers, *Economic and Engineering Study: Marketing Facilities for Grain and Tuberous Crops, Brazil*, Vol. I (Kansas City, August 1963), p. 124.
[a] Double-logarithmic function, estimated by the FGV.

To their estimate of income elasticity from budget data, the FGV then applied a correction that takes into account the effect of the changing rural-urban composition of the population and the different rates at which rural and urban income increased. Because the FGV report offers very little detailed information regarding the method used to arrive at this correction, it is difficult to evaluate it or even to explain its effect upon the coefficients.[7]

[7] To take account of the effect of urbanization upon income elasticity, the FGV divided its projection model into separate urban and rural sectors according to the following formula:

$$C_i^T = [\eta^r (\dot{X}^r) + 1]\left(\frac{P_i^r}{P_o^r}\right) C_o^r + [\eta^u (\dot{X}^u) + 1]\left(\frac{P_i^u}{P_o^u}\right) C_o^u$$

Where C_i^T = total demand in year i.
$\dot{X}^r$ and $\dot{X}^u$ = percentage change in per capita real disposable income in rural and urban sectors, respectively.
η^r and η^u = respectively the rural and urban cross section income elasticity.
P_o^r and P_o^u = respectively rural and urban population year o.
P_i^r and P_i^u = respectively rural and urban population year i.
C_o^r and C_o^u = respectively rural and urban consumption year o.

Using the above projection model, the FGV predicted average national per capita rice consumption for the years covered by its study. This projection explicitly incorporates the effect of urbanization upon consumption and the income elasticity (but, it should be noted, takes no account of the effect of interregional migration). It then regressed the projected time series upon weighted average income derived from its macroeconomic model and estimated what it chose to call the "potential demand" and the "coefficient of potential long-run income elasticity—the individual's future preference for agricultural consumptions without taking into account the fact that either the physical conditions of the supply or unbalances in the relative prices do force many substitutions" (*23*, p. 51). Then, by subtracting the weighted average cross section income elasticity from the long-run potential income elasticity it finds what it calls "the coefficient of substitution resulting from domestic migration" (really the coefficient of rural-urban migration).

TABLE 3.—RICE: THE "LONG-RUN POTENTIAL INCOME ELASTICITY" AND THE "COEFFICIENT OF SUBSTITUTION DUE TO RURAL-URBAN MIGRATION," 1960, 1965, 1970, AND 1975*

	1960	1965	1970	1975
Long-run potential income elasticity (the effect of rural-urban migration has been added).	.16	.18	.20	.23
Coefficient of substitution resulting from rural-urban migration.	−.12	−.10	−.08	−.05

* Data from The Getúlio Vargas Foundation, Brazilian Institute of Economics, Center for Agricultural Studies, *Projections of Supply and Demand for Agricultural Products of Brazil Through 1975* (published for the USDA Economic Research Service by Israel Program for Scientific Translations, Jerusalem, 1968).

Table 3 shows the corrected income elasticity coefficients—denoted as the long-run potential income elasticity—and the coefficient of substitution due to domestic migration, actually rural-urban migration alone, calculated by subtracting the potential income elasticity from the weighted cross section estimate for the years 1960, 1965, 1970, and 1975. According to these results, between 1965 and 1975 the effect of urbanization combined with differential rural-urban income growth would be to partly counteract the influence of changes in total income alone. Though the FGV study does not supply sufficient data to project the potential income elasticity coefficient backwards before 1960, from the trend in Table 3 it appears that the value declines asymptotically over time to a value somewhat below .15.

While the FGV model takes explicit account of the effect upon consumption of rural-urban migration, it takes no account of the effect of interregional migration. This strategy was unfortunate since the FGV's own data (Table 2) indicate that past, present, and expected future patterns of interregional migration—largely from the northeast to the south, east, and central west—have the effect of moving consumers from regions with relatively low average per capita rice consumption to regions where per capita rice consumption is quite high.[8] In effect, the FGV predictions of past levels of per capita rice consumption are biased upward, giving the historical series a flatter trend than was actually the case. The FGV model also includes no mechanism that accounts for the influence upon rice consumption of changes in the price of rice or of other closely related commodities.

At this point in the study the FGV could go no farther without confronting its model predictions, based upon reliable family budget data, with the rice consumption time series generated by admittedly error-prone balance sheet methods. For this purpose it used the balance sheet computations of the Conselho Nacional de Abastecimento.[9]

[8] We have no direct knowledge of the effect of migration upon consumer behavior in Brazil. Do northeasterners consume less rice than Cariocas because their "taste" for that commodity is weaker or because the combination of regional price differences and the conditions of the household differ in the two regions? When they move to Rio de Janeiro, do they experience a "taste change" or adjust to altered socio-economic conditions? We can only speculate about this and do so at the end of the paper.

[9] In Appendix II, which calculates a new rice consumption time series by balance sheet methods, we show that the Conselho Nacional de Abastecimento's calculations routinely employ data and coefficients which are inaccurate and have been superseded by published information.

It must have been immediately evident to the authors of the FGV study that the long-run potential income elasticity computed by its model is an extremely poor predictor of the observed historical evolution of per capita rice consumption. The long-run potential income elasticity was estimated as approximately .16 in 1960. According to the national accounts series computed by the Fundação Getúlio Vargas, real per capita disposable income increased by about 72 per cent between 1947 and 1964. Multiplying 72 by .16, one would predict an 11.5 per cent rise in per capita rice consumption for the period 1947–67. In fact, per capita rice consumption rose by about 74 per cent.

The authors of the FGV study might have reconsidered the validity of their procedures—the specification of their equations, their choice of functional form, their use of measured income rather than expenditures as an independent variable, their neglect of interregional migration and taste changes, and most important, their assumption that cross section and time series coefficients are perfect substitutes and can be used interchangeably. They chose not to do so. Instead, they attributed the unaccounted for increase in rice consumption to the substitution of rice for other preferred commodities; that is, they regarded it as a deterioration in the diet caused by the relatively high prices of customary foodstuffs. This kept the analysis consistent with structuralist views.

By regressing the time series upon a single explanatory variable, "real, per capita, disposable income," the FGV estimated what it calls "the effective consumption coefficient." Such variables as the price of rice, the prices of related commodities, and proxies for taste change, habit formation, and a time trend, which are common elements of the specification of time series consumption functions, were not included in this function. This is particularly damaging to the FGV analysis since it purportedly sustains the hypothesis that "substitution induced by scarcity of other commodities"—an economic process ordinarily mediated via relative price changes—was largely responsible for the rise of rice consumption.

From the "coefficient of effective consumption" the FGV then subtracts "potential income elasticity" (previously estimated by fitting a cross section consumption function to budget data) and derives an "elasticity of substitution" which it asserts measures the substitution "caused by relative price variation and increased or decreased supply response to demand stimuli" (*23*, pp. 88–89).

In 1960 the FGV found the "coefficient of effective consumption" to be .92, the cross section income elasticity .28 (.16 when corrected for rural-urban migration), and the coefficient of substitution .76. The FGV study interprets these coefficients to mean that in 1960 a 1 per cent increase in per capita income would have resulted in a .28 rise in consumption of rice, rural-urban migration reduced its effect to .16, and then current trends in relative commodity prices resulted in a .76 increase due to substitution.

From these results the FGV concluded that the three principal influences affecting per capita rice consumption were, in order of their importance: the substitution of rice for other staple foods owing to limitations of supply, increased per capita income, and rural-urban migration. That so large an increase in per capita rice consumption was due to relative price variations and increased or decreased response to demand stimuli implies that the rice price declined relative to other starchy staple foods (*23*, pp. 88–89). Since the FGV study nowhere refers to price statistics, it never checked the validity of this implication of its argument.[10]

STAPLE FOOD PRICES, 1947–67

To assess the movement of the prices of the major Brazilian staple foods relative to the price of rice between 1947 and 1967, to secure price data for the subsequent time series analysis, and to test the hypothesis that the price of rice declined, a number of price series were compiled and analyzed. These are retail food prices collected by Serviço Estatístico de Produçao of the Ministry of Agriculture, and commodity prices on the São Paulo and Pôrto Alegre commodity exchanges. Appendix I presents further information regarding the sources from which they were obtained, certain problems encountered in their compilation, and the complete retail price series in current terms, deflated by an appropriate cost-of-living index, and as an index of the deflated price (base 1948–52 average = 100).[11] Charts 2, 3, and 4 summarize these data. They show ratios of the current prices of potatoes, manioc flour, wheat flour, and black beans to the current rice price in the same year.

Inspection of Chart 2 shows that the retail prices of manioc flour, corn, black beans, and potatoes declined relative to rice. The retail price of wheat remained roughly constant. The decline of the prices of potatoes and wheat flour was fairly marked while the others declined only slightly. Charts 3 and 4, which show staple food prices on the São Paulo and the Pôrto Alegre commodity exchanges, respectively, tell a similar story. The prices of most staple foods displayed a slight downward tendency while the price of potatoes declined markedly. Only the price of wheat flour on the São Paulo exchange rose relative to rice.

The FGV concluded that a very large share of the increase of rice consumption between 1947 and 1967 occurred because of relative *price changes*. The price data we have been able to assemble fails to sustain their conclusion. Relative price changes that took place among the principal staple foods would have given consumers little reason to increase their rice consumption and might have had the opposite effect.

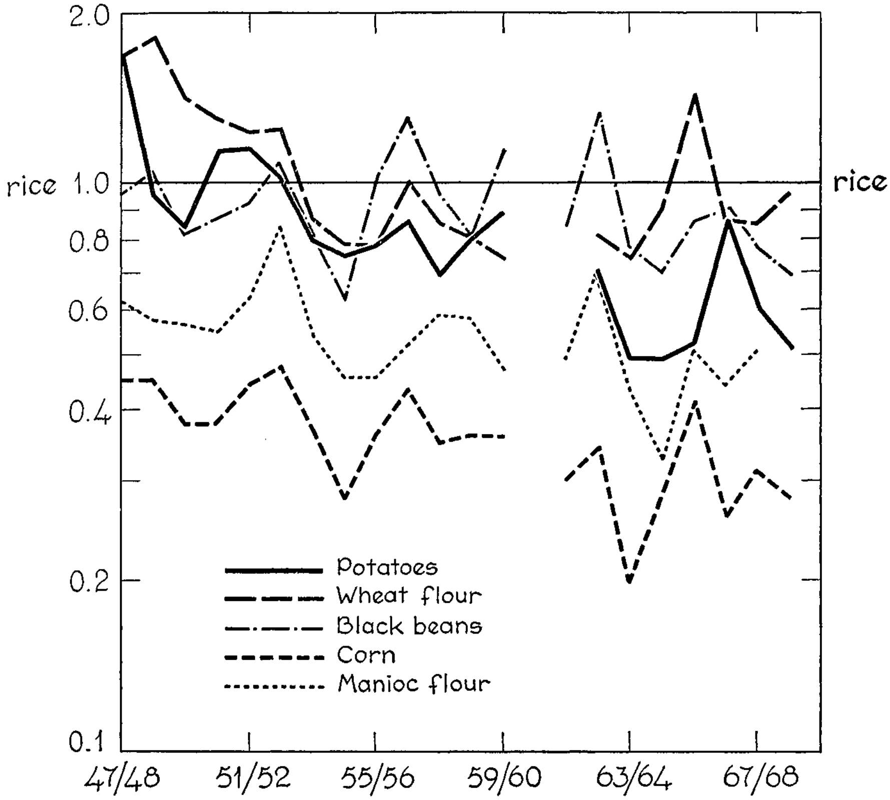
A REVISED CROSS SECTION ANALYSIS

There is a great discrepancy between the levels of per capita rice consumption predicted by the FGV's cross section analysis and the actual data. The FGV rationalized that discrepancy was the result of substitution due to supply limita-

[10] It is unfortunate that a model that places so much stress upon substitution, employing it as a residual category, pays so little attention to prices. The FGV study appears to say that the prices of Brazilian food staples moved so as to induce the substantial enlargement of rice consumption. So far as marketed foodstuffs are concerned, the evidence does not support this thesis. It remains possible that in subsistence households the rate of substitution of rice for other staples was substantially modified by the growing number of farmers producing rice and by changes in the real cost of preparing various dishes when all of the inputs (labor, implements, space), employed in their preparation, are considered. But this has nothing to do with substitution "caused by limitation of supply."

[11] It must be stressed that these data refer only to *marketed* foodstuffs and take no account of what might be called intrahousehold subsistence transactions, i.e., changes in the rates of substitution of staples in the subsistence sector. Those ratios reflect the interdependence of production and consumption decisions and the scarcities of nonmarketed or incompletely marketed family labor.

CHART 2.—BRAZIL, RATIOS OF RETAIL PRICES OF SELECTED FOODS TO RETAIL PRICE OF RICE, 1947–68*



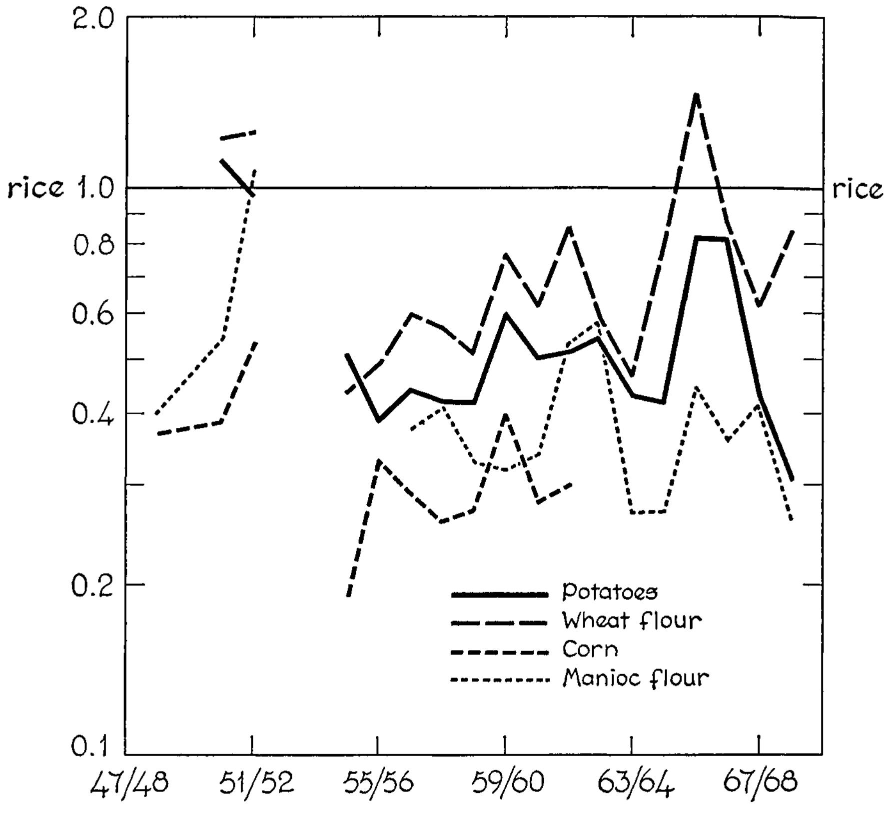
* Based on prices in Appendix Table I.

tions. In the last section we demonstrated that this is inconsistent with price data and could not have occurred as the FGV supposed. This leads us to look elsewhere for its explanation. There is no more obvious starting point than the FGV's cross section model.

There are two principal grounds upon which the FGV's methodology warrants criticism. The first is the fundamental inadequacy of the analysis of a historical process upon the basis of cross section data alone. The second is that a number of the routine procedures ordinarily used in the cross section analysis of consumption and adopted by the FGV are inappropriate.

The use of cross section analysis to explain historical phenomena and to project their future course does not rest upon any theoretical demonstration of the adequacy of cross section analysis for that purpose. It is ordinarily an accommodation to the absence or unreliability of data and serious collinearity in the independent variables of the time series. On the contrary, the literature argues that the step from the estimation of cross section income elasticity coefficients to their use for time series prediction is perilous. The underlying determinants of the functional relationship between income and consumption in a cross section sur-

CHART 3.—SÃO PAULO, BRAZIL, COMMODITY EXCHANGE: RATIO OF PRICES OF SELECTED FOODS TO PRICE OF RICE, 1947–68*



* For sources of data see Appendix I.

