MODELING THE BRAZILIAN ECONOMY

Macroeconomics, Social Security and Consumer Demand

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Edited by
Takao Fukuchi
Marco Antônio F. H. Cavalcanti

Seki Asano
Ana Luiza N. H. Barbosa
Kaizô Iwakami Beltrão
Mirta N. S. Bugarin
Roberto Ellery Jr.
Eduardo P. S. Fiuza
Paulo Mansur Levy
Mamoru Obayashi
Noriyoshi Oguchi
Francisco E. B. de Oliveira
Suminori Tokunaga

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Brasília
SBS - Quadra 1 - Bloco J - Ed. BNDES, 10º andar - 70076-900 - Brasília - DF
Phone: 55 (61) 315-5336 - Fax: 55 (61) 315-5314
E-Mail: editbsb@ipea.gov.br

Rio de Janeiro
Av. Presidente Antônio Carlos, 51 - 14º andar - 20020-010 - Rio de Janeiro - RJ
Phone:: 55 (21) 3804-8118 - Fax: 55 (21) 2220-5533
E-Mail: editrj@ipea.gov.br

www.ipea.gov.br

EDITORS

TAKAO FUKUCHI holds a Ph.D. degree in Economics from the University of Tokyo. He is a Professor of Economics at the School of Business Administration of Asahi University. His research fields are Macroeconomics and Econometrics.

MARCO ANTÔNIO F. H. CAVALCANTI holds an M.S. degree in Economics from the London School of Economics. He is a research economist at IPEA's Directorate of Macroeconomic Studies. His research topics include macroeconometric modeling, monetary policy, and Econometrics.

NOTES ON CONTRIBUTORS

SEKI ASANO holds a Ph.D. degree in Economics from the University of Wisconsin at Madison. He is a professor of economics at Tokyo Metropolitan University. His research fields are consumer demand system, optimal taxation, and Microeconometrics.

ANA LUIZA N. H. BARBOSA holds a Master´s degree in Economics from the School of Business Administration of the Getulio Vargas Foundation in São Paulo (EAESP/FGV). She is a research economist at IPEA's Directorate of Macroeconomic Studies. Her research field is Public Finance, in particular optimal commodity taxation.

KAIZÔ IWAKAMI BELTRÃO holds a Ph.D. degree in Statistics from Princeton University. He is the superintendent of the National School of Statistical Sciences ENCE/IBGE. His research topics include Demography and social policies in general (social security, education, welfare, etc.).

MIRTA N. S. BUGARIN holds a Ph.D. degree in Economics from the University of Illinois at Urbana-Champaign. She is a professor of Economics at the University of Brasília. Her research fields are growth theory, real business cycles and Public Finance.

ROBERTO ELLERY JR. holds a doctoral degree in Economics from the University of Brasília. He is a professor of Economics at the University of Brasília. His research topics are Public Finance, growth theory, and real business cycles.

EDUARDO P. S. FIUZA holds an M.A. degree from Yale University. He is a research economist at IPEA's Directorate of Macroeconomic Studies. His current research topics are empirical Industrial Organization, regulation and contracts, and empirical analysis of consumer economics.

PAULO MANSUR LEVY holds an M.A. degree in Economics from the University of California at Berkeley. He is the Coordinator of Conjunctural Analysis at IPEA's Directorate of Macroeconomic Studies. His research fields are Macroeconomics, monetary policy, and development.

MAMORU OBAYASHI holds a Master's degree in Public Administration from the International Christian University. He is a professor of Economics at the School of Commerce of Senshu University. His research topics are macroeconometric modeling and Industrial Economics.

NORIYOSHI OGUCHI holds a Ph.D. degree in Economics from the State University of New York. He is a professor of Economics at the School of Commerce of Senshu University. His research topics are social security and economic growth.

FRANCISCO E. B. DE OLIVEIRA (deceased) held a doctoral degree in Industrial Engineering from the Federal University of Rio de Janeiro. He was the Social Security Studies Coordinator at IPEA's Directorate of Macroeconomic Studies. His research field was social security.

SUMINORI TOKUNAGA holds a doctoral degree in Regional Economics from the University of Pennsylvania. He is a Professor of Economics at the University of Tsukuba. His research topics are Econometrics and Moral-based Economics.

FOREWORD

This book is the result of a Joint Study Project undertaken by the Institute of Applied Economic Research (IPEA) and the Japan International Cooperation Agency (JICA) from April 1999 to March 2002. The purpose of the research collaboration was to strengthen IPEA's technical capability in economic policy modeling.

The macroeconomic background of the IPEA/JICA collaboration is the stabilization of the Brazilian economy achieved by the Real Plan in 1994. During the eighties and early nineties, the Brazilian economy was recurrently threatened by hyperinflation. Macroeconomic instability was amplified by the successive heterodox stabilization attempts that failed before the Real Plan. Under these circumstances, building econometric models for the Brazilian economy became a Sisyphean endeavor, as estimation and specification were impaired by wild price dynamics and frequent policy shocks. The Real Plan brought both price stabilization and endurance to the monetary and fiscal policy framework, thus reviving the possibilities of modeling the Brazilian economy.

The immediate reference of the collaboration is the institutional restructuring of IPEA in the late nineties. Starting in 1995, IPEA renewed both the computers infrastructure and the research team to which up to 1998 approximately one hundred new junior economists were added. Training of the junior team was an important part of the restructuring efforts to which the IPEA/JICA Joint Study Project provided invaluable contributions.

On several other grounds the Project was a successful teamwork. The focus on macroeconometric models, social security models and consumer expenditure systems of the Brazilian economy were of great relevance both from analytical and policy perspectives. Research tasks, schedules and outputs were well designed, thus providing a very fruitful research partnership, as well as innovative results. Last but not least, for IPEA's young research team, the project provided unique opportunities for cultural, scientific and technical exchange with Japanese economists, institutions, and society.

The macroeconometric models of the Brazilian economy presented in Part I of the book were the core of the project. Based upon the Model for Projections and Simulations of the Brazilian Economy (MOPSE-B) previously developed at IPEA, the smaller and user-friendly version and the multiplier and stochastic simulation analysis of the model were two major contributions. The quarterly and monthly models were inventive tools to analyze short run impacts of Brazilian macroeconomic policies. Parts II and III dealing with social security and consumer demand systems brought important contributions to areas which are top priority in Brazilian economic policies.

JICA deserves acknowledgements for taking the initiative and funding the Project. Special thanks are due to Prof. Takao Fukuchi, who was a remarkable Project Leader. With enviable enthusiasm and energy, he would start working right after landing in Rio, coming all the way from Tokyo. Marco Cavalcanti also deserves special thanks for assisting the project both technically and as a joint coordinator. As the alternate, Eduardo Fiuza always kept the good standard. Masahiro Yamashita, at JICA, Murilo Lobo and Marcelo Lara Resende, at IPEA, deserve our gratitude for the invaluable logistic support they provided to the project. Thanks are also extended to the staff of JICA both in Brasília and Tokyo, to Mariza Graça Lima at the Agência Brasileira de Cooperação, and to Helena Rodarte, Louis Masochini and the publishing team at IPEA. Finally, we are all grateful to Regina Pacheco for her kindness in providing the secretarial support to the project.

Eustáquio J. Reis
Director of Macroeconomic Studies
IPEA
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CONTENTS

PART I: MACROECONOMETRIC MODELING

CHAPTER 1
INTRODUCTION 03
Takao Fukuchi and Marco Antônio F. H. Cavalcanti

CHAPTER 2
A HISTORICAL OVERVIEW OF THE BRAZILIAN ECONOMY 05
Paulo Mansur Levy and Ana Luiza N. H. Barbosa

CHAPTER 3A
CHRONOLOGICAL DEVELOPMENT AND MAIN
FEATURES OF IPEA'S ANNUAL MACROECONOMETRIC MODEL 23
Marco Antônio F. H. Cavalcanti

CHAPTER 3B
A NOTE ON THE MINI-MOPSE-B 35
Mamoru Obayashi

CHAPTER 4A
CHRONOLOGICAL DEVELOPMENT AND MAIN FEATURES
OF IPEA'S QUARTERLY MACROECONOMETRIC MODEL 45
Marco Antônio F. H. Cavalcanti

CHAPTER 4B
A QUARTERLY ECONOMETRIC MODEL FOR THE BRAZILIAN ECONOMY 51
Suminori Tokunaga

CHAPTER 5
CONSTRUCTION OF A MONTHLY ECONOMETRIC MODEL 85
Takao Fukuchi

CHAPTER 6
STOCHASTIC SIMULATIONS AND MULTIPLIER ANALYSIS 133
Mamoru Obayashi

CHAPTER 7
CONCLUDING REMARKS 145
Takao Fukuchi and Marco Antônio F. H. Cavalcanti

PART II: QUANTITATIVE ANALYSIS OF SOCIAL SECURITY

CHAPTER 8
INCOME REDISTRIBUTION IN PUBLIC PENSION SYSTEMS IN BRAZIL AND JAPAN 149
Noriyoshi Oguchi, Kaizô Iwakami Beltrão and Francisco E. B. de Oliveira

CHAPTER 9
IMPLICATIONS OF THE BRAZILIAN SOCIAL SECURITY SYSTEM ON SOCIAL WELFARE 197
Roberto Ellery Jr. and Mirta N. S. Bugarin

PART III: ECONOMETRIC ANALYSIS OF CONSUMER'S EXPENDITURE SYSTEM

CHAPTER 10
AN ANALYSIS OF THE BRAZILIAN CONSUMER BEHAVIOR: A MICROECONOMETRIC STUDY
BASED ON REGIONAL PRICE INDEXES AND METROPOLITAN HOUSEHOLD EXPENDITURES 221
Seki Asano and Eduardo P. S. Fiuza

PART I
MACROECONOMETRIC MODELING

CHAPTER 1

INTRODUCTION

Takao Fukuchi
Marco Antônio F. H. Cavalcanti

1 INTRODUCTORY REMARKS

Econometric model building has two basic purposes: (a) structural analysis to describe the basic structure and functioning of the economy and (b) applied simulation studies to assess the effectiveness of instruments in achieving policy targets and/or to make conditional forecasts to evaluate the economy's future development capacity. Modeling efforts aim to achieve these objectives through the collection of data, estimation procedures and simulation studies.

The recent history of the Brazilian economy poses an interesting challenge to macroeconometric modeling. On the one hand, the continuous struggle to suppress the past trend of hyperinflation through various stabilization plans gives rise to many interesting research topics, such as: why did the Real Plan succeed in controlling inflation when previous plans could not? What were the consequences of inflation on different economic and social groups? What caused the exchange rate regime change in January 1999? What are the major pros and cons of the floating exchange rate regime for Brazil? How were fiscal and monetary instruments manipulated to counter the devaluation shock? The answers to these and many other questions could be found through insightful structural analysis and accompanying policy discussions—which would also be useful for future prediction and policy formation.

On the other hand, the policy shocks caused by the various stabilization plans translate into multiple structural breaks in the data-generating process of the economic time series, thereby providing very difficult conditions for modeling efforts.

But such difficulties should not prevent economists from searching for answers to the above questions. In particular, given the existence of multiple research topics with different relevant time spans, we could envisage a workable strategy based on models with three different frequencies:

a) an annual long-term model (1980-2000) to capture the real economy's structural features that remained constant throughout the various stabilization plans and policy regimes;

b) a quarterly medium-term model (1994-2000) to analyze the economy's basic features, particularly the effectiveness of policy instruments, after the Real Plan;

c) a monthly short-term model (1996-2000) to analyze the preconditions and actual effects of the 1999 exchange rate regime change.

Given that one of the key issues in macroeconomic analysis is the study of the government's behavior in manipulating fiscal and monetary policy instruments, we constructed two versions of each model—in the first we treated policy instruments as exogenous, whereas in the second we endogenized the government's behavior through the estimation and inclusion of policy reaction functions. Therefore, we constructed in total six model versions as follows.

Model	Number of endogenous variables	
Version	Version 1 (instruments exogenous)	Version 2 (instruments endogenous)
Annual model (1980-2000)	15	18
Quarterly model (1994.2-2000.2)	28	31
Monthly model (1996.6-2000.6)	21	25

Part I of this book is concerned with such modeling efforts. Chapters 2, 3 and 4 present the results of the annual, quarterly and monthly model respectively. Chapter 5 provides a comparative simulation analysis of the three models. Chapter 6 presents a few concluding remarks.

CHAPTER 2

A HISTORICAL OVERVIEW OF THE BRAZILIAN ECONOMY

Paulo Mansur Levy
Ana Luiza N. H. Barbosa

1 INTRODUCTION

The 1980s and early 1990s were a period of severe macroeconomic instability in Brazil. After the country's external debt crisis and the chronic and accelerating inflation with which it had to cope, growth slowed down and became volatile. Five heterodox inflation stabilization plans were implemented as an attempt to deal with these problems, but none was successful in breaking the deteriorating trend.

Part of the failure can be attributed to the lack of acknowledgement that at the roots of macroeconomic imbalances were the distortions created by a development strategy that was pursued for almost 50 years. In fact, the Second National Development Plan (II PND), implemented between 1975 and 1979, may be considered the last momentum of the import substitution strategy, which, coupled with strong government intervention, either directly through investments by state-owned companies or indirectly by channeling public savings to specific sectors of the economy, led Brazilian industrialization since World War II.

During the '90s, on the other hand, important structural reforms were gradually implemented. Trade and capital account liberalization, privatization, deregulation, and institutional developments on public finance meant a dramatic change with respect to the policy framework of the previous period, setting forth the conditions for a resumption of growth. The Real Plan, launched in 1994, was finally able to bring inflation down by combining a tight monetary policy with a gradual deindexation of the economy. In its formulation, great emphasis was given to fiscal deficit reduction and, more generally, to a changing role of the state in the economy. Fiscal policy, however, remained very loose until 1998. Given the intense capital flows to emerging economies observed in that period of high liquidity in international financial markets, stabilization was only successful by relying on a strong real appreciation of the exchange rate. Excess dependence on the exchange rate anchor, however, increased external vulnerability to international capital flows, as successive crises—like that in Mexico in 1995, Asia in the second half of 1997 and Russia in August 1998—reduced those flows to developing countries. Monetary policy was thus overburdened and the growth record for this period is also very weak.

In January 1999, the currency peg, under pressure from financial markets, was eventually abandoned in favor of a floating exchange rate regime. That move followed a sharp turnaround of the fiscal policy, announced in October 1998 and designed to produce sizable primary surpluses. Measures announced at the time included a tax hike, strict observance of renegotiation agreements of state and local governments debt, the Fiscal Responsibility Law, and a transitory social security reform. Primary surpluses were dimensioned to generate a convergent public debt to GDP trajectory. Later in that year, an inflation targeting regime was put in place by the Central Bank, so as to prevent inflation from getting out of control as result of the large exchange rate depreciation that occurred in the first few months of the new regime. Fiscal austerity, a floating exchange rate regime, and a monetary policy based on inflation targeting has since then become the cornerstones of Brazilian economic policy.

The main goal of this introductory chapter to the book is to present an overview of the Brazilian economy in the last three decades along the lines previously described. Following this introduction, the second section makes a brief review of the '70s and the crisis period of the early '80s. The third section describes the heterodox period, from 1985 to 1993, when the Brazilian economy experienced five stabilization plans without succeeding in bringing inflation to an end. The Real Plan is discussed in Section 4, while the last section discusses prospects for the Brazilian economy.

2 THE "ECONOMIC MIRACLE" OF THE '70s AND THE "HANG OVER" OF THE EARLY '80s

The beginning of the '70s is highlighted by the "Economic Miracle," with output average growth rates above 10 percent a year between 1968 and 1973 and, by future standards, a reasonable inflation stability (see Figure 1).[1] It is important to point out the very high participation and intervention of the public sector in the economy as a whole. Public investment, comprising both public administration and state-owned companies, was responsible for approximately 40 percent of total capital formation during this period.

1. The figures and the table with the main economic indicators are presented in the Appendix of this chapter.

The fast economic growth during the miracle years relied heavily on the expansion of the consumer durables sector and led to the emergence of imbalances that would foster inflation pressures and deficits on the trade balance, in spite of a rapid increase in exports. The maintenance of the expansion cycle in late 1973 would depend on a favorable external situation that was eventually reversed by the first oil shock.

Therefore, in 1974-1975 there was a deceleration in the growth trend that can be explained by a more adverse external environment, and this deceleration raised the need to promote changes in the growth model based on durable goods. Political conditions at that time prevented the required adjustment policies on aggregate demand from being implemented. Instead, the government tried to maintain economic growth and further stimulate industrialization by deepening the import substitution strategy so as to shift the growth engine towards the capital good and basic input sectors—including an ambitious program of energy substitution. Investments in these sectors were made in the context of the Second National Development Plan (II PND), launched in 1974, and involved huge transfers from the National Development Bank (BNDES) to the private sector by means of under-indexed loans and massive investments by state-owned companies.

One of the main problems in the execution of the plan was precisely its financing. Given the excess liquidity in international markets arising from the recycling of petrodollars, state-owned companies were constrained by official limits in their access to domestic credit markets, which forced them to borrow abroad. This external borrowing was crucial for financing the balance of payments imbalances over the period, but led to a rapid growth of the external debt.

2.1 The '80s Crisis: The External Adjustment Process

In the late '70s the Brazilian economy experienced high growth rates and large current account deficits, which made it vulnerable to sudden changes in external conditions. The second oil shock and the tightening of monetary policy in the United States in 1979 led to a rise in international oil prices, to the deceleration of world growth and to an increase in international interest rates. Given the rapid increase in Brazil's external debt over the previous five years, such a perverse combination of shocks had a devastating impact on the balance of payments.

The adjustment process in the early '80s initially involved an expectations-based stabilization attempt: after a 30 percent nominal devaluation of the exchange rate, the monetary and exchange rate correction paths were predetermined so as to reduce the inflationary impacts of the exchange rate correction. The result was negative real interest rates (Figure 6) and a real exchange rate appreciation, causing the economy to boom in 1980—GDP grew 9.3 percent—and to plunge into a deep recession in 1981, when GDP growth rate was -4.3 percent (Figure 2).

The balance of payment crisis became the main determinant of economic policy in the first half of the '80s. The significant loss of reserves in 1982 led to an agreement with the International Monetary Fund (IMF) and the beginning of external debt negotiations with foreign creditors. In the meantime, the private external debt was gradually transferred to the government. The need to generate huge trade balance surpluses was pursued through an aggressive exchange rate policy, additional restrictions on imports, and incentives to exports.

The 30 percent maxidevaluation of the Brazilian currency in 1983, in addition to the IMF-supported program involving a tightening of fiscal and monetary policies, led the economy to a deep recession in 1983-1984. At the same time, inflation accelerated sharply, reflecting the supply shock and the generalization and deepening of indexation schemes in the form of ever-shorter intervals for wage adjustments and monetary correction of financial assets.

A troublesome element in the adjustment program was the unsuccessful attempts to control the public deficit. Part of the difficulties came from the sheer impact of the exchange rate devaluation on the public sector external and exchange rate-linked domestic debt. But an additional source of difficulties was the accounting chaos in public finances, with five budgets in the federal government alone (Treasury, monetary, state-owned companies, indirect administration, and social security) of which only one, the Treasury's, was subject to public scrutiny through the Congress. Subsidies and other forms of tax spending ran at very high levels over this period as the existing institutional framework granted Banco do Brasil "money issuing rights" through an open account at the Central Bank (known as "*conta movimento*").

In such an environment of vulnerability to supply shocks, in which external and fiscal imbalances had their effects amplified by widespread indexation, stabilization turned out to be elusive and the result was an acceleration of inflation and a squeeze of real wages.

3 THE "HETERODOX" PERIOD

The period from 1981 to 1992 was characterized by macroeconomic instability and low growth. Over this time span, *per capita* income declined at an average of 1.4 percent a year and the persistently high inflation was the most distinctive feature of the Brazilian economy. Several elements can explain the persistence of inflation. One traditional element links inflation to the government's need of inflation tax to finance its budget deficits. A second element, also of fiscal nature, makes accelerating inflation a means of reducing the real value of public spending, which is set in nominal terms at the beginning of each time period. That obviously reflects the political resistance to nominal spending cuts and the already mentioned state of confusion of spending budgets. Finally, persistence also reflected the presence of widespread indexation, both formal and informal, which made inflation reduction extremely costly but which also allowed society to live with very high inflation for close to 20 years. In the early '80s the inflation rate rose to above 200 percent a year, reaching 1,700 percent a year in 1989 and over 80 percent *on a monthly basis* in March 1990 (see Figure 4 and table).

Inflation presented a strong component of inertia. This meant that relative prices could only change through the acceleration of the inflation rate, and, due to widespread indexation, transitory shocks would set new floors for future inflation. A passive monetary policy would ratify these new inflationary levels due to the existence of highly liquid, daily indexed public bonds, which functioned as quasi-money. Paradoxically, the existence of this "indexed" money in the form of extremely liquid public bonds would also prevent, or delay, the flight from the domestic currency observed in other high inflation or hyperinflation episodes elsewhere.

The widespread indexation prevented the reduction of inflation through monetary policy alone, so some form of income policy had to be introduced in order to break up inertia. This perception formed the basis of a series of heterodox stabilization programs undertaken between 1986 and 1991. Although specific mechanisms could change, they usually included price, wage, exchange rate, and public tariff freezes, as well as rules to adjust wages, financial liabilities, and other contracts (like rents, for instance) to a low inflation environment, either by converting them to a new currency through past averages or by using *tablitas* (discount factors) in the case of forward looking prices and contracts.

Five economic stabilization programs attempted to end inflation: the Cruzado Plan (1986), the Bresser Plan (1987), the Summer Plan (1989), the First Collor Plan (1990), and the Second Collor Plan (1991). However, none of these plans reached deeply enough into the underlying causes of inflation and all of them ended in failure.

The Cruzado Plan was the first of this series of heterodox attempts to try to reduce inflation. Being the first plan, it was able to gather the strongest support. It also came closest to succeeding in maintaining inflation low. After its introduction, the economy boomed (due to loose monetary and fiscal policies), while inflation was kept low by strict price controls. Shortages and black markets were common at that time.

Even though adjustment policies in the first half of the decade (especially the exchange rate devaluation and subsequent maintenance of its real value through a crawling peg) had led to significant trade surpluses, a large external debt remained a serious constraint upon economic policy. As the normalization of international capital markets, after the debt crisis, proceeded very slowly, new loans to indebted countries could only be obtained in the context of costly negotiations with creditor banks and within a framework of IMF-sponsored adjustment programs. The adoption of exchange rate freezes during heterodox stabilization attempts eventually contributed to the increase in current account deficits and, combined with overheated domestic demand, led to a payments suspension on the external debt in 1987.

Thus, maintaining a fixed exchange rate during a booming demand and during adverse conditions in the international financial markets, and not taking into account public deficit issues (according to a widely held view of the problem at that time "deficits were the consequence, not the cause of inflation"), were the main obstacles to keeping inflation low.

The other economic plans that followed the Cruzado—Bresser Plan (June 1987) and Summer Plan (March 1989)—resorted to the same basic set of tools to curb inflation (price freezes *cum* contracts adjustments) but with ever-shorter success and much sharper inflationary rebounds. Although inflation was not conquered, a growing concern regarding the public deficit and other features of the Brazilian economy developed over the second half of the '80s.

4 THE BRAZILIAN ECONOMY IN THE '90s

The Brazilian economy in the '90s experienced a series of fundamental changes that brought about new perspectives in the macroeconomic environment. The end of hyperinflation, trade and capital account liberalization, resumption in foreign direct investment, extensive privatization, financial sector strengthening and fiscal austerity at all government levels were important steps that contributed to this economic outlook.

The most remarkable fact of the decade was the success of the Real Plan, first announced in December 1993 and implemented in 1994. This stabilization program was responsible for an almost instantaneous reduction of inflation (see Figure 4). Before this success, however, two additional stabilization programs were implemented in the early '90s with important impacts on aggregate output and on future developments concerning fiscal and public debt. We address them in the following section.

4.1 Stabilization *cum* Liberalization: The Collor Plans

In the beginning of 1990 Brazil was on the verge of hyperinflation. President Collor inaugurated his term on March 15, 1990 with an ambitious stabilization program (the First Collor Plan). The program tried to avoid the pitfalls of previous stabilization attempts and was centered on a freeze not of prices and wages, but of liquid assets, including current and savings accounts, quotas on open market funds, time deposits and other financial assets. The idea was to eliminate the "monetary overhang"—including a very liquid public debt, as discussed above—and to force a disinflationary process by squeezing liquidity.

Simultaneously, Collor proposed a quick reduction of tariff and nontariff trade barriers in order to increase competition in the domestic market, and an aggressive privatization program to support public debt retirement. In order to be successful, however, the program also needed to deal with the "flow" variables. And that was precisely where it failed. Political and administrative difficulties eventually deviated the Plan from its original track, causing it to derail. Strong pressures to relax the asset freeze eventually led to a disorganized process of liquidity expansion, causing prices to gradually resume their upward trend. The impact of the asset freeze on economic activity, however, was very intense, causing industrial output and GDP to plummet abruptly. GDP fell 8 percent in the second quarter on seasonally adjusted basis, and these effects lasted for almost a year before output recovered its previous level.

In the beginning of 1991, a second attempt at stabilizing inflation (Second Collor Plan) was made. This time more weight was placed on the traditional price and wage freeze. As usual, inflation accelerated quickly, but it was restrained later in the year by an extremely tight monetary policy. It should be noted that by force of the assets freeze of the First Collor Plan, the pressures on public debt were much milder at that time, for interest rates on the frozen assets were predetermined and their release after 18 months of forced permanence at the Central Bank—which began in September of 1991—took place only gradually.

In 1992, the liberalization of the capital account (the so-called Annex IV of the Central Bank) combined with record low interest rates in the United States and very high domestic interest rates gave rise to a gradual process of foreign reserves accumulation (see Figures 6 and 10). Along with the reduction of public debt and tighter controls over public spending, which reduced the public deficit, this recovery of reserve levels would be crucial in creating the conditions for yet another inflation stabilization program. In the new framework of structural reforms, all these factors combined to create a favorable set of conditions for the new program to be successful.

This improved macroeconomic outlook could already be felt in the beginning of 1993. A nondisruptive solution to the political crisis that led to the impeachment of President Collor contributed to the perception—especially amongst foreign investors—that the country was becoming stronger and therefore more reliable in institutional terms. A quick recovery started in the first quarter of 1993, in spite of the still high levels of inflation. In general terms, the macroeconomic instability characterized by high inflation, and the crisis in the public sector's finances, inevitably resulted in an environment that was extremely hostile to investment and growth between 1981 and 1992 (see Figures 2, 3, 4 and 5). Therefore, the sustainability of that growth revival depended on the success of a new stabilization program.

4.2 The Real Plan—Phase I

The Real Plan began to be implemented in the second half of 1993. It evolved gradually, with preannounced steps in an attempt to avoid the surprises that were so common in previous stabilization plans and which had contributed to the erosion of public support for those programs. It started with the definition of an emergency set of fiscal measures to reduce the potential growth of public deficit in an environment of price stability. The main goal of this package was to liberate some of the previously earmarked revenues that prevented gains in government revenues from reducing the fiscal deficit. The released funds would form the so-called Emergency Social Fund to finance expenditures without specified revenue sources. As discussed later on, this measure alone was not enough to prevent fiscal policy from remaining strongly expansionary after stabilization. The rest of the program was conditioned on the approval of this Emergency Social Fund by the Congress.