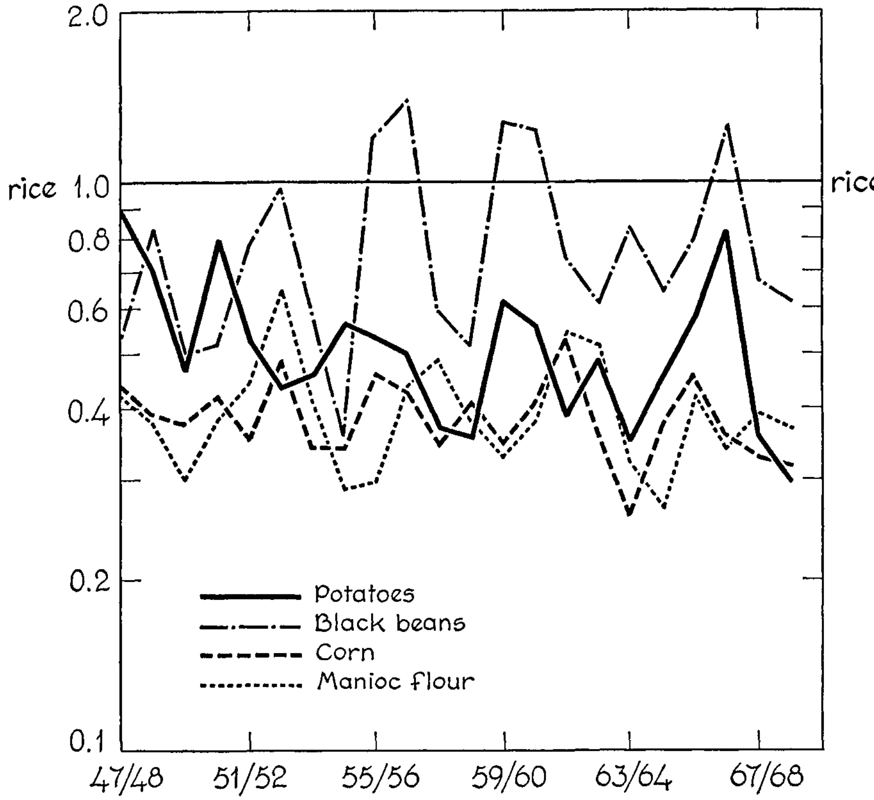
vey may be very different from those that influence their relationship over any considerable period of time. Houthakker and Taylor's explanation of their choice of time series over cross section analysis as the basis for projection is representative: ". . . it has been realized increasingly in recent years that the income elasticities provided by cross-section and time-series analyses are conceptually different, and that the latter are probably more suitable for projection over time" (*27*, p. 6).

The FGV's estimate of substitution was significantly exaggerated by its employment of certain inappropriate statistical procedures. The most serious are its exclusive use of the double-logarithmic (constant elasticity) consumption function and its use of income as an independent variable instead of some more satisfactory proxy for expected income.

The appropriate considerations involved in the choice of functional form have been discussed extensively in the literature and the consensus is that economic and statistical considerations should prevail over practicality (*48*, pp. 82–86).[12]

[12] S. J. Prais and H. S. Houthakker provide an extended and rounded discussion of the considerations involved in the choice of functional form in cross section demand analysis (*48*, pp. 79–106). A. S. Goldberger examines the same problem in a more general framework (*25*, pp. 125–35).

CHART 4.—PÔRTO ALEGRE, BRAZIL, COMMODITY EXCHANGE: RATIOS OF PRICES OF SELECTED FOODS TO PRICE OF RICE, 1947–68*



* For sources of data see Appendix I.

S. J. Prais and H. S. Houthakker suggest that the consumption function of necessities should have "an initial income level below which a commodity is not purchased" and that at the other extreme "there is a satiety level" (*48*, p. 82).

Statistical considerations advanced as criteria for the selection of the functional form include consistency among coefficients (of relatively little importance in a single commodity study), goodness of fit, and well-behaved residuals (*48*, pp. 84–86). Prais and Houthakker selected the semi-logarithmic function on *a priori* economic grounds and found that it produced superior statistical results. Their data covered a fairly narrow range of income. Where the range of income is broad, L. M. Goreux suggests that the log-inverse function is likely to be superior (*26*, p. 2).

The importance of selecting the functional form that most closely approximates the actual consumption-income relationship is more than a matter of achieving the best possible fit. Whether the objective of a demand study is projection or explanation, differences between alternative functional forms imply entirely different conceptions of the long-term evolution of the demand for a commodity. If one's interest is in the long-run pattern of consumption, then at least as much attention should be given to the turning points and slope changes of the consumption function as to its current elasticity. In Brazilian rice consumption there appear to be two important turning points: beyond some very low threshold income, per capita rice consumption rises quite rapidly in response to increases in income; beyond some middle income level the rate of increase of per capita consumption shows a declining response to the rise of income. Because time series data aggregate over diverse regions and are composed of a time sequence of complexly constituted cross sections, it is often difficult to detect these turning points by time series analysis. They show up much more clearly in cross section data.

Chart 5 depicts average per capita consumption of rice as a function of per capita income in the northeastern cities of Fortaleza, Campina Grande, São Luís de Maranhão, and Salvador, and the rural area of the eastern state of Guanabara. In three of the four northeastern cities (São Luís excepted), rice consumption increases at a diminishing rate with income and reaches an asymptotic limit at very high incomes. In rural Guanabara, rice consumption in the highest income class appears to rise above the supposed asymptotic limit. The nonconforming stratum, composed of families that operate high income truck farms, enjoys an income and style of life comparable to the urban population of Rio. If we eliminate it from the sample, the remainder of the observations display the same shape as the others. This suggests that it would be worthwhile to re-analyze the sample data, fitting variable elasticity log-inverse and semi-logarithmic functions to them as well as the constant elasticity double-logarithmic function used by the FGV.

The procedure that we will follow is to fit three alternative functional forms to the sample consumption data and then select the function that offers the most satisfactory results.

The three functional forms used are: the double-logarithmic function,

$$\log Y = a + b \log + e \tag{1}$$

where Y is the per capita rice consumption in kilos, X per capita disposable income in cruzeiros, and e an error term. In this function elasticity (η) is constant and equals the regression coefficient b; the log-inverse function,

$$\log Y = a - \frac{b}{X} + e \tag{2}$$

where $\eta = \dfrac{b}{X}$;

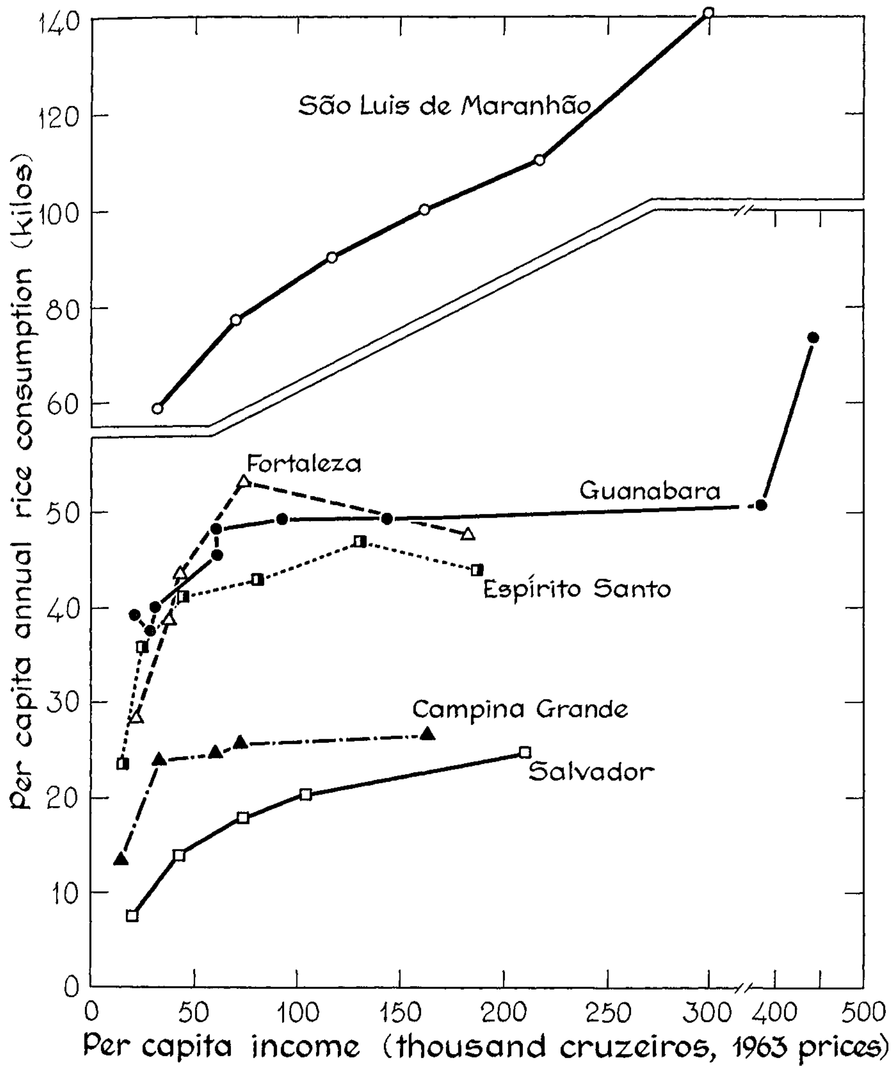
and the semi-logarithmic function,

$$Y = a + b \log X + e \tag{3}$$

where $\eta = \dfrac{b}{Y}$.

Consumption and income data are reported by the FGV as the arithmetic means of classes stratified by monthly income. Regressions fitted directly to these means differ from regressions fitted to the individual values in several ways: if

CHART 5.—PER CAPITA RICE CONSUMPTION AND INCOME: SELECTED BUDGET SURVEY DATA*



* For sources of data see footnote 6.

the coefficient of determination (R^2) of the regression fitted to grouped data is less than .98, then the R^2 of the regression fitted to individual data will be several times smaller (*13*, pp. 246–47); the regression coefficients of the unweighted grouped data are unbiased but relatively inefficient estimators. The loss of efficiency due to groupings can be corrected by multiplying each observation (the arithmetic mean of its class) by $\sqrt{n}$ (where n equals the number of individual observations in that class). This normalizes the variance of the class averages. Regressions run on the weighted values provide unbiased and efficient estimates of coefficients (*38*, pp. 242–46). This transformation was applied to the grouped data and generates the following equations:

$$\sqrt{n} \log Y = a\sqrt{n} + b\sqrt{n} \log X + \sqrt{n}\, e \qquad (4)$$

$$\sqrt{n} \log Y = a\sqrt{n} + b\sqrt{n}/X + \sqrt{n}\, e \qquad (5)$$

$$\sqrt{n}\, Y = a\sqrt{n} + b\sqrt{n} \log X + \sqrt{n}\, e \qquad (6)$$

where n = the number of observations in the class.

In the selection of the best functional form, goodness of fit is the paramount criterion; the scatter of residuals with respect to the determining variable is also taken into account. Because the R^2 values of regressions run on grouped data are very much higher than when run on individual values it seemed appropriate to discount them according to a formula suggested by J. S. Cramer.[13] The corrected measure of fit is denoted as $\check{R}^2$ and is considered in the place of R^2.

Having selected the best functional form we next compute and compare the income elasticities implied by each of the functions. If these results show that the log-inverse function is superior *and* that the aggregate (market) income elasticity it implies is greater than the elasticity estimated from the double-logarithmic function, our hypothesis that the FGV systematically underestimated the income elasticity of rice is supported.

The FGV's family budget surveys for the northeastern cities of Campina Grande (Paraíba), Fortaleza (Ceará), Salvador (Bahia), and São Luís de Maranhão, and the rural areas of the state of Guanabara report consumption and income data as average values for each income class of sample population. Due to the small number of income classes into which the observations were divided, we pooled the data from the cities of Campina Grande, Fortaleza, and Salvador into a single sample, and analyzed these cities separately as well. This was unnecessary for rural Guanabara. In all, we analyzed six separate samples, the cities of Campina Grande, Fortaleza, Salvador, São Luís de Maranhão, pooled northeastern cities (Campina Grande, Fortaleza, and Salvador) and rural Guanabara.

Linear regressions were fitted to each of our samples. In every instance but one, consumption was regressed on a single determining variable. The regression for the pooled northeastern data (Campina Grande, Fortaleza, Salvador), the single exception, included two dummy variables intended to "catch" the variation

[13] It is well known that "the correlation coefficient based on grouped data . . . is a quite unsatisfactory estimate of the correlation of the population and in consequence is of little statistical interest" (*47*, p. 2). In general, grouped observations lead to very much larger values of R^2 than the individual observations (*13*, p. 233). With some reasonable approximations J. S. Cramer (*13*) derives a formula for estimating the degree by which the R^2 on grouped data is inflated and measures the degree of overestimation for some common values. The result most relevant to our work here is that R^2 values that are already high for individual values increase relatively less than R^2 values that are low, i.e., small differences between R^2 values at the high end of the scale for grouped data are equivalent to substantially greater differences between the R^2's on ungrouped data. With a little manipulation of Cramer's results we may derive a formula transforming the R^2 on grouped data to its mean value for ungrouped data ($\check{R}^2$).

$$\check{R}^2 = R^2 / (1-K)\, R^2 + K$$

$$K = -(n-2) / (t-2)\, (1 - \frac{W^2}{12t^2})$$

where t is the number of classes into which the original observations are grouped, n the total number of observations, and W the tabulated statistic, "Mean Range in Normal Samples of Size n," (*43*).

due to "uncontrolled" inter-sample variation. The family budget studies from which these data derive were collected over a highly inflationary two-year period. Relative prices differ somewhat in each city; though they share a common regional tradition, each has evolved somewhat different dietary habits.

Table 4 summarizes the results of the regressions of all three functional forms for the seven samples. It shows the $\check{R}^2$ and R^2 (corrected for degrees of freedom); the regression coefficient of per capita income, the coefficient of income elasticity at the arithmetic mean, the median, the income associated with the weighted average level of consumption, and the mean incomes of the highest and lowest income strata. The income elasticity estimates of the double-logarithmic functions (equal to the regression coefficients) are close to the ETENE's estimates and appear to differ only by the extent of rounding errors. The log-inverse function results in a higher $\check{R}^2$ than the double-logarithmic function for the Campina Grande, Fortaleza, Salvador da Bahia, and rural Guanabara samples. It also results in a larger $\check{R}^2$ for the pooled northwestern cities for which $\check{R}^2$ could not be computed. The double-logarithmic function gives a better fit for São Luís de Maranhão. Since the dependent variables of the double-logarithmic and log-inverse functions are identical, we may at once conclude that the log-inverse function gives a better fit and in most samples should be chosen over the double-logarithmic function as statistically superior. Though the R^2's of the log-inverse functions and semi-logarithmic functions ordinarily cannot be directly compared in this case, the great differences between them suggest the rejection of the semi-logarithmic function.

The differences in $\check{R}^2$ are often small (and the differences in R^2 even smaller), e.g., pooled northeastern cities, but the evidence of the statistical superiority of the log-inverse function along with its more appealing economic properties weighs heavily in its favor. These results validate the first part of our hypothesis, that in general the log-inverse function fits Brazilian family budget data for rice consumption better than the double-logarithmic function.