Since that was finally achieved, the second phase of the program began in February 1994, with the introduction of a superindex in March 1994, the "Unidade Real de Valor" (URV), into which all prices and contracts would be converted on a voluntary basis, except for wages, whose conversion was to take place immediately on the basis of the average values of the four previous months. The URV would be corrected daily on the basis of the exchange rate, whose path, in turn, would follow a rule that took into account past and future expected inflation. At the end of four months of progressive indexation of prices and contracts into the URV (period that may be characterized as an induced dollarization) a monetary reform was finally launched. On July 1, a new currency (the Real) was introduced, and its exchange rate against the US dollar was allowed to float.

The superindexation of prices, wages, and contracts, before the monetary reform, was crucial in order to allow for a synchronization of relative prices, thus reducing the pressure for the required corrections to take place under the new currency. The index, called URV, was adjusted daily for changes in the exchange rate, and prices were free to be changed in terms of the index. One of the virtues of this mechanism is that it contributed to an increased visibility of relative prices, as this perception tends to get blurred under very high inflation with prices changing very frequently.

Previous experience, especially in the Cruzado Plan, had showed the importance of steering monetary policy, in the first months of the plan, toward curbing the excess demand through high real interest rates. Given these high interest rates, and in the face of the confidence inspired by the reforms included in the program as well as by the recent conclusion of the external debt renegotiation, capital inflows intensified and the new currency showed a tendency to appreciate not only in real terms, as it is usual in exchange rate-based stabilizations, but also nominally. The real appreciation of the exchange rate led to a quick reversal of the trade surpluses, mainly as result of a sharp acceleration of imports, which also reflected an overheated domestic demand (see Figure 7 and table). The level of international reserves, crucial for ensuring the stability of the exchange rate, began to depend on the generation of capital account surpluses. Nevertheless, due to deregulation of key sectors (mining, oil and telecommunications among others), and privatization of state-owned companies, it was possible to count on large capital inflows, specifically on foreign direct investment.

This scenario started to change in the first quarter of 1995. In response to the Mexican currency crisis at the end of 1994, which produced the so-called "Tequila Effect," foreign capital inflows to the Brazilian economy slowed down. In order to offset the change in external environment, some restrictions were raised on imports competing with domestic production. More importantly, the risk of an exchange rate crisis, at a moment when price stability was still far from consolidated, led the government to introduce a new exchange rate regime to substitute the floating exchange rate that had been in place since the beginning of the Real. A mechanism of narrow sliding bands was introduced to promote a gradual correction of the appreciation of the previous period without threatening the gains already achieved on the inflation front.

Along with the change in the exchange rate regime, monetary policy also shifted to an even tighter stance. In order to reduce external vulnerability, interest rates were raised in real terms so as to control unsustainable high demand and to attract foreign capital—mostly of a short-term nature—and accumulate reserves. Output fell during the following two quarters and in the next couple of years (1996-1997) growth recovery followed an unstable path determined, to a large extent, by the environment abroad.

International crises of great proportions highlighted some fragile foundations of the Brazilian stabilization program, both in terms of fiscal equilibrium and the balance of payments. The currency crises of Southeast Asian countries, in 1997, and the Russian crisis in August 1998, changed the existing favorable conditions in international financial markets, putting the Real under strong pressure and making it increasingly harder to sustain large current account deficits (see Figure 8). Even though the exchange rate policy had been made more flexible after the Mexican crisis, an overvalued exchange rate required dramatic increases in interest rates, and that had undesirable side effects on the output growth, employment, and public sector accounts. Deregulation and extensive privatization continued to ensure positive foreign direct investment inflows (see Figure 9), but even that seemed to face a limit in the medium term, thus indicating that adjustments were needed.

After the Russian crisis, and with a substantial increase in risk aversion in international financial markets, Brazil reached out for support from the IMF and from other international financial institutions and industrialized countries. Multilateral financing came in the form of a US$ 41.5 billion loan, including an upfront disbursement of about US$ 20 billion aiming at halting the loss of reserves and the spreading of the contagion to other countries. On the policy front, an ambitious fiscal adjustment program was designed in order to reduce the public deficit. Tough measures on deficit reduction were agreed upon and included compliance with targets in terms of the primary deficit, which should move from balance to a 3.2 percent of GDP surplus. Based on the hypothesis of relevant variables, this should lead to a declining trend for the debt/GDP ratio. Although the financial support and agreement with the IMF provided temporary relief, the loss of reserves continued, eventually leading to the change in the exchange rate regime in the beginning of January 1999.

4.3 The Real Plan—Phase II

Before the international crises of 1997 and 1998, the positive inflows of foreign capital, the prospect of a sustained resumption of economic growth, and the advances in the privatization program had guaranteed the funding of balance of payments deficits.

The fiscal deficit, however, remained the weakest element of the Real Plan. Due to lack of coordination and institutional means to enforce austerity at sub-national levels, the public deficit increased sharply in the first years of the stabilization program. That, combined with the need to pursue a tight monetary policy, which resulted in very high real interest rates, produced a growing path for the public debt from 1994 onward. This rapid growth in the public sector debt played an important role in exacerbating the domestic impact of the financial crises of 1997 and 1998.

After the crisis in Russia, with important impacts on international capital markets, including the failure of a large hedge fund in the US, market confidence suffered continuous erosion. Capital flight produced a rapid reduction in reserves and, after a brief attempt at controlling devaluation while keeping the exchange rate peg, the government switched the exchange rate regime to one that was free-floating. There was an initial overshooting of the exchange rate, with a depreciation of 80 percent in the first two months after the floating. Gradually, however, the exchange rate returned to a level closer to what was thought to be consistent with equilibrium in the balance of payments. By the end of that year the accumulated depreciation had been reduced to 50 percent.

Several factors help to explain that behavior of the exchange rate. A firm response from the Central Bank raising interest rates, along with a reduction of the reserves' floor established in the agreement with the IMF, which increased the scope for Central Bank interventions in the foreign exchange market, had an important impact in the first moment. Significant primary surpluses in the fiscal front ensured that the debt/GDP did not enter an explosive path. Due to the presence of a large external and internal debt indexed to the exchange rate, however, that ratio increased from 42 percent to 52 percent of GDP in the first months of the new exchange rate regime. Finally, a large output gap reduced the impact of the depreciation on inflation rates, which came out much below expectations.

At the end of the second quarter of 1999, the new exchange rate regime was consolidated and the Central Bank announced a new monetary policy regime based on inflation targeting with the intention to coordinate inflation expectations and to provide a monetary anchor to the system.

In order to stabilize the net public sector debt as a percentage of GDP (at around 50 percent of GDP at the end of 1999) the government committed to primary fiscal surplus targets of 3.1 percent of GDP in 1999, 3.25 percent in 2000 and 3.35 percent in 2001. In addition to the short term targets of the government's primary surplus, the long-term fiscal and structural adjustment measures, including a first step toward changing the rules that allowed for early retirement in the social security system, also contributed to the perception that reverting the path of debt/GDP ratio was not an impossible task. The effect of fiscal adjustment at local and state government levels resulting from the debt renegotiation agreements carried out in the two previous years should also be stressed.

The trade balance started to recover in the second half of 1999, and the trade deficit fell from US$ 6.6 billion to US$ 1.3 billion (see Figure 7). Most of the gains resulted from a reduction in imports. And, as the economy started to recover, the trade position deteriorated somewhat. The usual lags, coupled with a reduction in the dollar price of exports, explain the weak performance of exports, whose growth would actually start only in the following year. In the current account, the deficit fell from US$ 33.5 billion to US$ 25 billion, also helped by a decline of some US$ 3 billion on the nonfactor services deficit (see table).

With interest rates beginning to drop (from 45 percent a year in March to 19.5 percent a year in July), growth finally resumed by the end of 1999. So that in 2000, the GDP grew 4.5 percent, mainly driven by consumption (especially of consumer durables) but with a nonnegligible contribution of exports.

In 2001, the economy faced once again an adverse environment abroad stemming from a cyclical reversal of the world economy, especially in the US, and by the intensification of the crisis in neighboring Argentina. An energy crisis, reflecting a deficient regulatory framework which failed to produce the incentives for the required investments in electricity generation, and a long and severe drought period that led to an energy rationing of as much as 20 percent of the amount consumed in the previous year, contributed to the bleak output performance, as growth slowed down to 1.5 percent in that year. New market-led adjustments in the real exchange rate forced the Central Bank to raise interest rates as a means of keeping inflation from extrapolating the limits set in the targeting regime, whereas the fiscal policy was further tightened to offset the negative impacts of the exchange rate depreciation on the public debt. On the other hand, the trade balance reacted swiftly, and a new reduction on the current account deficit took place.

Developments in 2001 showed that the new policy framework, in place since 1999, is capable of dampening the negative effects of external instability upon the economy. The basis for such a framework is fiscal austerity, now helped by the Fiscal Responsibility Law, which establishes hard budget constraints at all government levels. It also includes a Central Bank enjoying a considerable degree of operational independence to pursue inflation targets set by the Executive branch and a floating exchange rate regime.

5 PROSPECTS

The Brazilian economy is currently in much better condition to begin a new sustained growth cycle than it was a decade ago. Various constraints on growth have been removed, inflation was stabilized, and institutional reforms changed the role of the state in the economy and reduced excessive regulation that prevented foreign investment from performing a more decisive role in the growth process. Even though the growth record in the past eight years is far from brilliant, all these changes were achieved without the economy sliding into a recession.

Nevertheless, several challenges still lie ahead if economic stability is to be joined by sustained growth, especially as a significant reduction in poverty levels assumes an emergency character. Therefore, as the inflation problem is gradually overcome, the agenda for the years ahead will be ruled by economic growth and equity issues. Other high priorities in the agenda are to raise domestic savings, improve quality in and access to public education, and to spur technological progress.

The public sector still has an important role as a growth promoter, one that goes beyond simply maintaining stability. In particular, in spite of the recent evolution of the exchange rate, raising the competitiveness of domestic production remains a key issue. A tax reform should be included in the list of policies to reach that goal, as such reform is needed to reduce the distortions of the current structure, which depends excessively on cumulative taxes and penalizes production over consumption. Over the longer term, expanding the social security reform is necessary both to create new savings instruments and to avoid potential disequilibria that usually arise from interferences in investment decisions. In the same vein, a reform of domestic capital markets is also essential to increase the supply of long term financing and make it available to small and medium size firms.

Each one of these reforms can be seen as a component of an ongoing process of economic structural adjustment. These changes are fundamental for a solid macroeconomic stability and the challenge to achieve long-term economic growth.

APPENDIX

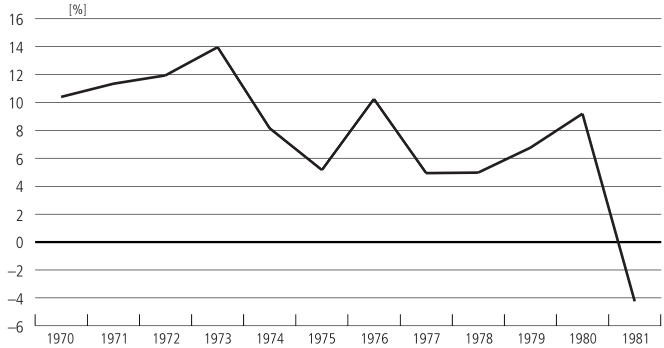
MAIN ECONOMIC INDICATORS—1981-2000

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
GDP										
Real GDP Growth (%)	–4.3	0.8	–3.0	5.4	7.9	7.5	3.5	–0.06	3.2	–4.2
Investment (% of GDP, 1980 Prices)	21.6	20.0	17.2	16.3	16.4	18.8	17.8	17.0	16.7	15.5
Prices										
IGP-DI (%)	95.2	99.7	211.0	223.8	235.1	65.0	415.8	1,037.6	1,782.9	1,476.7
Public Sector										
Primary Deficit (% of GDP)	N.A.	N.A.	N.A.	N.A.	–2.6	–1.6	1.0	–0.9	1.0	–4.7
Operational Deficit (% of GDP)	6.3	6.9	3.2	2.9	4.4	3.6	5.6	4.9	7.1	–1.3
Real Interest Rate (%)*	–2.9	8.4	–4.0	8.3	9.7	3.6	–15.0	–5.7	15.9	–1.7
Foreign Sector										
Trade Balance (US$ Billion)	1.2	0.8	6.5	13.1	12.5	8.3	11.2	19.2	16.1	10.8
Export (US$ Billion)	23.3	20.2	21.9	27.0	25.6	22.3	26.2	33.8	34.4	31.4
Export (% of GDP)	9.0	7.4	11.6	14.2	12.1	8.7	9.3	11.1	8.3	6.7
Import (US$ Billion)	22.1	19.4	15.4	13.9	13.2	14.0	15.1	14.6	18.3	20.7
Import (% of GDP)	8.5	7.2	8.1	7.3	6.2	5.4	5.3	4.8	4.4	4.4
Current Account (US$ Billion)	–11.7	–16.3	–6.8	0.1	–0.2	–5.3	–1.4	4.2	1.0	–3.8
Foreign Direct Investment (US$ Billion)	2.3	2.7	1.1	1.5	1.3	0.2	1.0	2.6	0.6	0.4
Foreign Reserves (US$ Billion) **	7.5	4.0	4.6	12.0	11.6	6.8	7.5	9.1	9.7	10.0