Our next step is to investigate the increase in rice consumption that would occur in response to a given percentage increase in income affecting all income classes equally if the population's consumption follows the variable elasticity log-inverse function. This increase is then compared to that predicted by the constant elasticity double-logarithmic function for the same sample.[14]

Since the double-logarithmic function implies that individuals at all income levels display identical income elasticities, aggregate (market) and individual elasticities are identical. Not so with the log-inverse function. Individual elasticities vary inversely with income. The aggregate (market) income elasticity of a population whose consumption is best fitted by a log-inverse function is related to the distribution of income and cannot be summarized by taking the elasticity at any particular point along the consumption functions, e.g., at the mean per

[14] If we had all of the cross section samples employed by the FGV we could estimate an aggregate all-Brazilian elasticity and compare it to the FGV result. This would provide a definitive test of our hypothesis. Since we used only a few samples our comparison is limited to these samples and can only be suggestive. To the extent that the available samples embody the rice consumption-income relationship throughout Brazil our results are general. The fact that they represent rural and urban populations in the northeast and the east lends some credence to the general conclusions we draw from them.

TABLE 4.—CROSS SECTION RICE CONSUMPTION FUNCTIONS*

(Weighted regressions)

Location	Coefficient of Determination[a] R^2	$\check{R}^2$	b_1 regression coefficient of income (*t-value*)[b]	Income Elasticity (η): At average income of lowest income stratum	Associated with income at weighted average consumption level	At median income level	At weighted arithmetic mean income level	At average income of highest income stratum
Campina Grande, Paraíba								
Income (*cruzeiros*)[c]				14,480	22,490	27,360	30,910	162,130
Per cent of sample[d]				55				4
Double-logarithmic	.986	.09	.417	.417	.417	.417	.417	.417
			(3.49)					
Semi-logarithmic	.870	.01	7.797	.475	.383	.395	.417	.268
			(3.74)					
Log-inverse	.998	.38	1294	.894	.575	.473	.418	.080
			(9.70)					
Fortaleza, Ceará								
Income (*cruzeiros*)[c]				22,000	37,040	48,460	53,140	182,000
Per cent of sample[d]				26				11
Double-logarithmic	.983	.17	.267	.267	.267	.267	.267	.267
			(2.53)					
Semi-logarithmic	.724	.01	10.15	.300	.263	.245	.242	.190
			(2.67)					
Log-inverse	.995	.41	1518	.690	.410	.313	.286	.084
			(5.94)					
Saõ Luís de Maranhão[e]								
Income (*cruzeiros*)[c]				35,200	68,870[f]	115,100[g]	149,170[h]	298,000
Per cent of sample[d]				...				...
Double-logarithmic	.969	...[i]	.374	.374	.374	.374	.374	.374
			(12.4)					
Semi-logarithmic	.898	...	34.46	.635	.446	.362	.331	.269
			(6.71)					
Log-inverse	.821	...	2922	.830	.420	.254	.196	.098
			(4.88)					

Salvador Da Bahia								
Income (*cruzeiros*)[c]				20,630	25,540	47,140	66,220	209,410
Per cent of sample[d]				32				12
Double-logarithmic	.911	.01	.537 (6.66)	.537	.537	.537	.537	.537
Semi-logarithmic	.977	.05	7.542 (22.83)	.924	.774	.529	.449	.298
Log-inverse	.992	.13	2564 (20.11)	1.24	1.004	.544	.387	.122
Pooled Northeastern Cities								
Income (*cruzeiros*)[c]				16,820	21,360	36,740	48,750	197,450
Per cent of sample[d]				43				8
Double-logarithmic	.990	...[f]	.484 (8.81)	.484	.484	.484	.484	.484
Semi-logarithmic	.938	...	7.681 (10.26)	.412	.377	.317	.293	.212
Log-inverse	.991	...	1733 (8.95)	1.030	.811	.472	.355	.088
Rural Guanabara I[k]								
Income (*cruzeiros*)[c]				20,800	49,700	68,000	82,900	459,000
Per cent of sample[d]				2.7				1.3
Double-logarithmic	.999	.74	.136 (4.32)	.136	.136	.136	.136	.136
Semi-logarithmic	.979	.15	6.313 (4.34)	.167	.143	.137	.133	.107
Log-inverse	.999	.81	904.4 (5.65)	.435	.182	.133	.109	.020

TABLE 4.—CROSS SECTION RICE CONSUMPTION FUNCTIONS*—*Continued*
(*Weighted regressions*)

Location	Coefficient of Determination[a] R^2	$\check{R}^2$	b_1 regression coefficient of income (*t-value*)[b]	Income Elasticity (η): At average income of lowest income stratum	Associated with income at weighted average consumption level	At median income level	At weighted arithmetic mean income level	At average income of highest income stratum
Rural Guanabara II[l]								
Income (*cruzeiros*)[c]				20,800	58,690	66,000	81,050	386,000
Per cent of sample[d]				2.8				3.8
Double-logarithmic	.998	.74	.127 (3.63)	.127	.127	.127	.127	.127
Semi-logarithmic	.980	.20	5.644 (3.76)	.149	.128	.122	.119	.096
Log-inverse	.999	.83	904.4 (5.63)	.435	.154	.137	.112	.023

* See text for description.

[a] Corrected for degrees of freedom. In addition $\check{R}^2$ has been further adjusted to remove the effect of using grouped data (see text).

[b] Significant at the 99 per cent level except 98 per cent for Campina Grande double-logarithmic, and 95 per cent for Fortaleza double-logarithmic and semi-logarithmic.

[c] Average income in cruzeiros per capita per year at 1962 prices.

[d] Per cent of total individuals falling in the lowest and highest groups.

[e] Unweighted regression since data are insufficient to compute weighted regressions.

[f] Average income of second income stratum.

[g] Average income of third income stratum.

[h] Unweighted mean due to lack of data.

[i] Data insufficient to compute $\check{R}^2$.

[j] Tabulated w statistic needed to compute $\check{R}^2$ unavailable.

[k] Highest income stratum included.

[l] Highest income stratum excluded.

capita income. The aggregate (market) elasticity must be computed by aggregation over all income classes.[15]

Table 5 summarizes the results of this calculation. In every case but Salvador da Bahia, the aggregate elasticity of the log-inverse function is greater than the elasticity of the double-log function. In percentage terms, differences range from a high of 44 per cent for Fortaleza to a low of 15 per cent for the pooled northeastern cities. This implies, *a fortiori*, that, barring substantial income redistribution, in the past when lower income levels prevailed the aggregate (market) cross section income elasticity was even higher. The cross section income elasticity computed by the FGV would be even less relevant for those years than for the base year in which it was computed. Thus the FGV coefficient systematically underestimates the degree to which past growth of per capita rice consumption was due to the growth of income. The extent of this bias is greater the further

[15] Richard Stone shows that, in general, the aggregate elasticity (which he calls the market elasticity) is equal to the weighted average income elasticity taken over all individuals (*51*, pp. 264–67). That is:

$$\eta_{ag} = \frac{1}{Y}\sum_{i=1}^{n} Y_i\,(\eta_i)\,(\eta_{x_i x_{ag}})$$

where Y is the total consumption of the commodity considered,
Y_i is the consumption of that commodity by the i^{th} individual,
η_i the income elasticity of the i^{th} individual for the commodity being considered, and
$\eta_{x_i x_{ag}}$ the elasticity of the income of the i^{th} individual with respect to total income.
If the income of all individuals increases proportionately, then $\eta_{x_i x_{ag}} = 1$ and the formula reduces to

$$\frac{1}{Y}\sum_{i=1}^{n} Y_i\,\eta_i$$

Applying this to the particular functions considered in this analysis we get the following formulas for computing the aggregate elasticities of individual functions:

double-logarithmic function,

$$\eta_{ag}\,LL = \frac{1}{Y}\sum_{i=1}^{n} Y_i\,(b)$$
$$= \frac{b}{Y}\sum_{i=1}^{n} Y_i$$
$$= b\,;$$

semi-logarithmic function,

$$\eta_{ag}\,SL = \frac{1}{Y}\sum_{i=1}^{n} Y_i\left(\frac{b}{Y_i}\right)$$
$$= \frac{nb}{Y}\,;$$

log-inverse function,

$$\eta_{ag}\,LI = \frac{1}{Y}\sum_{i=1}^{n} Y_i\left(\frac{b}{X_i}\right)$$
$$= \frac{b}{Y}\sum_{i=1}^{n}\left(\frac{Y_i}{X_i}\right)$$

TABLE 5.—AGGREGATE ELASTICITIES COMPUTED FROM SAMPLE DATA FOR THE DOUBLE-LOGARITHMIC AND LOG-INVERSE FUNCTIONS*

	Double-logarithmic function	Log-inverse function	Difference as a per cent of double-logarithmic elasticity
Campina Grande	.417	.551	+32.1
Fortaleza	.267	.384	+43.9
Salvador da Bahia	.537	.514	− 4.3
Pooled Northeastern Cities	.484	.558	+15.3
Rural Guanabara (highest income stratum included)	.136	.157	+15.4
Rural Guanabara (highest income stratum excluded)	.127	.160	+26.0

* See text for description.

back in time one goes; it was quite large, perhaps on the order of 100 per cent, at the beginning of the 1947–67 period. Conversely, the FGV projections of future consumption overestimate the response to increased income.

Our second objection to the procedures used by the FGV to estimate cross section income elasticity of rice is that they misspecify the income variable so as to underestimate systematically the response of rice consumption to changes in permanent income.

Even before the publication of Milton Friedman's *A Theory of the Consumption Function* (*19*), economists had come to realize that, in any brief period, consumption is only indirectly related to current income. First Modigliani and Brumberg and later Friedman offered theoretical explanations of this observation, suggesting that consumer decision-making is conditioned by the "previous peak income" or "permanent income" (*40*; *19*). Friedman defined permanent income as "the income to which consumers adapt their behavior" (*19*, p. 221). It has become a common practice in demand analysis to use total expenditures rather than measured income as an explanatory variable, in the belief that it is a better measure of the true income of the consumer, i.e., his expected income according to Friedman's definition (*19*, p. 33).

Friedman pointed out that in any particular budget survey the measured income of poor families can be expected to be below and the measured income of wealthy families above their permanent incomes (*19*, pp. 34–35). Consequently consumption functions fitted to budget income data are likely to display a slope smaller than the true relationship between consumption and permanent income and to underestimate the income elasticity. The replacement of measured income by total expenditures on the assumption that expenditures are more stable than income partially circumvents this difficulty. The authors of the FGV study nevertheless chose to regress the quantity consumed upon measured income even when they had expenditure as well as income data at their disposal. This is likely to increase the extent to which it underestimated the cross section income elasticity coefficient.

To reach an approximate estimate of the extent of this bias we re-analyzed FGV data for rural areas of the state of Espírito Santo, the only published family

TABLE 6.—ESTIMATION OF THE QUANTITY ELASTICITY OF RICE WITH RESPECT TO INCOME AND EXPENDITURE FOR RURAL ESPÍRITO SANTO*

	R^2 *(corrected for degrees of freedom)*	b_1 regression coefficient (*t-ratio*)
Quantity elasticity with respect to income		
Double-logarithmic function	.992	.212[a] (3.1863)
Quantity elasticity with respect to expenditure		
Double-logarithmic function	.991	.369[b] (2.5401)

* The computations reported in this table and the accompanying text were done by Valimohamed Jamal. The interpretation or misinterpretation, as the case may be, is mine. Data are from Fundação Getúlio Vargas, Instituto Brasileiro de Economia, Centro de Estudos Agrícolas, *Estado do Espírito Santo, Orçamentos Familiares Rurais* (Rio de Janeiro, August 1969, mimeo.).
[a] Significant at the 95 per cent level.
[b] Significant at the 90 per cent level.

budget study available to us which provides both income and expenditure data, by running regressions on both the income and expenditure variables (*21*). Again the data were reported as income class averages and had to be weighted by the square root of the total number of members in each class.

Two equations were considered:

$$\sqrt{n}\log Y = a\sqrt{n} + b\sqrt{n}\log X + \sqrt{n}\,e \qquad (1)$$

$$\sqrt{n}\log Y = a\sqrt{n} + b\sqrt{n}\log E + \sqrt{n}\,e \qquad (2)$$

where Y is per capita rice consumption, X per capita income, E total per capita expenditure in cruzeiros, and n the size of the sample.[16]

Table 6 presents the results of these regressions. When rice consumption is regressed upon income, the income elasticity of rice is .212; when it is regressed upon total expenditures it rises to .367. In this particular sample, the FGV coefficient underestimates the true value by about 74 per cent.

According to previous calculations the double-log function underestimated the income elasticity of rice from 4 to 44 per cent in the samples analyzed. Let us assume that on the average it underestimates the true value by only 20 per cent. Then we might justifiably raise the FGV's estimate of the overall Brazilian cross section income elasticity of 1960 of .28 to .34. If we further assume that the bias resulting from the misspecification of the income variable was only 50 per cent (the estimated bias for the Espírito Santo data was 74 per cent), then correction for this bias would raise the weighted average income elasticity to .51. This corrected coefficient still falls below the .92 "effective consumption coefficient" (see page 173) but does substantially reduce the estimated "coefficient of substitution" from .76 to .41. Further explanation of the remaining discrepancy requires that we undertake time series analysis.

[16] Robert Summers showed that the use of total expenditure as an explanatory in a cross section consumption function leads to asymptotically biased estimators (*52*). Nissan Liviatan suggests that income be used as an instrumental variable to secure unbiased estimates (*36*). In the present case rice accounts for a sufficiently small share of total expenditures (<10 per cent) to obviate the necessity of using the procedure suggested by Liviatan.

Our cross section results imply that at the levels of income prevailing when the survey was taken (1962/63), the double-logarithmic function tends to underestimate modestly the increase in consumption that would result from an increased income affecting all income classes proportionately. The FGV procedures and results even more seriously underestimate the income elasticity at levels of income lower than those prevailing at the time the survey was taken and overestimate those that would prevail at higher incomes. Consequently it attributes far too little of the past growth of rice consumption to the rise of income and seriously overestimates the rate at which future consumption is likely to increase. These results not only dispute the FGV analysis of the past evolution of rice consumption but also cast some doubt upon its projection of future demand.

TIME SERIES ANALYSIS OF BRAZILIAN RICE CONSUMPTION, 1947–67

To project future Brazilian rice consumption the FGV chose to employ relatively reliable family budget data in a defective cross section model. The result was underestimation of the response of rice consumption to income change and spurious attribution of increased rice consumption to price induced substitution. While it would have been possible to improve the results substantially by explicit consideration of the effect of interregional migration, fitting alternative functional forms, and using expenditures rather than income as the dependent variable—corrections that this paper applies to the same data—a more direct approach would have been to complement the cross section study with time series analysis, even at the risk of employing reputedly unreliable data.

At best, the interpretation of historical data upon the basis of cross section analysis is a suspect undertaking. At worst it can be totally deceptive. Cross section and time series income elasticity coefficients may measure very different things and are used as substitutes only at great risk.[17] Skillfully constructed cross section models can accommodate changes in the rural-urban and interregional

[17] Though not entirely identical, the FGV analysis and the widely used method of "extraneous estimators" are similar. Each assumes that the cross section and time series income elasticity coefficients for a particular commodity are theoretically identical and could be used interchangeably for projection and explanation provided we could measure them correctly. In practice their unbiased measurement is well nigh impossible. On the assumption of the interchangeability of cross section and time series income elasticity coefficients, both methods replace coefficients (the FGV because they cannot be directly measured in the absence of needed data; the method of "extraneous estimators" because of the collinearity of the determining variables) with a more accessible coefficient estimated from cross section data. V. K. Chetty provides an up-to-date review of the literature on this subject and develops an improved estimation procedure (*12*). He assumes, of course, that the extraneous estimator and the inaccessible coefficient which it replaces are, in fact, equal and that the estimate of the extraneous coefficient is unbiased.

Criticism of the method of extraneous estimator applies equally well to the FGV procedures. Edwin Kuh argues that the biases of the extraneous estimator, particularly its specification errors, will almost certainly not coincide with those of the time series into which it is inserted (*34*). This seriously inhibits the interpretation of results.

Milton Friedman dismisses the use of extraneous estimators as "erroneous" unless explicit account is taken of the differing relative importance of permanent and transitory income in the cross section and time series data being analyzed (*19*, pp. 136–37, 207–9). Procedures have been developed for this purpose but were not employed by the FGV.