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
GDP										
Real GDP Growth (%)	1.03	–0.5	4.9	5.6	4.2	2.7	3.3	0.2	0.8	4.5
Investment (% of GDP, 1980 Prices)	15.2	14.0	14.4	15.2	16.7	16.5	18.0	17.7	16.3	15.8
Prices										
IGP-DI (%)	480.2	1,157.8	2,708.2	1,093.9	14.8	9.3	7.5	1.7	20.0	9.8
Public Sector										
Primary Deficit (% of GDP)	–2.7	–1.6	–2.2	–5.2	-0.3	0.1	0.9	0.0	–3.2	–3.5
Operational Deficit (% of GDP)	0.2	1.7	0.8	–1.1	5.0	3.4	4.3	7.4	3.4	1.2
Real Interest Rate (%)*	6.4	30.0	6.3	26.3	33.1	16.7	16.5	26.5	4.7	7.2
Foreign Sector										
Trade Balance (US$ Billion)	10.6	15.2	13.3	10.5	–3.5	–5.6	–6.7	–6.6	–1.3	–0.7
Export (US$ Billion)	31.6	35.8	38.6	43.5	46.5	47.7	53.0	51.1	48.0	55.1
Export (% of GDP)	7.8	9.2	9.0	8.0	6.6	6.2	6.6	6.5	9.1	9.4
Import (US$ Billion)	21.0	20.6	25.3	33.1	50.0	53.3	59.7	57.7	49.3	55.8
Import (% of GDP)	5.2	5.3	5.9	6.1	7.1	6.9	7.4	7.3	9.3	9.5
Current Account (US$ Billion)	–1.4	6.1	–0.7	–1.8	–18.4	–23.5	–30.4	–33.5	–25.4	–24.7
Foreign Direct Investment (US$ Billion)	0.1	1.9	0.8	1.5	3.3	11.3	17.9	26.0	26.9	30.5
Foreign Reserves (US$ Billion) **	9.4	23.8	32.2	38.8	51.8	60.1	52.2	44.6	36.3	33.0

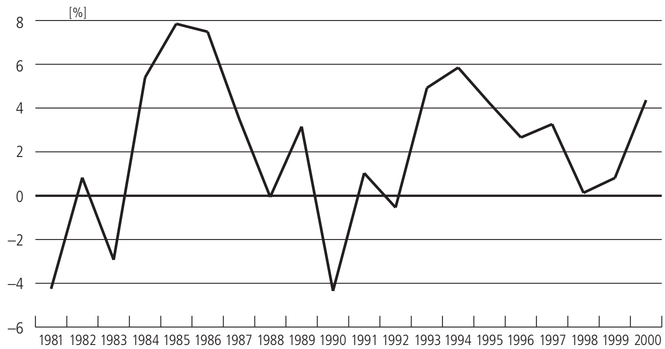
Sources: BACEN, IBGE, FGV and IPEA.
* SELIC interest rate deflated by the IGP-DI.
** Stocks in December.
N.A.= not available.

FIGURE 1
REAL GDP GROWTH—1970-1980



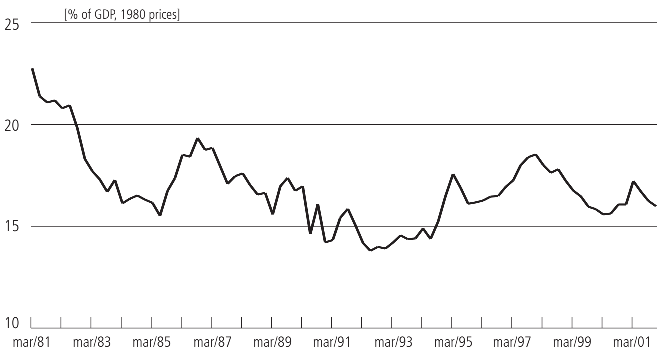
Source: Brazilian Institute of Geography and Statistics (IBGE).

FIGURE 2
REAL GDP GROWTH—1981-2000



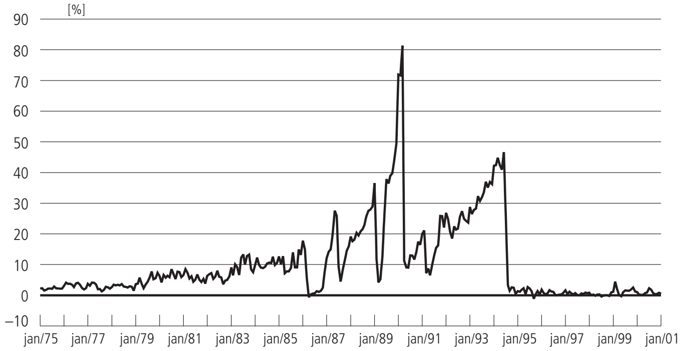
Source: Brazilian Institute of Geography and Statistics (IBGE).

FIGURE 3
INVESTMENT QUARTERLY



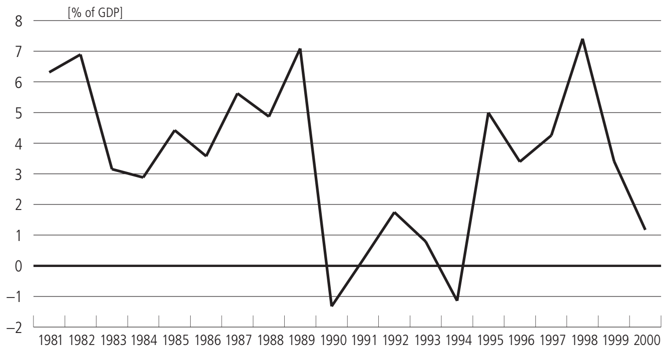
Source: Institute for Applied Economic Research (IPEA).

FIGURE 4
INFLATION (IGP-DI)—MONTHLY CHANGE



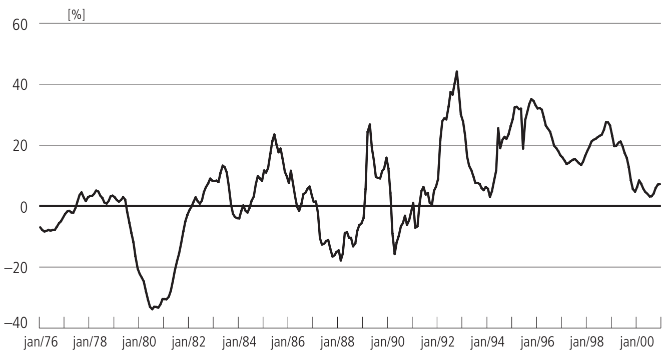
Source: Getulio Vargas Foundation (FGV)–*Conjuntura Econômica*.

FIGURE 5
OPERATIONAL DEFICIT



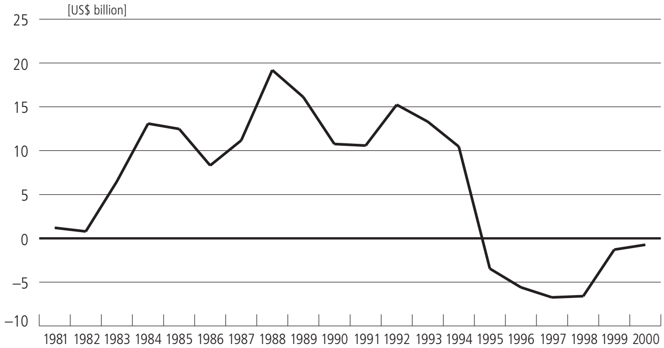
Source: Central Bank of Brazil (BACEN).

FIGURE 6
REAL INTEREST RATE—DEFLATED BY CENTERED IGP-DI



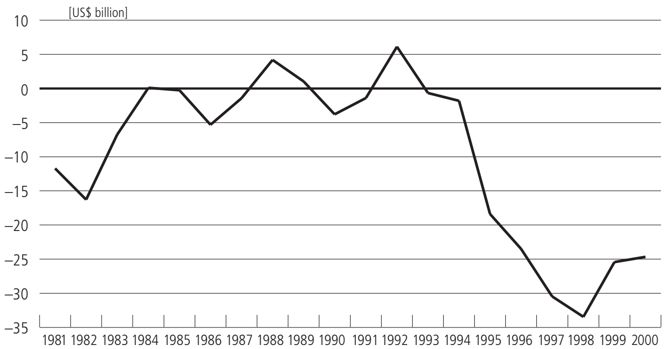
Source: Central Bank of Brazil (BACEN).

FIGURE 7
TRADE BALANCE



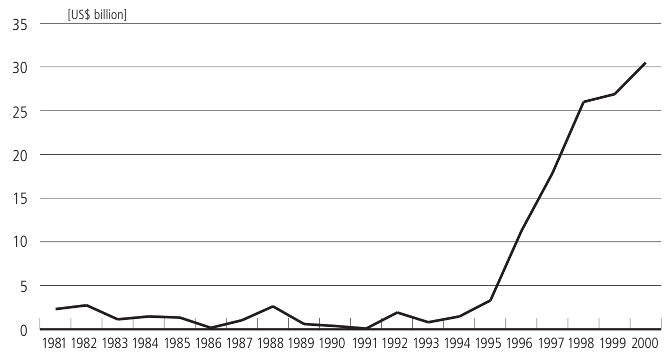
Source: Central Bank of Brazil (BACEN).

FIGURE 8
CURRENT ACCOUNT



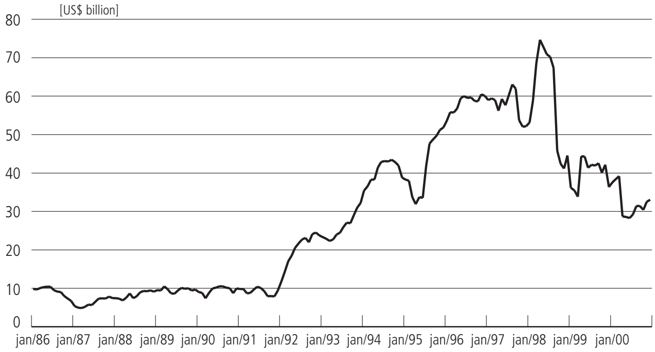
Source: Central Bank of Brazil (BACEN).

FIGURE 9
FOREIGN DIRECT INVESTMENT



Source: Central Bank of Brazil (BACEN).

FIGURE 10
FOREIGN RESERVES—MONTHLY



Source: Central Bank of Brazil (BACEN).

CHAPTER 3A

CHRONOLOGICAL DEVELOPMENT AND MAIN FEATURES OF IPEA'S ANNUAL MACROECONOMETRIC MODEL

Marco Antônio F. H. Cavalcanti

1 INTRODUCTION

During the late 1980s and early 1990s, as the Brazilian economy was completely dominated by hyperinflation, the focus of both academic and policy-oriented discussions concentrated mainly on stabilization issues and on the short run phenomena associated with inflation. Building and using structural macroeconometric models was considered not only an extremely difficult task, but also one of limited use, due to the uncertain and constantly changing economic environment.

Following the stabilization plan of 1994, Brazil witnessed the resurgence of interest in analytic tools for forecasting and simulating the evolution of macroeconomic variables and policies. At IPEA, this led to renewed efforts in the construction of large-scale macroeconometric models, and, therefore, to the resumption of an activity in which the Institute had produced important contributions in the past, as exemplified by Reis et al. (1988) and Moreira (1991).

One of the main outputs of such efforts was the Model for Projections and Simulations of the Brazilian Economy (MOPSE-B), an annual model designed to make medium run projections and policy simulations. The following sections provide an overview of the model's chronological development and main features.

2 HISTORICAL BACKGROUND

MOPSE-B took its acronym and inspiration from the Model for Projections of the Foreign Sector (MOPSE), a macroeconomic model developed at IPEA in the mid-1980s and described in detail in two publications—IPEA/INPES (1985) and Reis et al. (1988). The original MOPSE was basically concerned with projections for the balance of payments and, therefore, paid attention to other aspects of the economy only insomuch as they were important for the task at hand. As a consequence, the model presented relatively little simultaneity and treated some important macroeconomic variables as exogenous (e.g., inflation and wages) or as residuals (e.g., consumption).

From the outset, MOPSE-B was a more ambitious project, as it aimed to explain a wider range of variables than did its predecessor. Nonetheless, the model's first version—presented at the Project Link World Conference held in New York in March 1998—also put great emphasis on the foreign sector equations and lacked many important features in a macroeconomic model, particularly with regard to supply side, monetary and labor market considerations [see Castro and Cavalcanti (1998)]. That version built upon earlier work on trade equations by Castro and Cavalcanti (1997) and on public sector revenues and expenditures equations by Hernandez (1998).

The model's second version improved upon the earlier one by including aggregate supply and labor market blocks. These blocks were partially based on work by other researchers at IPEA: the methodology for the calculation of the domestic capital stock was taken from Morandi (1998), whereas the labor market equations followed Barros and Mendonça (1997). A full description of that version of the model may be found in Reis et al. (1999).

As the Brazilian exchange rate regime switched to a floating system in 1999, it was necessary to adapt MOPSE-B to the new economic environment. The main modification was the adoption of a new model closure, in which the real exchange rate was determined by the equalization of supply and demand of foreign reserves. This was a significant change in the functioning of the model, as it imparted new feedback effects among key macroeconomic variables and resulted in a truly complex simultaneous equations system.

Subsequently, the labor market model in Barros, Fogel and Mendonça (1997) was adapted and included in the model and other less significant changes were made to some equations. The model is currently under revision in order to be fully compatible with the new National Accounts methodology and to include a more detailed public sector block based on Carvalho (2001).

3 CURRENT MODEL STRUCTURE

The model is a large-scale annual model built upon the main identities of the Brazilian National Accounts and Balance of Payments. Estimation features include the use of single-equation and Full Information Maximum Likelihood (FIML) cointegration analysis, besides OLS and instrumental variables estimation. The use of systems methods is usually not possible due to the lack of sufficiently long data for many variables. In general, the development of the model's equations has explicitly tried to ensure desirable long-run properties as well as reasonable short-run dynamics.