These objections to the use of cross section and time series income elasticity coefficients as if they were interchangeable are widely known. Sophisticated demand studies attempt to correct for them or to find their way around them. There are, in addition, other difficulties in the combined use of cross section and time series data to which less attention has been paid. First, if the relationship between consumption and any of its principal determining variables changes over time, then the actual time series will surely diverge from any prediction made upon the basis of an earlier cross section analysis. Second, if the cross section relationship between consumption and any significant determining variable omitted is not constant, and if the relative frequency of the omitted variable composition of the population and the variation of the income elasticity with income. But without supplementary time series analysis there is very little that they tell about the effect of changes in the price of the commodity, the prices of commodities which are related to it in consumption, and changes over time of preference for that commodity.

In the end the FGV analysis could not gainsay the very rapid rate of increase of per capita rice consumption demonstrated by highly deficient balance sheet computations.

Direct measurement of changes in rice consumption by Brazilian households over the past several decades, such as might have been afforded by a series of family budget surveys at several year intervals, is unavailable. We can only infer rice consumption trends indirectly, from a time series computed by a "balance sheet" approach in which average annual per capita rice consumption equals available supply divided by the population.[18]

The validity of this procedure depends upon the accuracy of estimates of production. Though far from ideal, Brazilian rice production data are sufficiently reliable and comprehensive to permit the computation of a rice consumption time series by balance sheet methods that accurately reflects the rate of increase of rice consumption, provides a good measure of the absolute level of consumption, and satisfactorily, though less accurately, assesses year-to-year fluctuations.

Municipal statistical agents of the Instituto Brasileiro de Geografia e Estatística (IBGE), who are responsible for data collection in one or more *municípios,* collect annual production estimates. Their instructions call for them to estimate production in consultation with leading farmers, merchants, tax agents, warehouse operators, and credit agencies of the region. At best these are highly knowledgeable estimates based upon informed opinion, cross-checked against data compiled by tax, credit, and warehouse facilities. At their worst, they are guesses. While this method of collection led Werner Baer to question their value (*2*, p. 210), various characteristics of rice production suggest that for this crop the method of estimation produces results that are in accord with auxiliary evidence. The most impressive confirmation comes from the coincidence of the estimates of per capita rice consumption by family budget surveys and balance sheet construction (*23*, p. 34).

Much of Brazilian rice production comes from highly specialized producing zones. Farms that grow rice are relatively large and specialized, and market a large share of their output within established commercial channels. A larger share of rice than other crops is grown under the direct supervision of the farm owner; a smaller proportion is controlled by share croppers and other dependents; a rather small part of the total is interplanted with other crops; a greater proportion than of other crops is marketed (*49*, pp. 111–26). Specialized production and marketing *in* restricted areas promotes the concentration of information and communication about the state of the rice market. Since rice production domi-

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changes over time, then the cross section prediction of the evolution of the time series will surely be quite unreliable. Third, and of great pertinence in the present case, if the individual's consumption function is non-linear and/or has an initial level below which the commodity is not consumed, the time series generated by the aggregation of the individuals in the population responding to increments in income will bear a complex relation to the underlying individual functions.

[18] Available supply equals production less feed use, seed use, waste, milling loss, industrial use, net foreign trade, and year-to-year changes in stocks.

nates the economic life of such specialized municípios, the statistical agents share a large pool of information regarding the state of the local and regional markets. An experienced municipal statistical agent knows most of the large and many of the small producers in his area. He regularly consults with rice buyers, mill and warehouse operators, and the local tax agent who, by virtue of the Impôsto de Vendas e Consignações (now Impôsto de Circulação de Mercadoria), is well informed regarding rice shipments from the município. By following the flow of fact and rumor in the rice market, the principal preoccupation in every bar and at every gathering in rice-producing areas, the agent knows the acreage planted by many farmers shortly after cultivation begins and will learn the number of sacks of rice they produce soon after the harvest is completed. From such sources a diligent statistical agent is able to collect accurate production figures for many farms and reliable estimates for most of the rest. Not all agents perform their tasks so well and some estimates are perfunctory, but the conditions of rice marketing make the task easier than for other crops. There is good reason, then, to believe that production estimates are reasonably accurate.

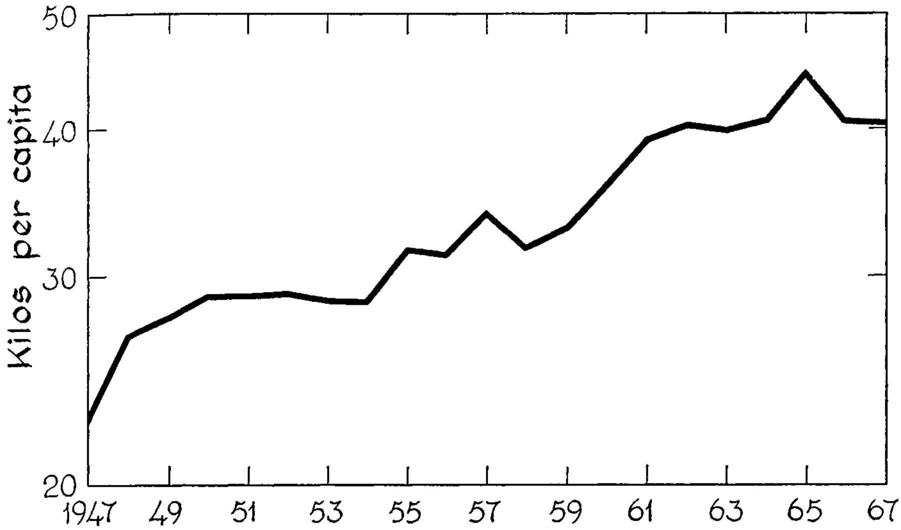
In its essentials, balance sheet construction involves little more than simple arithmetic. One secures national production statistics and to them adds or subtracts the losses and gains to supply before final consumption. If full, accurate, unambiguous data are available that is the end of the matter. In practice, it is always more difficult. Data for the sequence of additions, subtractions, and adjustments are even less reliable and more difficult to secure than basic production statistics. For example, since the early forties specialists have debated the extent of postharvest cereal losses in Brazil with estimates ranging from 25 to 40 per cent down to the more sanguine official estimate of 3 per cent (*33*, pp. 331–34). Comprehensive statistics on year-to-year changes in rice stocks are nonexistent. Demographers have questioned the validity of the Brazilian population census. So it goes for each item of the balance sheet identity. Helen C. Farnsworth noted the problematic nature of balance sheet estimates when she wrote (*16*, pp. 182–83):

> Contrary to a common misconception, national food balances are not customarily constructed in a routine, automatic manner by beginning at the production side of the equation, successively inserting the best available estimates of production, net trade, change in stocks, then deducting the several non-food utilization items and waste, and finally ending with a *residual* figure that is accepted as the national food consumption estimate. They are actually constructed in a number of different ways, depending on the nature of the available data, the supplementary information known to the estimator, and the estimator's own judgment, ingenuity, and available research time.

There are choices to be made at every step along the way in balance sheet construction. By following each branching network, one ends with an impractically large number of final series. How many alternatives should be tried? How should the research worker treat coefficients he knows to have changed over time? How should he evaluate the resulting final series?

To economize on effort, four series were constructed. The first, a straightforward application of balance sheet arithmetic, uses official statistics for pro-

CHART 6.—BRAZIL, PER CAPITA RICE CONSUMPTION, 1947–67*



* For sources of data and method of computation see Appendix II.

duction, foreign trade, and population without adjustment or modification. Coefficients for seed use and for crop and milling losses are taken from the official Brazilian Balanço Alimentar or the FAO food balance sheets. This series is comparable to those published by Brazilian and international agencies (*23*, p. 57). The second series replaces those data and coefficients at variance with the preponderant weight of evidence and expert opinion with alternative values calculated from one or more sources. The third series applies our judgment of the correct values based upon published and unpublished literature and personal field experience. The fourth series incorporates a further adjustment for the movement of stocks outside of the state of Rio Grande do Sul, the only state for which stocks statistics are published. Appendix II describes the preparation of all four balance sheet series in detail, and gives the base data, the intermediate values and the per capita consumption time series obtained in the fourth balance sheet computation. Chart 6 shows the results of the fourth series on a per capita basis for the period 1947–67. This series is believed to provide the best available estimate of the historical movement of Brazilian rice consumption and is used in all the regression equations reported here.

Some of the same problems that were faced in the cross section analysis as well as others that have not been heretofore considered need to be discussed before we proceed with the time series analysis.

We have previously argued that the selection of the functional form to be fitted to consumption data should be made on economic and statistical grounds. The evidence is overwhelming, according to these criteria—goodness of fit and economic plausibility—that for the cross section analysis of staple foodstuffs, variable elasticity consumption functions are superior to constant elasticity functions. With respect to time series analysis the evidence is less clear. Houthakker and Taylor attest to the inconclusiveness of current knowledge: "The mathematical form of the demand equation (in time series analysis) cannot be specified *a priori* in the present state of the arts. It is therefore advisable to try out different forms, especially those obtained by logarithmic transformation on one or more of the variables" (27, p. 7). We again consider the double-logarithmic, semi-logarithmic, and log-inverse functional forms in this analysis.

The selection of the independent variable was a particularly troublesome problem in the present analysis. Because stocks are carried from year to year and the Brazilian government regulated rice exports between 1952 and 1964, a year's supply was only partly determined by production in the previous year. Supply was therefore not completely predetermined, and an equation in which price is the dependent variable would very likely suffer from serious simultaneous equation bias.

Since 1947 the Brazilian government has intervened in the rice market with the objective of maintaining a stable retail price. Controls included export licensing, retail price ceilings, and the purchase, holding, and sale of stocks. The apparent stability of the real retail price of rice between 1947 and 1967 (see page 174), suggests that this policy was largely successful. On the strength of the exogenously determined stability of the rice price, it appeared reasonable to regard price as predetermined and to treat per capita rice consumption as the dependent, determined variable. Consequently our equations regress per capita rice consumption upon income, price, and a number of other determining variables. While this procedure is plausible and furnishes reasonable coefficients, we cannot demonstrate that it is completely untainted by simultaneous equation bias.

In all of the time series equations considered here the dependent variable is per capita rice consumption (Y) or its logarithmic transform (Y^*). Consumption data were obtained from the fourth balance sheet rice consumption series (see Appendix I).

The independent variables are suggested by demand theory, the past experience of demand analysts, and some hunches regarding the special character of Brazilian rice consumption.

A first group of independent variables are obvious derivatives of demand theory and require little further comment. They include real disposable income per capita, variable X_1 (see p. 193 for further information on the sources and treatment of these data); variable X_2, the real retail price of a kilo of rice (see Appendix I for further information on the sources and treatment of price data); and variables X_3 through X_7, the retail prices of rice's possible substitutes—wheat, manioc flour, potatoes, corn, and beans, respectively.

A second group of variables is introduced to test for the presence of a time trend in the consumption time series over and above the response of consumption to the rise of income and to learn something further about the possible causes of that trend. The first variable in this group, X_8, is time in years from 1947. A large and significant coefficient is indicative of the fact that important factors, above and beyond income and price, induced a steadily upward shift in rice consumption that was a simple linear function of time.

The next two variables, X_9 and X_{10}, past peak rice consumption and per capita rice consumption lagged by one year, respectively, were formulated with the objective of separating the increase of rice consumption resulting from adaptation and learning from the increase attributable to altered circumstances, such as migration and commercialization. Past peak consumption is intended to embody the effect of the growth of the habit of rice consumption. It assumes that this habit is strengthened by prior consumption acting as a form of psychological reinforcement which can induce increased but not diminished consumption. Consumption lagged by one year allows for greater flexibility in the process of habit formation, by hypothesizing that the intensity of the habit of rice consumption rises and falls with the level of consumption in the immediate past.

The sources of most of the data employed in the time series analysis have been discussed above. National accounts constructed by the Fundação Getúlio Vargas supply a time series of per capita disposable income for the period 1947–67. Since Brazilian national accounts are reported in current cruzeiros, it was necessary to convert them into real terms. An ideal deflator would be a comprehensive Brazilian cost-of-living index. None exists. The only alternative was to use the general price index No. 2 published in the FGV monthly *Conjuntura Econômica* which reflects the prices of producers and intermediate goods as well as final goods. It has risen less rapidly than the regional cost-of-living indices.

The retail prices of rice and related commodities were obtained from consumer prices statistics published in the *Anuário Estatístico do Brasil* and some issues of the *Revista Brasileira de Estatística*. Appendix I discusses them in detail. Wherever possible, prices were obtained for a single well-defined variety and quality on the assumption that the average weighted price of all rice varieties correlates with the price of any particular well-defined subclass. For example, for rice we use the prices of "*arroz agulha da 1ª*." Unfortunately both the collection and reporting of some data have changed from time to time and a certain amount of judgment was required to link various segments of the series and allow for changes in definition and coverage. These were also deflated by price index No. 2 of *Conjuntura Econômica*.

Table 7 presents the important results of the time series regressions. Variables are introduced in rough order of importance and then in various combinations to determine both their individual behavior and their interaction. Whenever they are applicable, double-logarithmic (*LL*), semi-logarithmic (*SL*), and log-inverse (*LI*) functions are fitted to each specification. For each equation, Table 7 shows the coefficient of multiple determination corrected for degrees of freedom ($\bar{R}^2$), the coefficient of multiple determination of the untransformed value of the dependent variable (relevant to the evaluation of the fit of alternative functional forms whose dependent variables differ), the Durbin Watson statistic, and the regression coefficients of individual variables (t ratios in parentheses).

Two variables, disposable income and time (1947 = 1), individually account for more than 90 per cent of the variance of per capita rice consumption (Table 7, equations 1 and 2). Time alone accounts for more than 95 per cent of total variance. Both coefficients carry the expected positive signs and are highly significant. However, their high $\bar{R}^2$'s and t ratios are less impressive when we note their low Durbin Watson statistics, indicative of positive serial correlation (significant at the 95 per cent level). Individually, income and time lack some element or elements of the correct specification.

Economic theory (and common sense) suggest that income and the price of

TABLE 7.—TIME SERIES RICE CONSUMPTION FUNCTIONS, 1947–67*

Equation number and form	$\bar{R}^2$ corrected for degrees of freedom	$\bar{R}^2$ of original untransformed value	Constant term	Coefficients of variables: Per capita disposable income (X_1)	Rice price (X_2)	Time 1947 = 1 (X_8)	Manioc flour price (X_4)	Wheat price (X_3)	Corn price (X_6)	Durbin Watson statistic
1. Income (X_1)										
LL	.93	.93	.98[c] (16.43)	1.25[c] (16.67)						1.01[d]
SL	.89	.89	−50.68[c] (7.73)	42.09[c] (13.01)						.70[d]
LI	.90	.90	4.71[c] (53.54)	−8.90[c] (13.83)						.69[d]
2. Time (X_8)										
LL	.95	.9480	3.12[c] (137.90)			.035[c] (19.69)				1.29[d]
3. Rice price (X_2)										
LL	.09		2.512[c] (4.24)		.47 (1.63)					.39[d]
4. Wheat price (X_3)										
LL	.17		4.71[c] (8.79)					.57[a] (2.24)		.29[d]
5. Corn price (X_6)										
LL	.20		4.31[c] (13.10)						−.75[a] (2.45)	.68[d]
6. Income, rice price (X_1, X_2): Basic equation										
LL	.95	.95	1.19[c] (7.34)	1.34[c] (17.45)	−.19[a] (2.40)					1.41[e]
SL	.92	.92	−41.19[c] (5.97)	46.11[c] (14.10)	−8.35[a] (2.53)					1.00[d]
LI	.92	.92	5.22[c] (19.87)	−9.59[c] (13.95)	−.20 (2.03)					.91[d]

7. Income, rice price, time (X_1, X_2, X_8)									
LL	.96	.97	2.36[c]	.61[a]	−.14[a]	.026[c]			1.47[e]
			(5.68)	(2.40)	(2.17)	(2.97)			
SL	.95	.95	14.03	11.36	−.63	.975[c]			1.06[e]
			(.85)	(1.12)	(2.04)	(3.55)			
LI	.96	.96	3.93[c]	−3.07	−.14	.026[c]			1.30[e]
			(11.25)	(1.94)	(1.97)	(4.34)			
8. Income, rice and wheat prices (X_1, X_2, X_3)									
LL	.95	.95	.71	1.43	−.18[a]			.15	1.93
			(6.91)	(2.05)	(17.43)			(2.04)	
SL	.94	.94	−66.77[c]	50.47[c]	−8.08[b]			7.70[b]	1.77
			(5.99)	(15.57)	(2.84)			(2.71)	
LI	.94	.94	4.88[c]	−10.62[c]	−.20[a]			.23[b]	1.69
			(18.69)	(14.93)	(2.35)			(2.65)	
9. Income, rice, wheat and manioc prices, time (X_1, X_2, X_3, X_4, X_8)									
LL	.97	. . .	1.49[c]	.91[c]	−.09	.014	−.08	.16[b]	2.17
			(3.11)	(3.60)	(1.36)	(1.97)	(1.60)	(2.68)	
SL	.97	. . .	−24.08	23.44[b]	−4.63	.731[c]	−2.62	7.85[c]	2.15
			(1.43)	(2.62)	(1.98)	(2.99)	(1.40)	(3.72)	
LI	.97	. . .	3.96[c]	−5.64[c]	−.10	.018	−.07	.20[c]	2.11
			(13.15)	(3.56)	(1.45)	(3.16)	(1.48)	(3.08)	
10. Income, rice and wheat prices, time (X_1, X_2, X_3, X_8)									
LL	.97	.97	1.85[c]	.73[c]	−.14[a]	.02[c]		.13[a]	1.90
			(4.20)	(3.08)	(2.37)	(3.05)		(2.17)	
SL	.97	.97	−12.86	17.83[a]	−6.25[c]	.90[c]		6.83[c]	1.87
			(.84)	(2.17)	(3.00)	(4.14)		(3.35)	
LI	.97	.97	3.85[c]	−4.65[c]	−.15[a]	.022[c]		.16[b]	1.88
			(12.73)	(3.12)	(2.42)	(4.26)		(2.63)	

TABLE 7.—TIME SERIES RICE CONSUMPTION FUNCTIONS, 1947–67*—*Continued*

Equation number and form	$\bar{R}^2$ corrected for degrees of freedom	Constant term	Per capita disposable income (X_1)	Rice price (X_2)	Past peak consumption (X_9)	Consumption lagged by one year (X_{10})	Wheat price (X_3)	Durbin Watson statistic
11. Income, prices of rice and wheat, past peak consumption (X_1, X_2, X_3, X_9)								
LL	.97	1.58[c]	.82[c]	−.08	.012[c]		.01	1.79[e]
		(5.05)	(4.76)	(1.35)	(3.79)		(.10)	
SL	.98	−24.57[b]	21.17[c]	−3.22	.593		.96	1.64[e]
		(2.63)	(4.12)	(1.80)	(6.11)		(.49)	
LI	.98	3.84[c]	−5.48[c]	−.08	.014[c]		.03	1.80
		(16.16)	(5.52)	(1.44)	(5.73)		(.53)	
12. Income, prices of rice and wheat, and consumption lagged by one year (X_1, X_2, X_3, X_{10})								
LL	.96	1.08[c]	1.17[c]	−.15[b]		.006	.10	2.07
		(2.94)	(6.30)	(2.17)		(1.51)	(1.28)	
SL	.96	−42.92[c]	34.27[c]	−6.40[a]		.352[b]	4.60	2.13
		(3.35)	(5.29)	(2.58)		(2.76)	(1.74)	
LI	.96	4.29[c]	−7.63[c]	−.15		.009[b]	.13	2.10
		(3.90)	(6.14)	(2.11)		(2.75)	(1.62)	

* See text for description of equations and data. The dependent variable is per capita rice consumption. The forms of functions are double-logarithmic (*LL*), semi-logarithmic (*SL*), and log-inverse (*LI*). Figures in parentheses are *t* ratios.

[a] Significant at the 95 per cent level.

[b] Significant at the 98 per cent level.

[c] Significant at the 99 per cent level.

[d] Positive serial correlation significant at the 95 per cent level.

[e] Test inconclusive at the 95 per cent level.

the commodity itself are prime candidates for the correctly specified demand function. This specification (Table 7, equation 6), hereafter the basic equation, does produce superior results: the $\bar{R}^2$ is almost as high as any other combination of variables, the coefficients are quite significant, and serial correlation is reduced though still significant. Most important, the signs and magnitudes of the coefficients of income and price are plausible: the coefficient of income (*LL*) is 1.34 and the coefficient of price −.19.

The addition to the basic equation of the price of wheat (equation 8), suggested by the literature and my own field experience as the most likely substitute for rice, results in a substantial improvement of the regression results: $\bar{R}^2$ is .95, serial correlation is no longer significant, and the coefficient of the price of wheat is significant and positive (.15), validating our belief that rice and wheat are competitive. Augmenting the basic equation with the time variable (equation 7) raises the $\bar{R}^2$ yet higher (.96) but does not reduce serial correlation. That achievement is apparently reserved for the wheat price. The most significant effect of time is to reduce substantially the income coefficient (*LL*) to .61 from 1.3. We return to the meaning of this reduction below.

Finally, combining the basic equation (income, price of rice) with the price of wheat and time (equation 10), we achieve a slightly larger $\bar{R}^2$ (.97), maintain serial correlation at an insignificant level, and secure significant coefficients with plausible signs and magnitudes: income .73, the price of rice −.14, and the price of wheat .13. More complex specifications — income, the prices of rice, wheat, manioc, and time (equation 9) — increase the $\bar{R}^2$ but only at the cost of the deterioration of the significant coefficients. For present purposes a satisfactory specification of the rice consumption function includes per capita disposable income, the prices of rice and wheat, and time, measured from 1947.

The significance of the time variable demonstrates that, to a substantial degree, the rise of per capita rice consumption was due to factors that evolved in a steady fashion over time. Factors that are likely to have contributed to this trend were interregional and rural-urban migration, the diffusion of rice production (and consumption) from farm to farm and from one farming region to the next as the rice frontier advanced northwards and westwards, taste change, and the transition of rural and urban families from traditional dietary patterns based upon manioc and corn supplemented by almost no rice to patterns based upon rice as the principal starchy staple. Net migration has tended to shift the population from the north and northeast, where rice consumption is low, to the south, east, and central west where consumption is quite high. The traditional dietary patterns, based upon corn and manioc, often in the form of the fresh root (manioc) and in the milk, soft dough, and green immature stages (corn), required abundant, low-priced household labor, special implements, and a spacious backyard, all of which grew increasingly difficult and costly to provide in the ever more crowded cities; female labor grew relatively more costly, fresh corn and manioc are costly to transport and store, and urban households are crowded. As a result migrants substituted rice for the traditional starchy staples. The diffusion of rice cultivation was often the cutting edge of commercialized agriculture and raised rural rice consumption to the degree that it raised rural incomes. Finally, adjustment to the drastically altered circumstances of rural and urban life could not have occurred instantaneously and must have required a substantial degree of adaptation and learning which we identify with the economic concept of taste.

Two variables, past peak consumption and per capita consumption lagged by one year, were formulated to deal more explicitly with taste change. The results are illuminating but by no means definitive. Augmenting basic specification of the time series rice consumption function by past peak consumption raises the $\bar{R}^2$ higher than regressions on time among other variables but at the cost of less significant regression coefficients. The regression coefficient on income and, by inference, the income elasticity, decline to a level intermediate between that in the equation with time excluded and the coefficient of the equation which includes time. The addition of consumption lagged by one year produces no improvement at all and will be considered no further.

It now remains to choose from among the alternative functional forms considered in this analysis, the double-logarithmic, semi-logarithmic, and log-inverse functions.

The $\bar{R}^2$'s of the double-logarithmic and log-inverse functions may be compared directly. In equation 10 (income, rice price, wheat price, and time), the two functional forms give almost identical values ($\bar{R}^2$ is .9695 compared to .9692). For less complete specifications the double-logarithmic function usually achieved a slightly higher $\bar{R}^2$.

To compare the semi-logarithmic function to the other two, it is necessary to adjust $\bar{R}^2$ so that it measures the percentage of the variance of the original untransformed dependent variable explained, as opposed to the variance of the logarithmically transformed dependent variable. To do so we compute the predicted values of the double-logarithmic function, take their anti-logs, calculate the correlation coefficient between the anti-logs and the original dependent variable, and then correct the correlation coefficient for degrees of freedom (*25*, p. 217). The results of this procedure are designated "$\bar{R}^2$ of the original untransformed value." They indicate that the semi-logarithmic functional form is slightly less satisfactory than the log-inverse and double-logarithmic functions.

On statistical grounds, the log-inverse and double-logarithmic functions are virtually indistinguishable. On economic grounds the log-inverse function is preferred and should be a better predictor of future rice consumption. It allows the income elasticity to decline with income and hence with consumption. It further assumes that consumption rises with income to an asymptote above which it increases no further.

Some of the results of these equations are novel. The elasticity of rice with respect to its own price is approximately the same in all functional forms and is −.15 in the complete log-inverse function (equation 10). See Table 8. The cross-elasticity of rice consumption with respect to the price of wheat is .164, validating the belief that wheat and rice are substitutes. The positive and highly significant coefficient of time indicates that per capita rice consumption, independent of the effect of income, rose each year by approximately .63 kilos.[19]

[19] Concern with the strong time trend exhibited by most of the time series data induced an attempt to fit time series regressions to first differences. Both arithmetic and double-logarithmic

TABLE 8.—SUMMARY OF ELASTICITIES DERIVED FROM ANALYSIS OF TIME SERIES DATA*

Equation number and form	$\bar{R}^2$ of original untransformed value	Durbin Watson statistic	Income elasticities at per capita real income and per capita rice consumption of the year[a] 1947	1952	1957	1962	1967	Price elasticity of rice[b]	Cross elasticity with respect to wheat prices[b]	Time coefficient	Time trend 1947–67 (*kilos per yr.*)
8. Income, retail prices of rice and wheat											
LL	.9534	1.93	1.426	1.426	1.426	1.426	1.426	−.182	.146		
SL	.9387	1.77	2.36	1.79	1.43	1.20	1.13	−.235	.223		
LI	.9419	1.69	2.015	1.550	1.334	1.158	1.109	−.196	.227		
10. Income, retail prices of rice and wheat, and time											
LL	.9701	1.90	.732	.732	.732	.732	.732	−.143	.128	.019	.529
SL	.9686	1.87	.822	.632	.521	.424	.398	−.182	.199	.920	.920
LI	.9702	1.88	.882	.678	.584	.507	.485	−.145	.164	.022	.627

* Data from, or derived from, Table 7, pp. 194–96.	*1947*	*1952*	*1957*	*1962*	*1967*
[a] Real per capita income at 1953 prices (*cruzeiros*):	52,705	68,538	79,586	91,710	95,802
Per capita rice consumption (*kilos per year*):	21.7	28.2	34.2	42.1	44.8

[b] At average level of rice consumption of 34.3 kilos per capita.

Finally, these time series results complement and further illuminate our estimates of the highly important coefficient of income elasticity of rice. It will be recalled that the FGV estimate of the income elasticity of rice in Brazil derived from cross section data was .28. Applying corrections suggested by this paper's cross section analysis the figure was revised upwards (page 187) to .51. We can regard this value as a lower bound to the true income elasticity of rice pertinent to the analysis of the evolution of rice consumption over time. It is untainted by the effect of changed preferences and the altered urban and interregional composition of the Brazilian population. On the other hand, it may not reflect the full adjustment of family expenditures for rice to rising income and altered living conditions.

Ordinarily the cross section estimate of the income elasticity of a commodity is considered to be a good indicator of the long-run adjustment of consumption to income, on the assumption that families in a cross section survey have had sufficient time to reach an equilibrium in their expenditures (*34*). With incomes rising steadily from very low levels and with dramatically altered living patterns this assumption may not be realized. Thus the true long-run value may rise even higher than the estimate derived from a cross section survey and the cross section provides us with a lower bound to the true value. We can better understand the time series results against this background.

In the completely specified time series rice consumption function that excludes the time variable, (Table 7, equation 8), the coefficient of disposable income (X_1) picks up not only the effect of income upon consumption but also the influences of the changing composition of the population and any shift in preference in favor of rice to the degree that they are correlated with income.

Table 8 summarizes the elasticity coefficients derived from the time series regressions. We note that the income elasticity in the log-inverse equation which does not include time ranges from a high of 2.02 in 1947—the initial year of the analysis—to a low of 1.11 in 1967, the final year. The coefficient reflects the response of rice to the rise of income and to all unspecified variables to the degree that they are correlated with disposable income. For this reason we interpret it as an upper bound to the true value.

By enlarging equation 8 (income, the prices of wheat and rice), with time, a variable that is closely related to the structural transformation of Brazil and the shift in preferences that occurred over time, the coefficient of income elasticity declines: it reached a high of .882 in 1947 and a low of .485 in 1967. In 1960, the base year of the FGV analysis, it stood at approximately .55, very close to this

functional forms were fitted to first differences with results generally sustaining those of the previous analysis, although equations $\bar{R}^2$'s were low and the coefficients barely significant. A good example of the result was

$$Y^* = .020 + .596X_1^* - .085X_2^*$$
$$(1.38) \quad (2.02) \quad (1.58)$$
$$\bar{R}^2 = .18$$

where Y is per capita rice consumption, X_1 per capita disposable income, and X_2 the real price of rice. All variables are transformed to logs. The own price elasticity of rice, −.09, is smaller than most estimates in the earlier equations; the income elasticity .596 is quite close to the estimates of equations including the variable time; the constant term is .020, again close to earlier estimates of the time trend to which the constant term in a first difference equation is equivalent. On the whole, these results sustain the previous time series regressions.

paper's revised cross section estimate of .51. It is tempting to accept this convergence of the cross section and time series estimates as confirmation of our conception of the evolution of Brazilian rice consumption over time and not merely coincidence.

RICE IN THE CHANGING BRAZILIAN DIET

Up to this point, the objective of this paper has been to construct as complete an economic framework as available data permit to serve as a basis for the interpretation of the broader circumstances surrounding the growth of Brazilian rice consumption. Critical steps in the construction of that framework hinged upon correct estimation of the income, price, and substitution elasticities of rice and identification of a time trend and taste change. But these abstractions, of great analytic value because of their precisely defined meaning and identifiability in econometric analysis, have been worked free from the particulars of Brazilian history, geography, and culture. They are as applicable to one time and place as to another. It is all very well to determine that the Brazilian income elasticity of rice is rather large and bears an inverse relation to income, but can we delve somewhat deeper into the imponderables of choice that we denote as taste to learn something about why this might be so? It is the purpose of this section to return to these abstract categories some of their concreteness by inquiring into the conditions that determined the particular values that they have assumed.

Let us take the first decade of this century as our point of departure. It coincides with the decline and disappearance of rice imports as a consequence of the imposition of a tariff and a sharp upturn in world rice price (*50*), the start of the growth of the rice industry in Rio Grande do Sul—signalled by heavy investment in irrigation equipment—and the initial association of upland rice production with cattle and coffee in São Paulo (*39*).

Projection of the trend of per capita rice consumption backward from 1920 to 1900 suggests that average consumption in 1900 could hardly have been greater than 10 kilos and in all probability stood between 5 and 10 kilos. However, averages alone can be deceptive. Even the deficient evidence that is available suggests that early in the century rice consumption was distributed very unevenly between the rural and urban population and over regions and across socio-economic strata.