The specification of the model is basically Keynesian. Aggregate demand is given by individually estimated equations for aggregate consumption, aggregate investment, and net exports of goods and services, while aggregate supply is determined by a Cobb-Douglas constant return production function. The equalization of aggregate demand and supply will determine real output, capacity utilization, employment and prices, and will typically correspond to an equilibrium with under employment.

The model contains 171 equations out of which 20 are stochastic and 41 are identities that define nominal variables and GDP proportions. Equations can be grouped in five major blocks: Aggregate Demand (equations 1 to 16), Aggregate Supply (17 to 24), Price Determination (equations 25 to 29), Monetary Sector (30 to 42), Public Sector Accounts (equations 43 to 49), Balance of Payments Accounts (equations 50 to 94) and the Labor Market (95 to 130).

The Aggregate Demand block defines and specifies the determinants of aggregate consumption and major categories of fixed investment (construction and equipment).

The Aggregate Supply block specifies the economy's production function and the determination of the domestic capital stock, disaggregated into construction and machinery and equipment components.

The Price Determination block consists of a Phillips Curve-type equation for wholesale prices and a set of equations relating the evolution of other price indexes to this "key" price. As a first approximation, all prices are supposed to grow at the same rate, so that the model behaves as if there were just one domestic price.

The Monetary Sector block also consists of a small set of equations that determine the real money stock, the amount of credit to the private sector, the nominal and real interest rate.

The Public Sector block specifies the evolution of the public debt and nominal deficit as a function of GDP growth and primary deficit.

The Balance of Payments block defines and specifies the determinants of the main categories of exports (manufactured, semimanufactured, and primary products) and imports (consumer, intermediate, and capital goods), as well as other items of the current accounts, and the external debt dynamics. Foreign investments (both equity and portfolio) and changes in reserves are exogenously specified. With a floating exchange rate, the real exchange rate is determined in this block in order to equalize supply and demand of foreign reserves.

The Labor Market includes two main sets of equations that determine labor supply and demand respectively. Adjustments in the labor market are accomplished either by changes in unemployment or in real wages.

The main policy variables in the model are:

- Nominal interest rate.
- Public sector investment.
- Tax rates.
- Import tariff rates.
- Export subsidy rates.

Other important exogenous variables are:

- Net foreign investment (direct and portfolio).
- International reserves.
- Imports of fuels and lubricants.
- United States' wholesale price index.
- Libor rate.
- World imports.

We typically simulate the model under exogenously given trajectories for these variables. It should be noted, however, that some of the policy variables may be considered partially endogenous, as most General Government expenditures and revenues depend on current GDP growth and inflation, while the nominal interest rate may be endogenized, depending on the particular model closure adopted, e.g., some form of interest rate parity, real interest rate rule, inflation targeting rule etc. On the other hand, the nominal exchange rate may be exogenized if we wish to simulate a fixed exchange rate regime.

3.1 Aggregate Demand

3.1.1 Private Consumption

Real private consumption expenditure is specified as a function of real disposable income, real interest rates, and total real credit granted to the private sector. The equation is estimated in first differences plus an error correction mechanism, which incorporates the existence of a 1:1 long-run relationship between consumption and income—thus ensuring that these two variables cannot drift permanently away from each other. The equation is estimated by instrumental variables in order to account for the endogeneity of both disposable income and credit, thus providing consistent coefficient estimates.

This is one of the most important equations of the model, as the dynamics of real demand will depend to a large extent on the value of the Keynesian multiplier. The estimated coefficient on disposable income is approximately 0.4, which implies a reasonably low short-run multiplier and therefore prevents the model from becoming too unstable.

It should be noted that the effect of interest rate movements on both consumption and investment (as we shall see below) is relatively weak, so that the effect of credit on private consumption is perhaps the main channel through which monetary policy may affect aggregate demand.

3.1.2 Private Investment

Real private investment is disaggregated into two main components: construction and equipment fixed investment.

The demand for investment in construction is a function of GDP, the real interest rate and inflation acceleration. The equation is specified as an error correction model, in which the cointegrating vector includes a 1:1 relationship between investment and GDP. It is interesting to note that GDP does not enter the equation unlagged, so that its only effect on construction investment operates through the error correction term. This also means that the equation can be consistently estimated by OLS.

Total demand for machinery and equipment is equal to the sum of capital goods imports and spending on domestic machinery. Capital goods imports are determined within the foreign sector block. Investment in domestic machinery depends on the real interest rate and on the rate of capacity utilization. It is worth noting that investment in domestic machinery displays a pattern of slow adjustment to exogenous shocks, as no exogenous variable enters the equation contemporaneously. Once again, the absence of unlagged GDP implies that the equation may be consistently estimated by OLS.

3.2 Aggregate Supply

Aggregate supply is given by a constant returns to scale Cobb-Douglas-type production function whereby domestic capital stock, multiplied by the capacity utilization rate, is combined with employed labor to produce output. Employed labor is proxied by active urban population multiplied by the complement of the unemployment rate. The equation is specified in terms of growth rates and estimated by OLS. Due to the lack of unemployment data before 1980, the sample period is very short, which may cause estimation biases. Estimation results, however, are quite reasonable: capital and labor account for roughly 70 percent and 30 percent of output growth, respectively. Although very high compared with international standards, this seems to be consistent with the observed pattern of income distribution. The main problem seems to lie in the negative sign of the estimated constant term, which implies negative productivity growth. This may reflect the stagnation of the Brazilian economy during the estimation period or other estimations problems. For simulation purposes, it is necessary to arbitrarily assume some other value for the constant term (interpreted as an exogenously given rate of growth of total factor productivity) while ignoring the econometric problems associated with such approach.

The domestic capital stock is calculated according to a perpetual inventory method, where the durability of net capital stock in residential construction, nonresidential construction, and machinery and equipment is assumed to be 50, 40 and 20 years, respectively.[1]

The capacity utilization rate will vary in order to equalize aggregate supply and demand.

3.3 Price Determination

Domestic prices are determined by a Phillips Curve-type equation, where current inflation depends on past inflation, on variation in foreign prices multiplied by the exchange rate and on capacity utilization. All parameters are calibrated, subject to the restriction that the coefficients on past inflation and foreign prices (in domestic currency) sum to one. The *ad hoc* specification of the price equation derives from the technical difficulties in the estimation of price behavior in an annual model for an economy that has experienced hyperinflation in recent history.

As a first approximation, all prices are supposed to grow at the same rate.

3.4 Monetary Sector

The evolution of M1 is indirectly given by the variation in the velocity of money, which is a function of the nominal interest rate. This equation was estimated by OLS.

1. This methodology follows Morandi (1998).

M0 is assumed to be a constant proportion of M1, calculated as the observed mean ratio between these variables.

Total real credit granted to the private sector depends on the percent change in M1. This equation was also estimated by OLS.

Depending on the model closure adopted, the nominal interest rate may be either exogenous or endogenous. In a fixed exchange rate regime, the nominal interest rate would be given by a parity condition, according to which the domestic interest rate must equal the international interest rate (Libor) corrected by expected domestic currency nominal devaluation and a risk premium. The risk premium would depend negatively on the trade balance and positively on Public Sector borrowing requirements and the next external debt—all measured as a percent of GDP. In a floating regime, the interest rate may be set either exogenously or according to some rule representing the monetary authorities' reaction function, such as an inflation targeting rule or a real interest rate rule.

3.5 Public Sector

The Public Sector block specifies the evolution of the public debt and nominal deficit as a function of GDP growth and primary deficit.

3.6 Balance of Payments

3.6.1 Trade Equations

The import and export equations follow a very standard specification. Imports depend on the real exchange rate (corrected by a category-specific tariff index) and real domestic activity (GDP), whereas exports performance is determined by the rate of growth of world imports, the real exchange rate (corrected by a sector-specific subsidy index) and domestic capacity utilization.

The equations have been estimated by Johansen's cointegration procedure within an error correction model framework. It is important to note that all equations, except one (consumer goods imports), have passed a battery of diagnostic tests, including Chow structural stability tests. Besides, various exogeneity tests were performed and, in most cases, the equations were found to possess all the desirable properties for making efficient and unbiased forecasts and policy simulations—i.e., strong and superexogeneity of the conditioning variables [see Castro and Cavalcanti (1997)].

Import equations were estimated separately for each category of use, capital, intermediate and consumer goods. Oil imports are exogenous.

The export equations were estimated for primary, semimanufactured and manufactured products.

3.6.2 Services

The equations for Services accounts are disaggregated according to standard classification into nonfactor and factor services. Nonfactor services basically depend on the value of the country's total trade; in the case of tourism expenditure, the real exchange rate is also included as an explanatory variable. Factor services depend on the international interest rate plus a spread, the net stock of foreign capital and net external debt. All equations are specified as autoregressive-distributed-lag (ADL) models and estimated by OLS and are usually characterized by well-behaved residuals and constant parameters.

3.6.3 External Debt

In a fixed exchange rate regime, the external debt dynamics is determined by the current account balance. Given that net capital inflows and changes in international reserves are assumed to be exogenous, the Current Account Deficit determines the variation in the country's external debt.

3.6.4 Exchange Rate

It is possible to adopt two basic model closures:

1) Fixed nominal exchange rate. The Central Bank sets the nominal exchange rate; given domestic and foreign prices, we obtain the real exchange rate, which determines the Current Account Balance. We assume that any deficits/surpluses will be financed either through capital inflows/outflows or through changes in international reserves.

2) Floating nominal exchange rate. Net capital inflows and changes in international reserves, assumed to be exogenous, determine the supply of foreign currency. Demand for foreign reserves is given by the Current Account deficit. The real (and nominal) exchange rate must therefore vary in order to equalize supply and demand of foreign reserves.

Given that Brazil now has a floating exchange rate regime, the current version of MOPSE-B adopts the second model closure.

It should be noted that:

a) since Services accounts are relatively insensitive to the real exchange rate, Current Account adjustments must be accomplished mainly through changes in Trade Balances; and *b*) given the relatively low short-run trade elasticities for Brazil, shifts in foreign capital inflows require relatively large changes in exchange rates.

3.7 Labor Market

Labor supply depends on a set of demographic and economic factors. Following Barros, Fogel, and Mendonça (1997), we use three basic elements in order to determine its evolution: *a*) population growth projections by age and gender; *b*) education indicators by age and gender; and *c*) estimates of the "activity rate" by age, gender, and education level. We classify the population in three age categories —10 to 24 (the "young"), 25 to 65 (the "mature"), and over 65 (the "elderly")— and two schooling levels—up to 8 years (the "unskilled") and over 8 years (the "skilled"). Under exogenously given trajectories for these variables, we obtain growth rates for each of the twelve possible population categories and can therefore determine the evolution of skilled and unskilled labor supply.

Demand for skilled and unskilled labor is determined separately in the agriculture, industrial and services sectors. In each sector, labor demand depends on the real wage, sectoral production, overall technology level and sector-specific "technology bias." By summing up labor demand in each sector, we determine total demand for skilled and unskilled labor.

The labor market is assumed to be characterized by rigidities that will typically prevent the equalization of labor supply and demand. A "wage curve" determines the degree of flexibility in real wages and, therefore, the degree to which adjustments in the labor market are accomplished by variations in wages or in the rate of unemployment.[2] Real wages for skilled and unskilled workers are thus given by their respective wage curves.

4 CONCLUSION

As we have seen, MOPSE-B is a constantly evolving macroeconomic model based on the work of many individuals at IPEA. The current version of the model already allows relatively rich projections and simulation exercises, which seem to provide fairly reasonable outcomes. Nonetheless, there still are significant improvements to be made.

Among the main shortcomings of the model we should point out the following:

2. The slope coefficient is taken from Barros and Mendonça (1997).

1. The price equation is specified in an *ad hoc* manner, due to the difficulties in estimating price behavior in an economy with a history of hyperinflation.

2. The monetary sector is poorly specified and has relatively little effect on real variables.

3. Capital flows are not explicitly modeled, which does not allow us to infer the positive impacts of high domestic interest rates/investment returns on the financing of current account deficits and on the accumulation of international reserves.

4. Inventories are not modeled, due to the lack of reliable data. This considerably constrains the model's investment dynamics—although it should be said that this problem is probably worse in higher frequency models.

5. There is no role played by expectations, so that the model is inherently backward looking. This problem is especially important in the specification of financial variables.

6. As a general difficulty, the estimated equations usually require a number of dummy variables to account for the frequent breaks and/or outliers in Brazilian macroeconomic series. It is very hard to avoid such modeling shortcomings that arise in economies with a history of severe structural breaks and policy regime changes.

The next improvements to be made shall focus on overcoming some of these difficulties.

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CHAPTER 3B

A NOTE ON THE MINI-MOPSE-B

Mamoru Obayashi

1 INTRODUCTION

This note presents the final test of a smaller version of IPEA's annual econometric model of the Brazilian economy, which we call mini-MOPSE-B. The complete model (Model for Projections and Simulations of the Brazilian Economy), originally developed by the Group of Macroeconomic Analysis and Modeling (GAMMA) at the Research Directorate of the Institute of Applied Economic Research (IPEA/DIPES), includes behavioral equations estimated on different sample periods. This estimation strategy aimed to provide the model with desirable properties for forecasting, but it prevented the assessment of the model's adequacy through the so-called final test. This note fills this gap by constructing a minimum sized model based on a single estimation period.

2 MODEL BUILDING

To check the sample tracking performance of the model, one needs to estimate the equations using a well defined sample set. For this purpose, we selected the sample period from 1980 to 2000 and started the estimation from 1982 to allow for the inclusion of lagged variables. MOPSE-B does not permit us to perform this kind of exercise due to the differences in the sample periods employed in each equation; we therefore decided to build a minimum sized model. The structure of the model does not greatly differ from MOPSE-B so we will not discuss it in detail here. The estimated results and the list of variables are presented in the Appendix.

Mini-MOPSE-B resulted in 37 equations: 16 endogenous and 21 exogenous variables. We should note that we have summarized the foreign sector as exports minus imports in the Gross Domestic Expenditure (GDE) definition by using the balance of payments data. Because of the differences in data sources, this treatment resulted in some differences from the original net exports values. We decided to add such differences to the consumption expenditure variable because this variable was already defined as a residual. Therefore the consumption expenditure contains additional residuals.

The demand side of the model is quite standard. The supply side of the model contains estimated equations for the unemployment rate and the real wage rate and an equation for the capital stock, which depends on cumulative investment. The model closure is obtained by estimating the capacity utilization rate; therefore the production function is implicit.

3 FINAL TEST

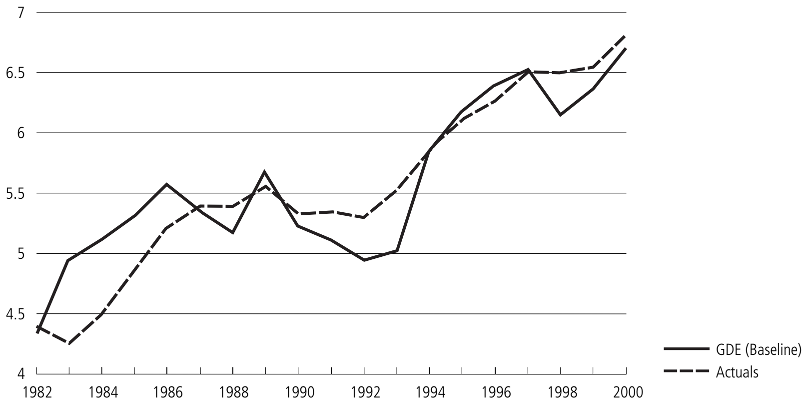
The results of the final test are presented in the table . Considering the short sample periods, the results are fairly good. As the table shows, the Mean Absolute Percentage Errors (MAPEs) of the final test reveal that the model performs particularly well for the expenditure variables, except in the case of the imports function. For instance, as can be seen from the figure, results for the GDE are satisfactory: the MAPE stands at 4.6 percent for the total sample, 2.5 percent for the last five years and 3.3 percent for the last three years.

For the price variables, MAPE's are also small; e.g. the MAPE for the GDP deflator (PGDP) is less than 5 percent. But other equations do not perform well. The unemployment rate (DESA), for instance, presents a large MAPE. However, the major problem is in the monetary sector, where the M1 and TJCDB (real interest rate) equations perform very poorly. Note that the TJCDB series becomes negative several times and, naturally, the corresponding MAPE has larger values.

THE RESULTS OF MAPEs

MAPE (Percent)	19 years	Last 5 Years	Last 3 Years
AWR, Real Wage Rate	7.76	8.44	7.52
CONS, Consumption	5.81	2.88	3.61
DESA, Unemployment Rate	28.36	20.97	22.06
EX, Exports	7.48	7.21	6.07
GDE, Gross Domestic Expenditure	4.56	2.45	3.33
IGPDI, General Price Index	7.71	8.78	7.27
IM, Imports	9.72	12.09	10.02
INV, Investment	8.55	2.83	3.68
IPCA, Consumer Price Index	6.58	2.85	1.11
KR, Capital Stock	2.26	0.38	0.27
M1, Real Money Supply, M1	17.71	13.90	11.43
M2, Real Money Supply, M2	24.47	19.56	9.22
NUCI, Capacity Utilization Rate	4.79	2.82	1.73
PGDP, Deflator of GDE	4.97	1.88	0.87
TAX, Real Tax	8.34	8.85	8.44
TJCDB, Real Interest Rate	63.23	56.50	78.24

FINAL TEST FOR GROSS DOMESTIC EXPENDITURE (GDE)
[R$ trillion — 1980 prices]



4 CONCLUDING REMARKS

To sum up, we have shown that it is possible to perform the final test of a small model that replicates the main features of IPEA's Brazilian Annual Model, and that while the real sector seems to be well represented by the model, other sectors are not.

This exercise is the first attempt to evaluate the annual econometric model within the sample period. It is clear that the interrelationships between sectors are insufficient and that further improvements are needed in the model's specification. On the other hand, our exercise shows promising possibilities for further modeling practices following the standard practice of performing the so-called "final test" before using the model for projection or simulation.

APPENDIX

The Structure of Mini-MOPSE-B

Sample: 1982-2000

Consumption Expendituгe

CONS = 0.2243640002 + 0.7605544026*(GDE-TAX) - 0.03616244354 *
(0.778031) (13.23940) (-4.860110)

* (DLOG(IPCA)*(GDE-TAX)) – 0.2912604626 * (D87+D88) +
(-2.680589)

+ 0.3757051386 * D94
(2.219005)

Adjusted R-Squared = 0.939663, S.E. of Regression = 0.288168, Durbin-Watson = 2.243616

Investment Function

D(INV) = 0.1848757665 - 0.4089061997 * D(KR(-1)) - 0.001444345584*
(2.511236) (-2.364114) (-1.195829)

*D(TJCDB(-1)) +0.1495952159 * D(GDE(-1)) - 0.1182064977 * D9000
(1.176615) (-2.472589)

Adjusted R-Squared = 0.376739, S.E. of Regression = 0.095575, Durbin-Watson = 2.047442

Exports

LOG(EX) = -24.72500221 - 0.8461110663*LOG(IGPDI/(RATE*IPAUS)) +
(-3.280623) (-7.559305)

+ 1.405181932 * LOG(GDPUS) – 0.2314845095 * D82 - 0.2205420199 *
(4.693039) (-2.446636) (-2.779815)

* D86 - 0.1394118053 * D9500
(-2.207198)

Adjusted R-Squared = 0.821106, S.E. of Regression = 0.073658, Durbin-Watson = 2.605451

Imports

LOG(IM) = 0.4249227559 - 0.9251328796 * (D8089 * LOG(GDE(-1))) +

(1.698900) (-5.789753)

+ 3.217909732 * (D9000 * LOG(GDE)) – 0.3391406694 * (D9000 *

(20.26443) (-17.52063)

* LOG((PGDP/(IPAUS *RATE))))

Adjusted R-Squared = 0.973266, S.E. of Regression = 0.042524, Durbin-Watson = 2.157907

GDP Deflator

DLOG(PGDP) = 0.009934771896 + 0.5089113276 * DLOG(AWR(-1)) +

(0.401606) (2.257594)

+ 1.008398877*DLOG(RATE*IPAUS) + 0.9740348395 * D(NUCI(-1)) -

(71.88897) (1.887355)

- 0.3738864695 * D83 + 0.1663800083 * D89 - 0.3195104852 * D99

(-5.562247) (2.526657) (-4.888584)

Adjusted R-Squared = 0.997086, S.E. of Regression = 0.060923, Durbin-Watson = 2.155410

General Price Index

DLOG(IGPDI) = 0.02065237463 + 0.9999621687*DLOG(PGDP) -

(0.700906) (72.67974)

- 0.03137957166 * D9200

(-1.036647)

Adjusted R-Squared = 0.996781, S.E. of Regression = 0.064328, Durbin-Watson = 1.661169

Consumer Price Index

DLOG(IPCA) = -0.03315743777 + 0.6345355297 * DLOG(PGDP) +
(-1.142000) (3.095596)
+ 0.3960820996 * DLOG(IGPDI) + 0.5325209522 * (DLOG(PGDP) *
(1.953267) (1.515256)
* D9200) - 0.5452873742 * (DLOG(IGPDI) * D9200) +
(-1.554603)
+ 0.04583179497 * D9200
(1.332782)

Adjusted R-Squared= = 0.998647, S.E. of Regression = 0.023373, Durbin-Watson = 1.948961

Interest Rate

TJCDB = 10.02036728 + 0.709709368*(PGDP(-1)/PGDP(-2)) -
(2.332887) (1.942068)
- 404732076 * (M1(-1)/PGDP(-1)) + 49.85470788 * D82
(-2.216191) (1.708264)

Adjusted R-Squared = 0.332859, S.E. of Regression = 12.64067, Durbin-Watson = 2.488739

M1

M1/GDE(-1) = 3.281239875e-08 - 3.410911748e-10*TJCDB +
(11.80768) (-2.508162)
+ 3.308489281e-08 * D82 + 5.328738156e-08 * D86
(3.606592) (5.904471)

Adjusted R-squared = 0.752739, S.E. of Regression8.75E-09 =, Durbin-Watson = 1.514544

M2

DLOG(M2/PGDP) = -0.09581460031 - 0.008882381939 * D(TJCDB) +
(-0.860634) (-1.815909)

+ 6.840943322 * DLOG(GDE) – 0.9305997973 * D94
(2.397056) (-2.295462)

+ 0.7761191303 * D92
(1.949037)

Adjusted R-Squared = 0.401107, S.E. of Regression = 0.365999, Durbin-Watson = 2.411544

Capacity Utilization Rate

NUCI = 1.44039619 + 1591461.142*(GDE(-1)/((1-DESA) * POP(-1))) -
(5.396904) (1.752052)

- 3955447.189 * (KR(-1)/((1-DESA) * POP(-1)))+ 0.004661357242 * TREND
(-4.730375) (4.354905)

Adjusted R-Squared = 0.654099, S.E. of Regression = 0.021388, Durbin-Watson = 1.532494

Real Wage Rate

DLOG(AWR) = 0.001659933421 - 3.398656431 * D(DESA) +
(0.9239) (-2.136418)

+ 1.067649771 * DLOG(GDE) + 0.1534443407 * D92
(2.254473) (2.739559)

Adjusted R-Squared = 0.567121, S.E. of Regression = 0.052220, Durbin-Watson = 2.305155

Unemployment Rate

DESA = 0.2105610501 + 0.03996133404 * (D9000 * D(GDE)) -
(3.458020) (1.768738)

- 0.04579509206 * D(GDE) - 0.1795871814 * NUCI(-1)

(-2.392359) (-2.389033)

– 0.009351680107 * DLOG(PGDP)

(-3.934693)

Adjusted R-Squared = 0.477714, S.E. of Regression = 0.010110, Durbin-Watson = 1.660683

Real Tax

LOG(TAX) = -1.381278585 + 0.2152421933 * GDE

(-8.550039) (7.469779)

Adjusted R-Squared = 0.752739, S.E. of Regression = 0.092097, Durbin-Watson = 2.515329

GDE Definition

GDE = CONS + INV + CG + IG + EX - IM

Capital Accumulation

KR = KR(-1) * (1 - 0.06) + INV

List of Variables

The data have been obtained from MOPSE-B and from the Ipeadata website (www.ipeadata.gov.br). EX and IM are converted from the balance of the payments data, and the residuals are added to the consumption expenditure to ensure the GDE definition. Sample periods are 1980 to 2000, while 1982 to 2000 are the estimation periods.

AWR	Real Wage Rate
CONS	Consumption Expenditure
DESA	Unemployment Rate
EX	Exports of Goods and Services
GDE	Gross Domestic Products
IGPDI	Wholesale Price Index
IM	Import of Goods and Services
INV	Investment Expenditure (Private)
IPCA	Consumer Price Index
KR	Real Private Capital Stock
M1	Money Supply M1
M2	Money Supply M2
NUCI	Utilization Rate
PGDP	GDP Deflator
TAX	Real Tax Receipts
TJCDB	Interest Rate
CG	Government Consumption Expenditure. Exog
D8089	Dummy 1980 to 1989 =1, O otherwise. Exog
D82	Dummy 1982=1, O otherwise. Exog
D83	Dummy . Exog
D86	Dummy . Exog
D87	Dummy . Exog
D88	Dummy . Exog
D8889	Dummy . Exog
D89	Dummy . Exog
D90	Dummy . Exog
D9000	Dummy . Exog
D91	Dummy . Exog
D92	Dummy . Exog
D9200	Dummy . Exog
D93	Dummy . Exog
D94	Dummy . Exog
D95	Dummy . Exog
D9500	Dummy . Exog
D96	Dummy . Exog
D99	Dummy . Exog
GDPUS	GDP of the United States of America. Exog
IG	Government Investment Expenditure. Exog
IPAUS	Wholesale Price Index of the United States of America. Exog
POP	Labor Force. Exog
RATE	Exchange Rate. Exog
TREND	Trend Variable. Exog

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CHAPTER 4A

CHRONOLOGICAL DEVELOPMENT AND MAIN FEATURES OF IPEA'S QUARTERLY MACROECONOMETRIC MODEL

Marco Antônio F. H. Cavalcanti

1 INTRODUCTION

IPEA's quarterly econometric model was developed as a higher frequency version of its annual counterpart, the MOPSE-B (described in Chapter 3A). The structure and specification of the two models are, therefore, very similar.

As in the case of the annual model, the starting point for the construction of the quarterly econometric model was the foreign sector block, which built upon earlier work by some of the authors [see Cavalcanti and Ribeiro (1998), Cavalcanti, Ribeiro and Castro (1998) and Reis et al. (1999)].

The first version of the quarterly model was presented to the audience of Project Link at the conference held in Rio de Janeiro in September 1998 [see Reis et al. (1998)]. However, soon after the conclusion of that version, two events made a full revision of the model necessary. First, the Brazilian Institute of Geography and Statistics (IBGE) introduced significant changes in the National Accounts methodology—which meant that most equations had to be respecified and reestimated. Second, the Brazilian exchange rate regime switched to a floating system—which required a significant change in the structure and functioning of the model. Partly as a consequence of these events, the second version of the model became operational only in 2000 [Cavalcanti (2000*a* and *b*)].