While no definitive statement can be made without substantially more primary data, several threads of evidence suggest that early in this century rice was relatively less important in rural than urban diets throughout most of Brazil. First, contemporary accounts of rural diets refer extensively to manioc and corn but only rarely to rice and then only in Maranhão and Rio, both exporting regions during the nineteenth century. Second, extensive and populous rural areas of central Brazil—mainly in Minas Gerais and São Paulo, where current rural rice consumption is quite large—formerly subsisted principally upon corn. Third, in the regions where rice consumption has always been relatively small, mainly the north and northeast, rural consumption is far below urban levels. In the past these regions accounted for a much larger proportion of the rural Brazilian population. Fourth, the current coincidence of rural and urban levels of per capita rice consumption, and the greater income elasticity of rice in rural areas, suggest that earlier rural rice consumption was lower than urban consumption. Fifth, the rising rice imports of the late nineteenth century could only have been destined for urban markets. And finally, rice production was far less widespread than it is today, with major turn-of-the-century producing areas located in Pará, Maranhão, along the São Francisco River, and at various points along the coast. Rural residents who did not produce their own rice were not likely to purchase it and pay the high cost of interregional transport.

Wide interregional differences in current levels of rice consumption are paralleled by the distribution of rice imports at the turn of the century. In 1904, before the imposition of an effective tariff, apparent per capita rice imports by the principal Brazilian cities ranged from a high of roughly 30 kilos in São Paulo and Rio de Janeiro (somewhat less than half of current levels) to less than 3 kilos a year in Maceió (Alagoas), Salvador (Bahia), João Pessoa (Paraíba), Teresina (Piauí), and Vitória (Espírito Santo). Even today, rice consumption in all of these latter cities except Vitória is small relative to the Brazilian average. Recife's (Pernambuco) apparent per capita imports were intermediate between the current levels in the northern and southern states but constituted a rather high proportion of the relatively low level of consumption reported by the 1962 family budget survey (*23*, p. 34). In the middle northern states of Ceará (Fortaleza) and Maranhão (São Luís) per capita rice imports were relatively large (as is rice consumption today). The Amazon ports of Manaus and Belém imported considerable quantities of rice per capita and, although a large share of imports undoubtedly moved out to trading posts along the river, urban consumption must have been high, perhaps as high as a third to a half of current levels.[20] Some turn-of-the-century urban Brazilian consumers were even then using relatively large quantities of rice in their diets. Based upon the results of the analysis of cross section data we may infer that they enjoyed relatively large incomes, acquired distinct dietary habits, and had limited access to cheap supplies of fresh corn and manioc. It is tempting to suggest that the large numbers of recent Italian, Spanish, and Portuguese immigrants in Rio, São Paulo, and Pôrto Alegre made a disproportionate contribution to this group but we have no evidence to support this.

But even *within* the cities consumption must have been far from uniform. The FGV and ETENE family budget studies show that in 1962–63 almost all families but the very poorest consumed rice. A study carried out in Recife in 1952 under the direction of Guerreiro Ramos found that 94 per cent of the surveyed families consumed rice. Josué de Castro, in a comparable survey made in Recife in 1934, had estimated that the proportion was only 20 per cent. A recent survey made in rural Pernambuco not only shows a low level of per capita rice consumption but also a high proportion of the families consuming little or no rice during the principal meal. All of this suggests that the rise in rice consumption involved not only the enlargement of consumption by families already consuming rice but, in addition, *a very substantial transfer of families from the non-user to the user category.*

For families whose diets did not include substantial quantities of rice, all of

[20] These figures are based upon an analysis of rice imports 1904–08. For further details see Appendix III.

the available evidence—scanty statistics, travellers' accounts, social histories, and the testimony of novels and short stories—points to manioc and corn as the principal starchy staples providing the bulk of calories. ". . . both in the area devoted to it and in the quantity produced, manioc—'the bread of the land'—occupied an undisputed position." (46, p. 191). Towards the south, "roughly along the frontiers of Bahia and Minas Gerais," manioc gave way to maize, and *farinha de mandioca* to *fubá* (cornmeal) (46, p. 192).

The traditional rural and urban economies of Brazil fully exploited the qualities of these plants. Manioc, a perennial root crop, is adaptable to diverse and inhospitable growing conditions, and can be flexibly integrated with the seasonal agricultural calendar presented by a number of regions. Corn is also adaptable to varied growing conditions, and offers a variety of products at different stages of its growth cycle. Adaptability, flexibility, and a long and variable growing season, qualities of which modern plant breeders are hardly enamored, were advantageous in a subsistence economy.

Manioc may be left unharvested with little loss until needed. Small quantities of the root are pulled from the ground as required and immediately prepared for the table. *Farinha d'agua* (flour made from fermented manioc) can economically be prepared in small quantities and furnished the basis of the morning *café* (or *desejum*), the mid-morning *merenda*, the main *almôço*, and often, the evening meal for poor rural families in the north, northeast, and central west. Bulk harvesting is timed for slack periods when the labor of the entire family can be employed to convert the harvest into manioc flour which could be stored from one year to the next without loss. This single crop, distinguished by its great calorie productivity per unit area, when supplemented by game and collected and planted spices, is able to provide families accustomed to its use with a surprisingly varied and interesting diet.

While less of a crop for all seasons and more inflexible in its seasonal labor demand, corn provided comparably diverse fare for those dependent upon it. Soups and gruels were prepared from corn when it was in the immature milk and soft dough stages; roasted green corn was a delicacy prized throughout the growing season. Cornmeal (*fubá*) and dried whole grains were prepared from the mature ear and sustained the family dependent upon corn until the following year. Soups, gruels, bread, cakes, and *angu* (a polenta-like mush) were prepared from cornmeal.

While the fullest expression of this kind of corn or manioc based economy was found in rural areas, it also sustained a considerable proportion of the urban population. In his social history of the nineteenth century, *The Mansions and the Shanties*, Gilberto Freyre describes the continued use of manioc and corn as the principal starchy staples along with the addition of bread. Large producing areas were still sufficiently close to the edge of the cities to furnish a significant share of the urban population with bulky and perishable roots and fresh corn at reasonable cost. Urban densities were low and many families maintained small *chácaras* in suburban and neighboring rural areas and backyard *quentais*, within the cities—common practices in many small interior cities even today. For wealthy families, servants were numerous and cheap. For poorer families, employment opportunities for wives, daughters, and young sons were not sufficiently remunerative to discourage laborious food preparation and the construction and maintenance of the household processing equipment that it required.

With the late nineteenth century coffee boom a coherent and relatively continuous process of modernization bound the urban-industrial and rural-agricultural sectors into continuous interaction. The rise in the demand for agricultural commodities for domestic consumption was closely related to the growth of exports, mainly coffee and cotton. The consequences for both urban and rural consumers were profound. In the succeeding competition for land, starchy staple food crops placed second to export crops and tended, as a whole, to locate at ever increasing distances from the consuming centers. Since rice could better bear the cost of transport from distant producing areas, its claim upon resources in those areas rose at the expense of corn and manioc. Until recent years, when truck transport costs from the interior have declined, commercially marketed fresh corn and manioc tended to be produced at relatively nearer locations than rice and consequently bore heavier land rent. Manioc flour, owing to its higher value relative to its bulk, continued to come from distant producing areas. In and near to the cities rising urban population density led to rising land rents which in turn increased the cost of raising field crops to uneconomic levels favoring the substitution of fruits, vegetables, and dairy products for traditional staples. The net effect of all this was to make the traditional diets more costly in terms of both cash and effort than in the past and to offer households an alternative dietary pattern based upon rice, a commodity that eased the life of the housewife and released labor for other activities.

The second element in the shift of urban families from corn and manioc to rice was more clearly a matter of preferences and probably goes far to explain the very large income elasticities for rice at low income levels. Traditional diets required as complementary inputs to manioc and corn a large kitchen area inside or just outside the house, abundant and cheap labor, and a set of specialized implements. Rising urban land costs, but perhaps also the colder and wetter climates of the urban-industrial south and east, resulted in the modification of the size and layout of dwellings in such a way as to make extensive processing and storage within the household difficult and costly (*17*, pp. 107–71). Alternative employment for men as day laborers and for women as household servants and washerwomen raised the opportunity cost of labor and increased their cash income. The likely result was to increase the purchase of processed manioc flour and cornmeal at the expense of fresh manioc roots and corn, to increase the use of rice, and to substitute more easily prepared dishes for the very heavy household food preparation of the past. Food processing and storage were thus transferred from the household to a growing food processing sector by the purchase of processed manioc and corn and the shift to milled rice.

While the above description applies, *pari passu*, everywhere in rural Brazil and to much of the poorer urban population at the turn of the century, there were important regional differences. Since the estimates of apparent per capita rice imports in 1904 correlate very closely with contemporary consumption patterns, we can infer broadly from current data to the past. The level of rice consumption in the north and northeast is low when compared to the south, east, and central west. Most of the difference is attributable to regional income differences but a significant share may be due to regional price differences, and a small share to intrinsic regional differences we might denote as taste.[21] Interregional migration has tended to flow from the north and northeast to the south, east, and central west. If migrants adapted to different conditions of supply and adopted the habits of their neighbors, the effect of migration would have been to push rice consumption above the levels determined by other factors.

What appeared in the aggregate as a steady rise in per capita rice consumption by that fictitious being, the "average" Brazilian, is revealed, upon further analysis, to be composed of changes deriving from various segments of the population. We have been able to demonstrate that the rise is constituted of three components, income, structural transformation, and taste change.

Although all income classes enjoyed rising per capita income, the income-induced increase of rice consumption must have come largely from the lowest and middle income strata. At the turn of the century many individuals consumed little or no rice. Only a few consumed very large quantities. According to both our cross section and time series analysis it was the poor consumer, using very little rice, who had the greatest propensity to increase his rice consumption with increasing per capita income. The more affluent consumer, already using a large quantity of rice, responded proportionately less to an equivalent increase in income.

In addition to the effect of rising income, rising aggregate per capita rice consumption also reflects the influence of interregional migration and urbanization, and of changing taste. Migration from the northeast to the south and from rural to urban areas brought consumers into circumstances which encouraged them to increase their consumption of rice at the expense of corn and manioc. Consumers also appear to have increased their preference for rice. In part this may be accounted for by rice's greater prestige, in part because it proved a useful adaptation to new and unfamiliar living conditions.

THE RICE INDUSTRY AND BRAZILIAN AGRICULTURAL DEVELOPMENT

Modern Brazilian development may be traced to the coffee boom of the late nineteenth century. In a few decades the coffee frontier overflowed the confines of the Paraíba Valley, swept across the fertile *terra roxa* mantled São Paulo plateaus and on into Paraná. In this first phase of development the growth of the export economy nurtured urbanization within the region specializing in the production of coffee. Santos became the principal coffee export port and São Paulo the region's commercial center, and a string of cities astride the main corridors of penetration of the coffee frontier became thriving local service centers for their

[21] To investigate further interregional differences in the demand for rice we fitted a regression equation to a cross section of state income and consumption data in 1960. In the resulting equation

$$\underset{(3.44)}{Y^* = 13.53} + \underset{(1.20)}{.286X_1^*} - \underset{(2.03)}{1.964X_2^*} + \underset{(3.15)}{.914X_3}$$

$$\bar{R}^2 = .6401$$

Y is per capita rice consumption, X_1 per capita disposable income, X_2 the retail price of rice in the capital of each state, and X_3 as a dummy variable for the southern and eastern states. Starred variables are in logarithms and t ratios are in parentheses.

The positive and highly significant coefficient of the dummy variable demonstrates the preferred status of rice in the relatively urbanized and industrialized south and east.

surrounding agricultural hinterlands. These cities formed the links that communicated the influence of export development to adjoining regions. In the second phase—chronologically contemporaneous but geographically distinct from the first—the growing urban and rural demand for marketed foodstuffs gave rise to a secondary pattern of interregional agricultural specialization. Rice farming and livestock production were the branches of agriculture upon which this secondary phase of agricultural development had its greatest impact.

The story of the rise of the rice industry is remarkable not for any single technological change which accompanied its unfolding but for its steady half century of progress and the huge area involved in its expansion. It was a complex, multifaceted process involving changing habits and consumption patterns, the evolution of a more efficient marketing system, and the advance of the agricultural frontier many hundreds of miles to the south and west of São Paulo. It loosed a process of modernization involving a sequence of steps taken in response to the interplay of technological change and the changing prices of farm resources. This paper tells only the part of that story related to demand but even within its confines we gain some useful insights into Brazilian agricultural development.

If we can extrapolate from the results of the time series analysis of the demand for rice during the period 1947–67 to the last half century (which takes in the great part of the rise of the rice industry) we may conclude that demand conditions were very salutary for the expansion of rice production. Not only did the high income elasticity of rice translate economic growth into a steadily rising demand for rice, but when taken in conjunction with the shift factor—approximately .6 kilos per capita per year—it substantially insulated farmers from short-run price fluctuations. We may hypothesize that once the irrigated rice industry of Rio Grande do Sul and the upland frontier of São Paulo were launched, farmers learned that long-run conditions favored the expansion of production and assured them of relatively steady prices. This enabled them to make such long-term decisions as opening up new frontier areas, the construction of roads and bridges, and the clearing of new land—all major steps in the Brazilian process of land-intensive agricultural development—with greater certainty than for other crops whose demand was growing less rapidly. Thus, although the demand for rice is inelastic with respect to price (our estimates range from $-.08$ to $-.18$) the steady shift of the demand function to the right under the impress of rising income, taste change, and structural transformation served to substantially insulate farmers from short-run fluctuations.

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APPENDIX I: BRAZILIAN STAPLE FOOD PRICE DATA

A satisfactory test of the hypothesis that the price of rice declined relative to the prices of other staple food commodities calls for comprehensive retail commodity price series for individual varieties, qualities, and regions, appropriately weighted by the value of sales. Data should be collected according to uniform procedures on the basis of unambiguous definitions of the qualities and varieties covered. These data do not exist and we must employ inferior substitutes instead.

During the period under study, a number of agencies collected incomplete, occasionally inconsistent, retail price data in a desultory fashion. In general, the narrower the geographic coverage of a particular series and the closer its point of origin to the wholesale level of trade, the more precisely it defined the varieties and quality classes that it covered.

To aid our effort to assess the movement of staple food prices and their possible effect upon rice consumption a number of price series were collected and analyzed. The series which comes closest to approximating a general commodity price series for all of Brazil has been collected by Serviço Estatístico de Produção of the Ministry of Agriculture and published by the Instituto Brasileiro de Geografia e Estatística, Conselho Nacional de Estatística, in various forms since 1948 in, at various times, at least two of its publications. From 1947 to 1951, the *Anuário Estatístico do Brasil* published a series, "Average Prices of Some Commodities in Retail Trade in the State Capitals," which reported the annual and monthly average prices per kilogram for the major staple commodities in 27 cities. It gave no information on commodity definitions employed and the method of collection used. Commodities were classified in such broad classes as, for example, "rice." From 1952 until 1959, the same series also appeared regularly in the IBGE's monthly *Boletim Estatístico*. The format of the tables and the time period they covered varied from issue to issue. In 1960 this series ceased to appear and did not reappear again until 1961 when it emerged in a substantially revised format. Beginning in 1961 (No. 80) each issue of the *Boletim Estatístico* reported the average monthly retail prices of the principal Brazilian foodstuffs. Number 83 of the *Boletim Estatístico* reports that it was based upon a sample of 81 cities, without enumerating them or describing the weighting or averaging procedure used. Over the years commodity definitions were substantially narrowed and improved. When it first appeared, it reported on two varieties of rice and later added two more. Beginning in 1962 the *Anuário Estatístico* also published annual and monthly averages of the prices collected from the same sample.

Despite its deficiencies, this series supplies the most comprehensive retail commodity price data available. For the period 1947–59 we took the arithmetic average of the prices for thirteen selected cities, choosing them according to their size and geographic distribution. For 1961–68, the published Brazilian average is used. Wherever a single commodity was subdivided into more than one class (beginning in 1962) they were combined into a single weighted price, with weights representing our best understanding of the relative importance of the varieties and qualities considered. For rice, for example, the data of "*arroz agulha, 1ª*" and "*arroz japonês, 1ª*" were given weights of .85 and .15 respectively. When these were further subdivided into four classes in 1966, an appropriate adjustment was made. Appendix Table I presents these retail commodity price data, in current terms, deflated by the price index No. 2 of *Conjuntura Econômica* and as an index of the real price (1948–52 average = 100).