Since November 2000, projections derived from the quarterly model have been regularly published in IPEA's *Boletim de Conjuntura* and used in the analysis of current economic issues—thus making GAC (group responsible for the analysis of such issues at IPEA) the model's main user. The interaction between the modeling group and GAC has been a major source of ideas and inspiration for the continuous improvement of the model.

Due to the lack of demand-side National Accounts data on a quarterly basis, the model, up to now, has had to rely on time series estimated by IPEA. The model is now under revision in order to make it compatible with the new Quarterly

National Accounts made available by IBGE since last year. In the following sections, we briefly present and discuss the version currently in use, which is still based on the time series data estimated by IPEA.

2 MODEL STRUCTURE

The model is designed to make short and medium run projections and policy simulations for the Brazilian economy. It is a medium-scale quarterly model built upon the main identities of the Brazilian National Accounts and Balance of Payments. The model contains 105 equations out of which 25 are stochastic.

Estimation features include the use of various econometric methods, such as Full Information Maximum Likelihood (FIML) cointegration analysis, OLS and instrumental variables estimation. In general, the development of the model's equations has explicitly tried to ensure desirable long-run properties as well as reasonable short-run dynamics. This has usually been accomplished through the use of error correction models.

The specification and estimation of the model's equations followed these basic steps:

a) selection, based on economic theory, of potential explanatory variables for each variable of interest;

b) analysis of each series statistical properties (seasonality, trending behavior, order of integration);

c) appropriate transformation of each series (seasonal adjustment, differencing, detrending);

d) estimation of unrestricted reduced form equations, starting from a maximum number of lags (between four and eight, depending on degrees of freedom) and selection of lag order based on information criteria (Schwarz, Hannan-Quinn); and

e) estimation and testing of restricted equations (exclusion of variables, imposition of long-run relations).

As in the case of its annual counterpart, the specification of the quarterly model is basically Keynesian. Aggregate demand is given by individually estimated equations for aggregate consumption, aggregate investment, and net exports of goods and services, while aggregate supply is determined by a Cobb-Douglas constant-return production function. The equalization of aggregate demand and supply determines real output, capacity utilization, employment, and prices. These equations make up the model's "domestic sector."

The "foreign sector" includes equations for the main categories of current account transactions and identities that determine the evolution of the capital account through exogenously given paths for net capital inflows and reserves.

2.1 Domestic Sector

Private consumption (c, in logs) is a function of disposable income (y^d), the real interest rate (r) and an error correction term that insures that c and y grow at the same rate in the long run. The equation is specified in first differences and estimated by instrumental variables, due to the simultaneity between consumption and income:

$$\Delta c_t = 0.556\ \Delta y^d_t - 0.073\ (c - y^d)_{t-1} - 0.0007\ r_{t-1}$$

This is one of the most important equations of the model, as the dynamics of real demand will depend, to a large extent, on the value of the Keynesian multiplier. The estimated coefficient on disposable income is approximately 0.5, which implies a reasonably low short-run multiplier and therefore prevents the model from becoming unstable. It may also indicate, following Campbell and Mankiw, that about half of Brazilian consumers are credit-constrained while the other half behave according to the permanent income hypothesis.

It should be noted that the effect of interest rate movements on consumption (and also on investment, as we shall see below) is relatively weak, so that the real effects of monetary policy in the model are very limited.

Investment in machinery and equipment depends on the capacity utilization rate (u), the real interest rate and an error-correction term:

$$\Delta im_t = -0.79 + 0.004\ \Delta u_{t-4} + 0.005\ \Delta u_{t-6} - 0.29\ (im - y)_{t-1} - 0.0008\ r_{t-1}$$

Investment in construction depends on the same variables as above, plus gross tax burden (T):

$$\Delta ic_t = -0.24 - 0.86\ T + 0.005\ \Delta u_{t-3} - 0.22\ (ic - y)_{t-1} - 0.0007\ r_{t-1}$$

Aggregate supply is given by a constant returns to scale Cobb-Douglas-type production function whereby domestic capital stock (k), multiplied by the capacity utilization rate (u), is combined with employed labor (L) to produce output. The equation also includes an exogenous trend (td) as a proxy for technical progress. OLS estimation gives the following result (variables in logs):

$$\Delta_4 y_t / y_{t-4} = 0.004 + 0.529\ \Delta_4 (k\ u)_t / (k\ u)_{t-4} +$$
$$+ (1 - 0.529)\ \Delta_4 (L\ (1 - td))_t / (L\ (1 - td))_{t-4}$$

The capacity utilization rate will vary in order to equalize aggregate supply and demand.

Domestic prices are determined by a Phillips Curve-type equation, where current inflation depends on past inflation, on variation in foreign prices (p^*) multiplied by the exchange rate (e), and on capacity utilization (u).

$$\Delta p = 0.3\ \Delta p - 1 + 0.1\ \Delta (e\ p^*) + 0.085\ u$$

2.2 Foreign Sector

The trade equations include the main categories of exports (manufactured, semi-manufactured, and primary products) and imports (consumer, intermediate, capital goods and oil).

The import and export volume equations follow standard specifications; imports depend on the real exchange rate (corrected by a category-specific tariff index) and real domestic activity, whereas exports performance is determined by the rate of growth of world imports (MW), domestic total net capital stock, the real exchange rate (corrected by a sector-specific subsidy index) and domestic capacity utilization (CU).

$$Q^X_i = f[P_X S_X E / P_{D,} MW, K, CU]$$

$$Q^M_i = f[e.(1+T_i).P^M_i / P^D_i, Y]$$

These equations were estimated within an error correction model framework. The long run elasticities, derived from cointegration analysis, are depicted in the Tables 1 and 2.

TABLE 1
LONG-RUN ELASTICITIES OF EXPORTS (*QUANTUM*)

Sector	Elasticities			
	$P_X S_X E / P_D$	K	P_X / P^*	M_W
Manufactured	0.78	1.76	-	-
Semimanufactured	0.34	2.12	-	-
Primary	-	-	–0,86	0.11

TABLE 2
LONG-RUN ELASTICITIES OF IMPORTS (*QUANTUM*)

Category	Elasticities	
	Y	$e.(1+T_i).P^M_i/P^D_i$
Capital Goods	0.89	–2.04
Intermediate Goods	0.94	–2.40
Consumer Goods	0.72	–1.64

Export and import prices depend on the USD Real Effective Exchange Rate (*USREER*), the Libor Rate and world imports. The effects of world imports and the *USREER* are more significant in the case of industrialized products, while the Libor rate affects only the prices of commodities.

$$P^X_i = f[USREER, MW, \text{Libor}]$$

$$P^M_i = f[USREER, MW, \text{Libor}]$$

It is worth noting that the estimated long-run elasticities indicate that Brazil's exports of industrialized products are determined by a supply curve, whereas exports of primary products seem to depend on a demand relation. Also, world trade seems to affect exports mainly in an indirect way, through its effects on export prices.

The Services accounts equations are disaggregated according to standard classification into nonfactor and factor services. Nonfactor services basically depend on the value of the country's total trade; in the case of tourism expenditure, the real exchange rate is also included as an explanatory variable. Factor services depend on the international interest rate plus a spread, the net stock of foreign capital and net external debt. All equations are specified as autoregressive-distributed-lag (ADL) models and estimated by OLS and are usually characterized by well-behaved residuals and constant parameters.

As in the case of MOPSE-B, the exchange rate is endogenously determined by the equalization of supply and demand of foreign reserves.

3 CONCLUSION

IPEA's quarterly macroeconomic model presents many limitations, particularly with regard to poorly specified monetary and financial sectors and the lack of expectations mechanisms. Nonetheless, the model has proved useful in the analysis of current economic issues and in specific applications, such as the calculation of "equilibrium exchange rates" [Cavalcanti (2001)].

As new improvements are implemented, the model should become an even more reliable instrument for policy analysis and simulation.

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CHAPTER 4B

A QUARTERLY ECONOMETRIC MODEL FOR THE BRAZILIAN ECONOMY

Suminori Tokunaga

1 INTRODUCTION

In this chapter, we will try to construct a prototype quarterly econometric model for the recent Brazilian economy after the Real Plan. The Brazilian economy experienced rapid changes—including a new exchange rate regime and a new framework for monetary policy—from the past structure of the hyperinflation period. It is important to have a global and systematic view of the "new" national economy by using a quarterly econometric model especially built for the 1990s.

There already exists a Quarterly Model of the Brazilian Economy (QMBE), developed by the Group of Macroeconomic Analysis and Modeling (GAMMA) at IPEA's former Directorate of Research (DIPES), now Directorate of Macroeconomic Studies. The QMBE, which is designed to make short-run projections for the Brazilian economy, was estimated based on different sample periods for each equation, which prevented the so-called "final test" from being preformed.

In this chapter, we present a prototype quarterly econometric model for the Brazilian economy for which such test may be performed. This prototype modeling is designed to be used both for forecasting and for simulations of policies—such as fiscal and monetary—on a variety of macroeconomic aggregate variables.

The structure of this paper is as follows. In Section 2, we sketch the structure of the model and briefly report the results of the estimation and the final test of the Version 1 Model. Section 3 reports the results of the extension to the Version 2 Model by including the policy reaction function. Section 4 shows the results of specific simulation analysis. Finally, we conclude in Section 5.

2 ESTIMATION OF THE QUARTERLY ECONOMETRIC MODEL (VERSION 1)

We have constructed a quarterly econometric model for the Brazilian economy (1994Q4-2000Q2) with 26 endogenous variables. Aggregate demand is given by individually estimated equations for aggregate consumption, aggregate investment, exports of goods and services, while aggregate supply is determined by a production function for the non-primary sector. The equalization of aggregate demand and aggregate supply will be adjusted by capacity utilization.

The main differences compared with the previous model (QMBE by IPEA) are: 1) the revision of the estimation period to the recent five years (from the Real Plan to recent years, 1994Q4-2000Q2). The data interval actually used goes from 1994Q1 to 2000Q2 because of lags for some estimated equations. 2) The primary sector GDP was specified as endogenous. 3) The consumer price index, IPCA, was specified as endogenous in the price sector. 4) We perform simultaneous equation estimation for the real wage rate (AWR) and the unemployment rate (DESA). Furthermore, 5) there are monetary and fiscal policy reaction functions for the nominal interest rate (SELIC), the money supply (M2) and the Public Sector Borrowing Requirements (NFSNO), which are endogenously explained. Balance of payments variables such as the current account balance and foreign currency reserves are endogenously explained as in the QMBE.

We set the estimation criteria as follows: 1) all explained variables on the left hand side are deflated by a suitable variable to eliminate the steady trend; 2) the determination coefficient must be higher than 0.90 in order to obtain a good fit; 3) all t-values must be higher than 1.0 to secure the explaining power of each explaining variable.

Estimation results of this model are as follows. The model contains eleven behavioral equations and fifteen identities (see Appendices A and B). The number of endogenous variables is 26. We use OLS estimation because no current endogenous variable is included in the set of explaining variables. The sample period for estimation is from 1994Q4 to 2000Q2 in order to analyze the monetary and fiscal policy as well as the Real Plan, which was introduced on July 1st, 1994.

Equations can be grouped into six sectors: *a*) the final demand sector; *b*) the supply and capital stock sector; *c*) the income sector; *d*) the labor sector; *e*) the price sector; and *f*) the balance of payments accounts sector. See the flowchart (Figure A1).

The final demand sector consists of private consumption (CP), government consumption (CG), investment in construction (INVC), investment in machinery and equipment (INVM), exports (X) and imports (IM). GDE is defined by each component of aggregate demand in equation (8). Due to the lack of data, we cannot estimate investment in inventories.

The aggregate supply sector consists of GDP for the primary sector (Y1) and GDP for the non-primary sector (Y23) and specifies the production function. The domestic capital stock is determined by definition, and the rate of capacity utilization (NUCI) depends on GDE, GDP for the non-primary sector, SELIC and FDI in equation (13). In the income sector, we define the disposable income (YD) according to equation (14).

The labor sector consists of a real wage rate (AWR), employment (EMP) and unemployment rate (DESA). The real wage rate is determined by equation (17).

In the price sector, a general price index (IGPDI) is determined by the exchange rate, the money supply, the real wage rate, the growth rate of the GDE and the capital labor ratio in equation (18).

The balance of payments sector defines the trade balance (TB$), current account balance (CA$), capital account balance (CAP$), balance of payments (BP$) and foreign reserves (RES$).

In this model, the main policy variables are the nominal interest rate (SELIC), money supply (M2), Public Sector Borrowing Requirements (NFSNO) and the nominal exchange rate (RATE).

2.1 Final Demand Sector

First, we estimated the final demand sector. Final demand is given by an individually estimated equation for private consumption, aggregate investment in machinery and construction, exports and imports. Government consumption and net non-factor services (SERNF$) are exogenous variables in this block.

In equation (1), *per capita* real private consumption expenditure (CP/PTO) is estimated as a function of *per capita* real disposable income (YD/PTO), the nominal interest rate (SELIC), real money supply (M2/IPCA), Public Sector Borrowing Requirements (NFSNO), the nominal exchange rate (RATE) and a time trend.

Real total private investment expenditure (INV) is divided into machinery and construction. We estimate the ratio of real private investment expenditure in machinery and equipment (INVM) to capital stock (KR) in equation (2) as a function of the growth rate of GDP for the non-primary sector (Y23), capacity utilization rate (NUCI), interest rate, accumulation of real FDI (SFDIR), import ratio (IM/GDE) and both the current and the lagged unemployment rate (DESA). The positive influence of the capacity utilization rate implies the lagged effect of demand growth. Furthermore, we have estimated the ratio of real private investment in construction (INVC) to capital stock in equation (3) as a function of the growth rate of the GDP, interest rate, capacity utilization rate and its own lagged value. Total investment showed an upward trend in 1996-1998, but it still stagnated at a low level after the devaluation.