A second source of staple food prices are the São Paulo and Pôrto Alegre commodity exchanges. They report daily and monthly averages of sales between rice millers and rice merchants and rice merchants and retailers. While these are wholesale and not retail prices, the well-defined and unchanging locale of their collection and the precision and consistency of the definitions of variety and quality qualify them as data that must be considered at least as a check upon the retail prices series. These data were compiled from various issues of the IBGE, *Anuário Estatístico* and *Boletim Estatístico*.

Comparison of the retail rice price series with the price series of São Paulo and Pôrto Alegre commodity exchanges demonstrates a general correspondence in the direction and magnitude of the price changes reported by both series. The correlation coefficient between the real retail price of rice and the real Pôrto Alegre price of *Agulha* (long grain) rice between 1947 and 1968 is .789, between the retail and the Pôrto Alegre exchange Blue Rose (medium grain) rice price .791, and between the retail price and the São Paulo exchange *Amarelão* (long grain, premium quality) .758. These are evidence that the retail series has some real substance despite our uncertainty regarding the method used in its collection and compilation.

Appendix Table I gives the Serviço Estatístico de Produção retail price series for rice, potatoes, manioc flour, wheat flour, corn, and black beans. Prices appear in current terms (Cr$/Kilo), in real terms Cr$ 1953, deflated by the price index No. 2, *Conjuntura Econômica*), and as an index of the real price (1948–52 avg. = 100). Chart 2, page 175, depicts the price movement of these commodities as ratios to the rice price 1947–68. Inspection reveals that the real price of rice rose slightly while the prices of manioc flour, corn, and black beans declined modestly and the price of potatoes and wheat flour (the most likely substitutes for rice) fell sharply. Linear time trend regressions of the form

$$P = a + b\,t$$

where P is real price and t is time in years, were fitted to these series. As expected the slope for rice was positive and the slopes for manioc, corn, black beans, wheat flour, and potatoes negative. Only the coefficients for potatoes and wheat flour were significant at the 95 per cent level. The coefficient for rice was significant at 90 per cent.

Price data from the São Paulo and Pôrto Alegre commodity exchanges may be obtained by writing directly to the author. Ratios to rice prices are shown in Charts 3 and 4, pp. 176 and 177.

Reference to the earlier period is also appropriate here. During the last years of World War II, restrictions on supply provoked unusually high wheat, wheat flour, and bread prices. Particularly since macaroni and other pastas may be the most important substitutes for rice, the rise in wheat prices may have induced a shift from them to rice. If the evolution of rice consumption is influenced by cumulative habit formation—a Dusenberry-type consumption function—then the wartime decline of bread, macaroni, and pasta consumption could have had a substantial and permanent effect upon the consumption of rice. Unfortunately data are not available for a direct test of this hypothesis.

APPENDIX TABLE I.—BRAZIL, RETAIL PRICE OF SELECTED STAPLE FOODS, 1947–68*

(Cruzeiros per kilo)

	Rice			Potatoes			Manioc Flour		
Year	Current price	Real price[a]	Index[b]	Current price	Real price[a]	Index[b]	Current price	Real price[a]	Index[b]
1947	3.37	6.36	88.3	5.74	10.83	148.2	2.10	3.96	87.4
1948	4.10	7.32	101.7	3.98	7.11	97.3	2.39	4.27	94.3
1949	4.92	8.20	113.9	4.12	6.87	94.0	2.82	4.70	103.8
1950	4.79	7.15	99.3	5.43	8.10	110.8	2.63	3.93	86.8
1951	5.12	6.56	91.1	5.92	7.59	103.8	3.21	4.12	90.9
1952	5.89	6.77	94.0	5.98	6.87	94.0	4.88	5.61	123.8
1953	9.30	9.30	129.2	7.37	7.37	100.8	5.06	5.06	111.7
1954	11.64	9.17	127.4	8.89	7.00	95.8	5.41	4.26	94.0
1955	12.25	8.28	115.0	9.51	6.43	88.0	5.58	3.77	83.2
1956	14.20	8.02	111.4	12.08	6.82	93.3	7.35	4.15	91.6
1957	19.21	9.51	132.1	13.22	6.54	89.5	11.25	5.57	123.0
1958	20.75	9.06	125.8	16.95	7.40	101.2	12.08	5.28	116.6
1959	28.29	8.95	124.3	20.81	6.59	90.2	13.17	4.17	92.1
1960	—	—	—	—	—	—	—	—	—
1961	37.4	6.69	92.9	—	—	—	18.36	3.28	72.4
1962	86.2	10.17	141.2	60.93	7.19	98.4	61.43	7.24	159.8
1963	169.7	11.52	160.0	83.00	5.63	77.0	73.00	4.96	109.5
1964	244.0	8.68	120.6	120.00	4.27	58.4	80.00	2.85	62.9
1965	267.0	6.04	83.9	140.00	3.17	43.4	140.00	3.17	70.0
1966	579.0	9.47	131.5	490.00	8.01	109.6	250.00	4.09	90.3
1967	717.9	9.13	126.8	430.00	5.47	74.8	360.00	4.58	101.1
1968	798.7	8.18	113.6	410.00	4.20	57.5	400.00	4.10	90.5

	Wheat Flour			Corn			Black Beans		
Year	Current price	Real price[a]	Index[b]	Current price	Real price[a]	Index[b]	Current price	Real price[a]	Index[b]
1947	5.71	10.77	106.4	1.53	2.89	94.4	3.28	6.19	94.6
1948	7.38	13.18	130.2	1.85	3.30	107.8	4.25	7.59	116.1
1949	6.98	11.63	114.9	1.87	3.12	102.0	4.01	6.68	102.1
1950	6.24	9.31	92.0	1.84	2.75	89.9	3.43	5.12	78.3
1951	6.29	8.06	79.6	2.27	2.91	95.1	4.72	6.05	92.5
1952	7.33	8.42	83.2	2.82	3.24	105.9	6.30	7.24	110.7
1953	8.01	8.01	79.2	3.40	3.40	111.1	7.60	7.60	116.2
1954	9.21	7.25	71.6	3.31	2.61	85.3	7.30	5.75	87.9
1955	9.70	6.55	64.7	4.45	3.01	98.4	12.38	8.36	127.8
1956	14.13	7.98	78.9	6.05	3.42	111.8	18.48	10.44	159.6
1957	16.31	8.07	79.7	6.69	3.31	108.2	18.58	9.20	140.7
1958	16.62	7.26	71.7	7.48	3.27	106.9	17.11	7.47	114.2
1959	25.18	7.97	78.8	10.12	3.20	104.6	35.40	11.20	171.3
1960	—	—	—	—	—	—	—	—	—
1961	—	—	—	11.26	2.01	65.7	31.42	5.62	85.9
1962	69.98	8.25	81.5	28.96	3.42	111.8	114.21	13.47	206.0
1963	126.00	8.55	84.5	34.00	2.31	75.5	130.00	8.83	135.0
1964	220.00	7.83	77.4	70.00	2.49	81.4	170.00	6.05	92.5
1965	380.00	8.59	84.9	110.00	2.49	81.4	230.00	5.20	29.5
1966	500.00	8.18	80.8	150.00	2.45	80.1	530.00	8.67	132.6
1967	610.00	7.76	76.7	220.00	2.80	91.5	550.00	7.00	107.0
1968	770.00	7.88	77.9	220.00	2.25	73.5	550.00	5.63	86.1

* See text, Appendix I for sources and description. Dashes (—) indicate that data are not available.
[a] Price in constant, 1953 cruzeiros.
[b] Index of 1953 real prices, 1948–52 = 100.

APPENDIX II: THE CONSTRUCTION OF RICE CONSUMPTION TIME SERIES BY BALANCE SHEET METHODS

The construction of the rice balance sheet for Brazil is less difficult than for commodities like corn and manioc because rice is used almost exclusively as a human foodstuff after milling, polishing, and packaging. Since accurate and comprehensive data on animal use of staple commodities in Brazil are nonexistent, the exclusive utilization of rice as a human foodstuff avoids one of the most problematic steps of balance sheet construction. Balance sheet construction begins with the production data already discussed in the text (pp. 188–89). It continues by making the additions and subtractions described below.

The official Balanço Alimentar estimates seed use at 100 kilos per hectare planted (*23*, p. 57); the FAO places it at 96.3 kilos per hectare (*53*). Both estimates fall between the approximately 170 to 200 kilos per hectare of seed use in Rio Grande do Sul and the much lower 20 to 80 kilos per hectare reported by various sources for high upland rice production in central and south central Brazil (*31*, p. 14; *10*, pp. 926, 890, 654–6). But both are entirely too high for an all around Brazilian average.

The average seed use in Rio Grande do Sul between 1947 and 1964 was 194 kilos per hectare (*31*, pp. 90, 160, 230). The average level of seed use in the upland producing regions of Minas Gerais, Mato Grosso, Goiás, and Maranhão is 30 kilos per hectare, 50 kilos in São Paulo, and 50 kilos in the remaining states. Rio Grande do Sul's share of Brazilian rice acreage between 1947 and 1964 was approximately 22 per cent; the share of the central Brazilian upland producing areas was 40.2 per cent. On this basis we estimate the weighted average rate of seed use at about 74 kilos of seed per hectare planted.[22]

In the first series seed use was computed at the FAO rate of 96.3 kilos per hectare. In the second we use our own estimate of 74 kilos per hectare. In the third and fourth series we calculate seed use for each year by multiplying the acreage in each state in the following year by our best available estimate of its rate of seed use and then summing over state values.

Losses in Transit

Since World War II investigators and consultants employed by the Brazilian and United States governments have been particularly concerned with the performance of the marketing sector. Their estimates of postharvest cereal losses have ranged as high as 40 and never lower than 20 per cent. These estimates, "educated guesses" by experts, were based upon brief field trips and a few interviews with farmers, merchants, and warehousemen. They may have been unduly influenced by very large losses observed on one or another occasion but particularly during the glut of rice in the Triângulo Mineiro in 1951 when buoyant expectations and a bumper crop resulted in a harvest far in excess of the capacity of warehouse and transport facilities. Disorganization and dreadful waste followed (*33*, pp. 415–32). Recently, a private firm of United States marketing con-

[22] In interviews in Goiás, farmers estimated seed use between 20 and 30 kilos of seed per hectare. In 1920, the state government, in response to a federal inquiry, placed seed use at 20 kilos per hectare (*10*, pp. 826, 654–6). A recent survey found that an average of 24.7 kilos of seed was used per hectare of rice planted (*9*, pp. 7–14).

sultants which interviewed knowledgeable people in the marketing sector placed Brazilian postharvest cereal losses somewhat between 15 and 20 per cent. The official Balanço Alimentar set the loss rate for its balance sheet computation at 3 per cent but offered neither explanation nor a rationale for this very low value (*23*, p. 57). The FAO rate is 2.75 per cent (*53*).[23]

Our first series adopts the FAO's 2.75 per cent loss rate. Based upon the cited expert opinion and my own field experience, a 19 per cent rate of loss between harvest and retail sale was used in the second series. The third and fourth series attempt to fully exploit all available data by incorporating expert judgment and our own experience in quantitative estimates of postharvest loss. While the Balanço Alimentar and FAO postharvest loss coefficients are far too low, estimates made by marketing experts in the late 1940s and early fifties were unduly influenced by a temporary situation which improved substantially soon after.[24] In the construction of the third series we assumed that there are two components of postharvest loss. The first, which we call the "normal" level of loss, prevails when existing storage facilities are used at less than their full capacity. The second, unusual losses, derive from production beyond the limit of existing storage and transport facilities and the consequent use of inferior (e.g., roadside storage) substitutes. With respect to the first, we assume that the postharvest rate of loss with existing facilities was 20 per cent in 1947 and declined to 10 per cent in 1967. Intervening years are interpolated arithmetically. Further we assume that warehousing facilities grew at the same rate as the "expected" rise of rice production. Thus, in any year facilities should be sufficient to handle the *expected* level of production with the normal level of loss for that year. The *expected* level of production was estimated by fitting a time trend line to the production series. The loss rate was then assumed to be 50 per cent greater than the calculated normal rate for that year for any excess above the expected level of production.

Milling Rate

According to the Balanço Alimentar, milled rice loses about one-third of its original weight. The FAO places the extraction rate at 60 per cent. This closely corresponds to the rate used by rice millers in central Brazil for estimating the profitability of commercial rice transactions and this value is used in all four series.

Foreign Trade

The usual method for correcting a balance sheet estimate of consumption in any year for the effect of foreign trade in that year is to take the algebraic sum for exports (+) and imports (—) in a calendar year and then subtract that sum

[23] The USDA estimates the postharvest loss of rice in the United States at 2.5 per cent, of which 1.5 per cent was attributed to insects (*54*, pp. 69–70). Anyone familiar with the storage and storage facilities of both countries would be incredulous at the assertion that crop losses are equal.

[24] G. W. Smith shows that the conditions that resulted in the high losses of the 1950s are associated with the early stage of the development of producing regions and were overcome with time (*49*, pp. 215–16). The improvement of the supply and quality of marketing facilities is likely to have reduced cereal losses below the high levels of the early fifties and to have brought about their long-run secular decline.

from the domestic available supply for the same calendar year. This procedure is employed by the FAO, the USDA, and the Brazilian Balanço Alimentar. The first series is constructed in this way. But, this procedure may not reflect the harvest from which exported rice was actually drawn.

The bulk of the rice harvest is completed between March and April in Rio Grande do Sul and between March and June in south and south central Brazil (*30*, p. 118). This year's harvest does not enter the export trade until August. Thus first semester exports are drawn from stocks derived from last year's production and should be subtracted from either end year stocks or last year's production. Without stocks data, the simple subtraction of each year's exports from the same year's production may result in a spurious estimate of the actual available supply. Since agricultural policy in the early 1950s tended to exaggerate the concentration of exports in the first semester of the year, it consequently heightened the likely severity of this kind of error.[25]

Based upon the previous description of the timing of the rice harvest and the renewal of exports after the harvest, it seems reasonable to subtract this year's first semester (January–June) exports from the past year's production. This year's production is discounted by the exports made in the second semester of the year and the first semester of the succeeding year. For the years 1947–54, Brazilian rice export statistics were reported by the month and the correction can be made directly. For the remaining years, monthly export statistics cover only Rio Grande do Sul. If we assume that Brazilian exports were distributed in the same monthly pattern as Rio Grande do Sul is, then we can apply this distribution to the total Brazilian exports and subtract exports according to the same criterion as before.

[25] From the early 1950s the main objective of Brazilian economic policy was the stimulation of industrialization by use of protective tariffs and exchange controls encouraging import substitution. As part of the general program of industrial development, the principal objective of agricultural policy was to lower or at least control the rise of urban food prices. Views regarding the objectives and the efficacy of agricultural policy in that period range along an ideological continuum. Werner Baer writes with sympathy regarding the role of the price control agency that "The function of SUNAB (formerly COFAP) is to control prices and the flow of essential consumer goods. It was at first set up to protect the consumer against monopolistic pricing of essential goods and to ease the flow of these goods to areas where shortages would appear. Unfortunately pricing has been erratic, political considerations often getting the upper hand in setting different maximum prices for different states, resulting in shortages in some places and surpluses in others" (*2*, p. 93).

Ruy Miller Paiva is more critical of these policies: "After the Second World War, Brazil adopted an aggressive economic policy in favor of industrial development neglecting, however, the agricultural sector, which as a result suffered on various occasions injust price controls, unfavorable exchange rates, lack of guaranteed minimum prices, in addition to other measures, which together contributed to the more rapid transfer of income from the agricultural sector to other sectors of the Brazilian economy" (*42*). Among its instruments licensing was used as a control of the export of foodstuffs. Gordon Smith dates the start of export controls on cereal exports to 1952. "Since 1952, however, exports have occurred only when large domestic surpluses accumulated, as government exchange rate and export license policies for the cereal became oriented primarily by the desire to limit increases in food prices in the inflationary process" (*49*, p. 107). The military government brought into power by the coup of April 1964 abandoned this practice. Its effect, while it was in force, was to reduce overall rice exports and to concentrate the export of rice drawn from any particular harvest in the early months of the following year.

Between 1920 and 1952, Brazil failed to export rice in only a single year (1924). From 1952 to 1964, it did not export rice in four years and exported fewer than 5,000 tons in another two years. From somewhat limited evidence on the monthly pattern of rice exports, it appears that before 1952 and after 1964, heavy first semester rice exports *never* took place on the heels of light second semester exports in the preceding years. This occurred in three years between 1952 and 1964 (1956, 1959, and 1961). Government officials issued licenses to export rice only after they assured themselves that exports would not raise the domestic price above the desired level. The *Boletim Estatístico Mensal* of the Instituto Rio Grandense do Arroz repeatedly protested government export control policy during the years 1957–61. (See especially No. 24, December 1958.)

Stocks

Stocks have been the Achilles' heel of the past balance sheet computation of Brazilian rice consumption by the FAO, the USDA, and Brazilian agencies. They report that the nonexistence of statistics on stocks prevents them from taking account of their year-to-year movement. Since a substantial stock of rice over and above that needed to supply immediate needs is held in warehouses in some years, neglect of stocks can seriously bias balance sheet computation of per capita rice consumption.

To achieve comparability with other balance sheet estimates of per capita Brazilian rice consumption, our first series also neglects stocks. The second and third series attempt to take account of the net change of stocks by incorporating estimates based upon some hitherto neglected data.

For a number of years the *Anuário Estatístico do Arroz* of the Instituto Rio Grandense do Arroz (the Rio Grande do Sul rice growers' association) has published a time series purporting to show the annual utilization of the rice produced in that state. One entry in this balance is "year-end stocks." The balance covers the "commercial year," a period beginning April 1 of the current year and ending March 31 of the year following. It runs from an early stage of one harvest to the next. Since Rio Grande do Sul accounted for from 20 to 25 per cent of Brazilian production during the years covered by this series and an even greater share of stocks, incorporation of this data in our series should improve its accuracy.

The second and third series are corrected for the net change in stocks in Rio Grande do Sul.[26] Several attempts to simulate the movement of stocks outside of Rio Grande do Sul on the basis of an econometric model of the behavior of stocks in Rio Grande do Sul and the very limited information available to us regarding stocks movement in the rest of Brazil were unsuccessful. In the end, we settled on estimating the net change on stocks in the rest of Brazil as a fixed percentage of Rio Grande do Sul stocks. The fourth series incorporated this estimate.

Population Data

Having estimated a time series of the net available supply of rice it remains only to secure population data to compute annual per capita consumption. Ordinarily these data are derived by the interpolation and, where need be, extrapolation of the decennial censuses. There are two objections to this practice. First, demographers have cast doubt upon the reliability of the census results and offer alternative series derived from demographic models as superior estimates of the Brazilian population on those dates.[27] Second, since the Brazilian population has

[26] With the inclusion of Rio Grande do Sul stocks, it then becomes necessary to subtract Rio Grande do Sul's exports on the basis of an April–March year. Exports from the rest of Brazil are still subtracted on the basis of a July–June year and partially correct for the neglect of the net change of stocks in Rio Grande do Sul. This is obviously a very crude procedure. The fact that the rice market throughout Brazil acts as a single fairly well integrated unit, arbitraged by interstate shipments, offers some basis for the use of this very primitive correction.

[27] João Lira Madeira, "Aplicação de um Modêlo Teórico na Reconstituição da Demografia Brasileira," *Revista Brasileira de Estatística*, Ano. XXVII, No. 106, Abril/Junho 1966, pp. 86–92, demonstrates that the results of the censuses and other demographic data are inconsistent and constructs a model which generates an alternative population series. His prediction of the 1970 population came closer to the actual census count than any other that we have seen.

APPENDIX TABLE II.—BALANCE SHEET COMPUTATION OF PER CAPITA RICE CONSUMPTION IN BRAZIL, 1947–67: FOURTH SERIES*

(Thousand metric tons, except as otherwise indicated)

	Production					Exports			Change in stocks			Net available supply			Population (*millions*)	
													Per Capita (*kilo*)			
Year	Total	Seed use	Waste	Milling loss	Net	Total	RGDS[a]	Rest of Brazil	Total	RGDS[a]	Rest of Brazil	Total	I[b]	II[c]	Interpolated Series	Demographic Series
1947	2,596	102	568	616	1,310	152	85	67	+74	+48	+26	1,084	22.5	21.7	48.2	49.9
1948	2,552	105	497	625	1,327	40	35	5	−20	−13	−7	1,307	26.7	25.6	49.0	51.1
1949	2,720	118	523	665	1,414	4	—	4	+17	+11	+6	1,393	27.6	26.5	50.5	52.5
1950	3,218	116	699	769	1,634	142	98	44	+12	+8	+4	1,480	28.6	27.5	51.8	53.8
1951	3,182	112	624	783	1,663	162	140	22	−32	−21	−11	1,533	28.9	27.8	53.1	55.2
1952	2,931	124	509	735	1,563	61	54	7	−92	−60	−32	1,594	29.2	28.2	54.6	56.6
1953	3,072	144	517	772	1,639	1	—	1	+14	+9	+5	1,624	28.9	28.0	56.1	58.1
1954	3,367	150	549	854	1,814	—	—	—	+130	+84	+46	1,684	29.2	28.3	57.7	59.6
1955	3,737	150	611	952	2,024	32	31	1	+56	+36	+20	1,936	32.6	31.6	59.4	61.2
1956	3,489	143	532	900	1,914	73	72	1	−133	−86	−47	1,974	32.3	31.4	61.2	62.8
1957	4,072	146	608	1,062	2,256	—	—	—	+49	+32	+17	2,207	35.0	34.2	63.1	64.5
1958	3,829	155	544	1,002	2,128	85	62	23	−91	−59	−32	2,134	32.8	32.2	65.1	66.2
1959	4,101	169	561	1,079	2,292	—	—	—	−3	−2	−1	2,295	34.2	33.8	67.2	67.9
1960	4,795	180	651	1,268	2,690	4	2	2	+115	+75	+40	2,577	37.1	37.0	69.4	69.7
1961	5,392	189	768	1,419	3,016	165	147	18	−63	−41	−22	2,914	40.6	40.7	71.7	71.6
1962	5,558	205	739	1,476	3,139	27	27	—	+11	+7	+4	3,100	41.9	42.1	74.0	73.6
1963	5,740	220	713	1,538	3,269	6	—	6	+57	+37	+20	3,206	41.9	42.4	76.5	75.5
1964	6,345	240	690	1,733	3,682	76	42	34	+211	+137	+74	3,395	43.0	43.8	79.0	77.6
1965	7,580	209	1,040	2,026	4,305	331	204	127	+151	+98	+53	3,823	46.9	48.0	81.6	79.7
1966	5,802	221	580	1,600	3,401	138	95	43	−424	−275	−149	3,687	43.7	45.0	84.3	81.9
1967	6,555	228	656	1,815	3,856	32	16	16	+53	+34	+19	3,771	43.2	44.8	87.2	84.2

* See text of Appendix II for sources and description.
[a] Rio Grande do Sul.
[b] Computed using the "interpolated series" population.
[c] Computed using the "demographic series" population.

been increasing at an increasing rate, the common procedure of interpolating at a constant rate of growth systematically overestimates the population in all but the base year.

To achieve comparability with balance sheet computation by international agencies, the first series uses the population series constructed by the Fundação Getúlio Vargas. It is derived from census data by interpolation at a constant rate of growth.

Exact interpolation between the 1940, 1950, and 1960 census estimates of population, which found the Brazilian population growing at an increasing rate, requires the fitting of a polynomial exponential function to three points. Instead we computed a time series of the intercensal rates of population growth and then, in turn, computed the rate of increase of these growth rates. From these we computed a series of annual population growth rates which could be applied to appropriate base periods. Some arbitrary smoothing was needed to link the various segments of the resulting series. These data are called "Interpolated Series" and are used in the computation of the second and third balance sheets.

The fourth series employs the results of a demographic model constructed by the Brazilian demographer João Lira Madeira. Both its logical consistency and superiority as a predictor in demand equations recommend its use. The preliminary results of the 1970 census, published after this research was completed, show that this choice was a wise one. The model's projection of a Brazilian population of 91,345,000 for 1970 came closer to the actual census count of 92,237,570 than any of the alternatives, which were from 2.8 to 3.0 million too large.

The Computed Series

Appendix Table II presents the fourth balance sheet computation of per capita rice consumption in Brazil. (The first three series may be obtained by writing directly to the author.) The first applies straightforward balance sheet procedures and covers the period 1920–67. It enables us to view the evolution of rice consumption over the entire period for which production data are available (see Chart 1). The second, third, and fourth series cover the period 1947–67 to which most of our time series analysis is confined. Our fourth series estimates of per capita rice consumption for the period 1947–67 are shown in Chart 6.

APPENDIX III: THE DISTRIBUTION OF BRAZILIAN RICE IMPORTS 1904–8

Appendix Table III was constructed to gain some idea of the relative importance of imported rice in the Brazilian diet early in this century. It shows Brazilian imports by port of entry from 1904 to 1908. It registers a sharp decline of imports in 1907. A large share of the decline occurred in São Paulo. Rice imports remained at about the same level until 1917 when they all but disappeared. The second segment indicates the apparent per capita consumption of imported rice in each port and its hinterland. In most cases we assumed that imported rice was entirely consumed within the area supplied by a particular port of entry. Where the market area served as an entrepôt for a larger hinterland (São Paulo, Rio de Janeiro, and Recife), we arbitrarily assumed that only 50 per cent of the imported rice was consumed in that city. We thus calculate that in 1904—before

APPENDIX TABLE III.—BRAZIL, RICE IMPORTS BY PORT OF ENTRY, 1904–8*

Port	State	1904	1905	1906	1907	1908
		RICE IMPORTS (*tons*)				
Maceió	Alagoas	50.6	21.2	15.0	7.8	3.2
Manaus	Amazonas	2,098.7	2,184.5	1,946.6	2,086.0	1,714.3
Salvador	Bahia	333.6	565.2	822.8	190.7	6.6
Fortaleza (Ceará)[a]	Ceará	1,212.9	1,464.6	522.7	345.7	157.7
Vitória	Espírito Santo	6.7	12.0	24.1	70.8	35.4
São Luís de Maranhão	Maranhão	301.3	621.1	341.9	110.8	54.9
Belém	Pará	4,077.2	4,700.7	4,618.3	3,307.2	2,221.0
Cabedelo (João Pessão)[a]	Paraíba	81.5	84.0	77.2	90.8	32.3
Recife	Pernambuco	2,332.8	1,899.6	688.2	353.2	87.2
Parnaíba (Teresina)[a]	Piauí	17.3	15.0	—	13.0	—
Rio de Janeiro	Rio de Janeiro	29,059.0	31,759.4	14,451.3	1,866.5	1,821.6
Santos (São Paulo)[a]	São Paulo	18,841.7	12,251.5	13,350.8	1,547.8	107.8
Brazil		60,801.1	58,701.2	40,288.9	11,581.5	6,767.8
		POPULATION (*thousand people*)[b]				
Maceió	Alagoas	44.9	47.2	49.8	52.4	55.2
Manaus	Amazonas	67.2	68.8	70.4	66.0	66.7
Salvador	Bahia	245.2	256.2	267.7	230.6	234.4
Fortaleza (Ceará)[a]	Ceará	54.7	56.4	58.2	60.0	61.9
Vitória	Espírito Santo	14.1	14.8	15.4	16.1	16.8
São Luís de Maranhão	Maranhão	42.7	44.3	46.0	41.9	42.7
Belém	Pará	212.8	227.1	242.7	188.3	191.8
Cabedelo (João Pessão)[a]	Paraíba	35.1	36.9	38.8	37.0	38.4
Recife	Pernambuco	139.4	147.1	155.2	163.9	173.1
Parnaíba (Teresina)[a]	Piauí	46.6	46.9	47.3	49.3	49.9
Rio de Janeiro	Rio de Janeiro	774.2	796.3	817.3	833.4	860.1
Santos (São Paulo)[a]	São Paulo	268.2	275.8	283.7	328.2	343.2
Brazil		19,421.9	19,965.7	20,570.9	21,163.8	21,851.0
		PER CAPITA RICE IMPORTS (*kilo*)[c]				
Maceió	Alagoas	1.1	.4	.3	.1	.1
Manaus	Amazonas	31.2	31.7	27.6	31.6	25.7
Salvador	Bahia	1.4	2.2	3.1	.8	.03
Fortaleza (Ceará)[a]	Ceará	22.2	26.0	9.0	5.8	2.5
Vitória	Espírito Santo	.5	.8	1.6	4.4	2.1
São Luís de Maranhão	Maranhão	7.1	14.0	7.4	2.6	1.3
Belém	Pará	19.2	20.7	19.0	17.6	11.6
Cabedelo (João Pessão)[a]	Paraíba	2.3	2.3	2.0	2.5	.8
Recife	Pernambuco	16.7	12.9	4.4	2.2	.5
		(8.4)	(6.5)	(2.2)	(1.1)	(.3)
Parnaíba (Teresina)[a]	Piauí	.4	.3	—	2.6	—
Rio de Janeiro	Rio de Janeiro	37.5	39.9	17.7	2.2	2.1
		(18.8)	(19.9)	(8.8)	(1.1)	(1.1)
Santos (São Paulo)[a]	São Paulo	70.2	44.4	47.1	4.7	.3
		(35.1)	(22.2)	(23.5)	(2.4)	(.2)
Brazil		3.1	2.9	2.0	.5	.3

* Calculated from J. P. Wileman, *The Brazilian Yearbook*, Second Issue—1909 (Rio de Janeiro, 1909), pp. 44–347.

[a] Principal city if different from the named port.

[b] Estimated by an exponential trend from IBGE, *Anuário Estatístico do Brasil*, Ano V, 1939–40, pp. 1, 294–7.

[c] Figures in parentheses assume that 50 per cent of the imported rice was transshipped.

the imposition of an effective tariff barrier—the apparent per capita consumption of imported rice ranged from a high of 35.1 kilos in São Paulo (which transshipped a large quantity of imported rice to the cities of its hinterland) to less than 3 kilos a year in Maceió, Salvador, João Pessão, Teresina, and Vitória, all places where rice consumption is still small relative to the Brazilian average. In

Recife, Pernambuco, the apparent per capita consumption of imported rice in 1904 (8.4 kilos) was almost as large as the average per capita consumption recorded in 1962 by a family budget survey (5). In the middle northern states of Ceará and Maranhão per capita rice imports were relatively large (as is rice consumption today). The Amazon ports of Manaus and Belém imported very large quantities of rice per capita and although a certain share of this undoubtedly trickled out to trading posts along the river, most of it must have been consumed within those cities. Their imports did not fall after 1907 as they did elsewhere since the expanding domestic producing zones were too distant to compete with imported rice, and local production, so far as can be told, did not expand very rapidly in these early years. Expansion came several decades later.

If we assume that per capita consumption averaged about 20.0 kilos a year in 1904, then in Manaus, Belém, Fortaleza, São Luís de Maranhão, Recife, Teresina, Rio de Janeiro, and São Paulo (which consumed more than the average), imported rice accounted for 60 to 90 per cent of total rice consumption. Nationally, imported rice was much less important, providing not more and probably less than 20 per cent of the total supply. Its share of the commercially marketed supply must have been considerably greater. On the whole, however, it offered a significant opportunity for import substitution. By 1908, imported rice accounted for no more and probably less than 1.5 per cent of Brazilian consumption.