In equation (5), export (X), which is normalized by lagged GDP, depends on the growth rate of the GDP of the US, the lagged capacity utilization rate, the GDP for the primary sector ratio (Y1/GDP) and both the current and the lagged real exchange rate (RATE/IGPDI). As expected, the real exchange rate exerts a strong positive effect on export. As regards imports (IM), which are normalized by lagged GDP, they depend on the GDE growth rate, on lagged foreign currency reserves (RES$) ratio and on its own lagged ratio as expected, but can be negatively affected by the real interest rate and real exchange rate in equation (6). The exchange rate shows a negative effect as expected. Imports in 1995-1999 showed a steady upward trend, but stagnated after the devaluation.

Government consumption and net non-factor services are exogenous variables in this model. Thus, real GDE is determined by summing up these expenditure items.

2.2 Supply and Capital Stock Sector

Next, we estimated the aggregate supply side. Real GDP is divided into primary sector and non primary sector. The production function for the GDP of the non-primary sector (Y23) per employment (EMP) is mainly estimated by the real capital stock (KR) and multiplied by the capacity utilization rate divided by labor (EMP) as the Cobb-Douglas-type function in equation (9). This equation also includes the money supply ratio and the growth rate of accumulated FDI (SFDIR). The domestic capital stock is calculated according to the definition in equation (12). In equation (13), the capacity utilization rate index (NUCI), in which there was a cyclical tendency during 1995-2000 (except for the big devaluation in 1999), is determined by the growth rate of the GDE, the GDP of the non-primary sector per labor unit, the real interest rate, the growth rate of FDI and its own lagged value. It will vary in order to equalize aggregate supply and demand.

2.3 Income Sector

Disposable income (YD) is defined by nominal GDP in equation (14).

2.4 Labor Sector

Next, we estimated the unemployment rate function (DESA) in equation (15). The unemployment rate is influenced positively by labor productivity (GDE/EMP), and negatively by real wage (AWR), by capital intensity of labor (KR/EMP) and by capacity utilization. Employment level (EMP) is defined as economically active population (PTO) multiplied by (1-DESA) in equation (16).

The real wage index (AWR) in equation (17) is determined by the employment growth rate, capacity utilization, unemployment, price variation and both the current and lagged real exchange rate—quite an eclectic equation.

2.5 Price Sector

We estimated the general price index (IGPDI) in equation (18) as a function of real exchange rate (RATE/IGPDI), of money supply (M2), of the real wage, of the GDE, of the capital/labor ratio (KR/EMP) and of a time trend. The influence of exchange rates, in particular, dominates as an explanation of the steep increase in inflation after 1999. The consumer price index (IPCA) of equation (19) is a function of the nominal exchange rate, of the real exchange rate, of money supply, of the import price index (PIM), of the nominal interest rate (SELIC), of the Public Sector Borrowing Requirements (NFSNO) and of a time trend.

2.6 Balance of Payments Sector

Finally, the balance of payments sector defines the trade balance (TB$), the current account balance (CA$), the capital account balance (CAP$), the balance of payments (BP$), and the foreign reserves (RES$).

2.7 Final Test of the Model

The historical simulations of the "final tests" are very important for evaluating how well the model can simulate the real economy. Based on the results of a single estimation, we first constructed a 26-equation (Version 1) model that treated NFSNO, M2, SELIC, and the exchange rate (RATE) as exogenous. This model was simulated over the period from 1994Q4 to 2000Q2, using the dynamic Gauss-Seidel method. Figures 1A and 1B show the main results of the final test for Version 1. As can be seen from these two figures, the model performs particularly well for the expenditure variables (except in the investment function), for the price variables and for the balance of payments variables; but the unemployment rate (DESA) function does not perform well. However, from the results of this final test, we have found that this model generally performs well.

FIGURE 1A
RESULTS OF FINAL TEST FOR VERSION 1

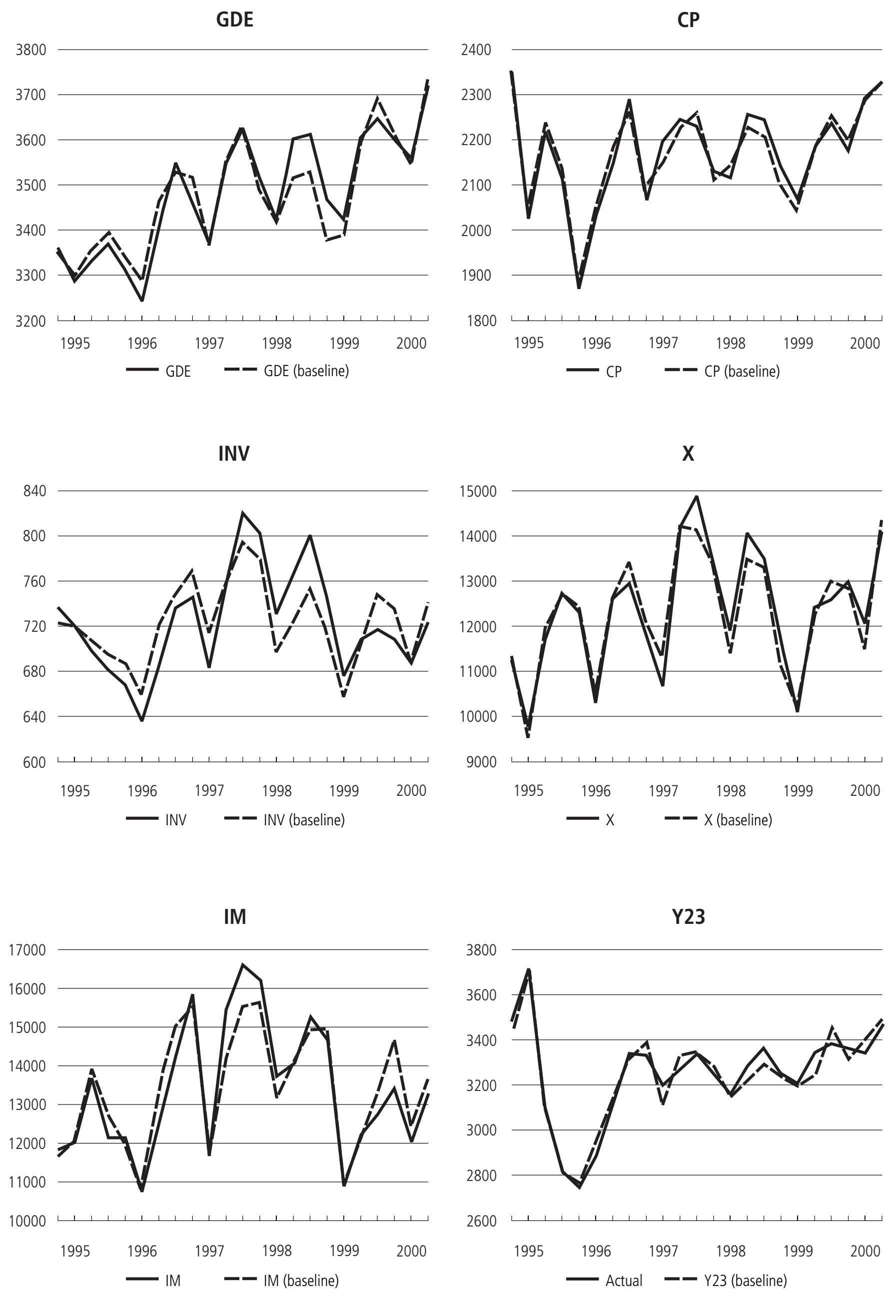
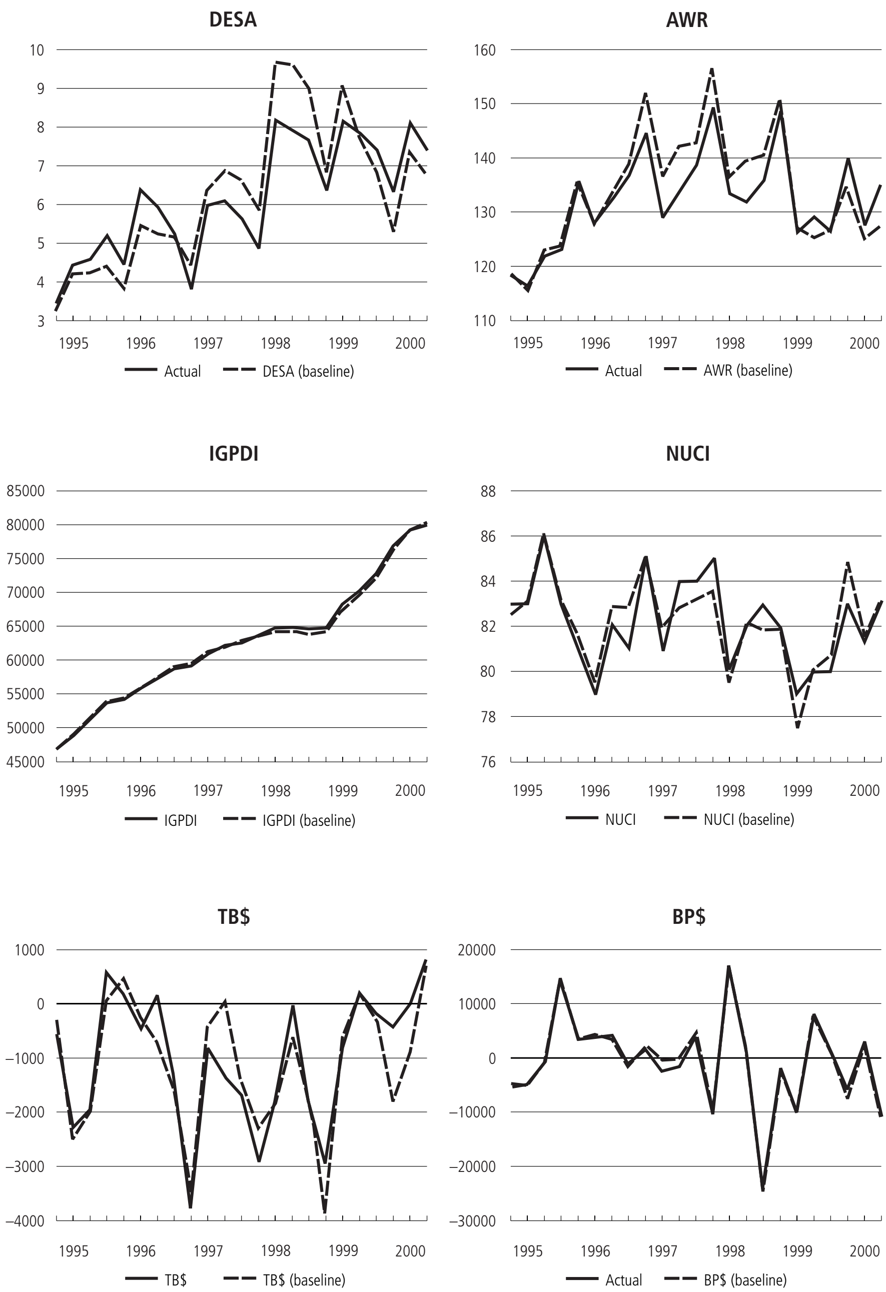


FIGURE 1B
RESULTS OF FINAL TEST FOR VERSION 1



3 EXTENSION OF QUARTERLY MODEL (VERSION 2)

3.1 Reaction Function Sector

In the previous section (Version 1), three variables (SELIC, M2, NFSNO), which are monetary and fiscal instruments, were treated as exogenous. But the government changes these instruments to achieve economic targets, while considering important restraints. For that reason, we estimate the reaction functions similarly to the Monthly Econometric Model in Chapter 4. The results are equations (27) to (29), wich we add to the previous model, thus obtaining fourteen behavioral equations and fifteen identities in Figure A.2 [see Appendices A and B as well].

In equation (27), the result of the estimation of the interest rate (SELIC) is shown. SELIC is positively influenced by GDE, Public Sector Borrowing Requirements, the FDI ratio and its own lagged value, and is negatively influenced by M2, the real exchange rate and the balance of payments. Therefore, the Central Bank reacts by increasing the SELIC rate whenever either GDE or NFSNO is increasing. But the reaction coefficient of SELIC to M2 is negative due to the market pressure of money. Since the reaction coefficient of SELIC to the balance of payments is negative, SELIC tends to be lower when the surplus of the balance of payments rises. These are "reasonable" reactions by the Central Bank.

The result of the estimation of M2 is shown in equation (28). The money supply (M2) is positively influenced by the current account balance (CA$) and its own lagged value, and negatively influenced by price growth, SELIC growth, exchange rate growth and GDE growth. Therefore, M2 tends to increase when the growth rate of the GDE is lower, as the reaction coefficient of M2 to GDE is negative. As the reaction coefficient of M2 to IPCA is negative, M2 tends to decrease when there is higher inflation. These are reasonable reactions by the Central Bank.

In equation (29), the result of the estimation of the Public Sector Borrowing Requirements (NFSNO) is shown. The NFSNO is positively influenced by the GDE ratio, SELIC and GDP for the non-primary sector growth, and is negatively influenced by the price variation, and by NUCI. Thus, as the reaction coefficient of NFSNO to IGPDI is negative, NFSNO tends to be lower when there is higher inflation. Furthermore, NFSNO tends to increase with the GDE when the reaction coefficient of NFSNO to GDE is positive. These are reasonable reactions by the central government.

3.2 Final Test of the Model

Based on the results of the three estimations, we constructed a 29-equation (Version 2) model that treated NFSNO, M2 and SELIC as endogenous. This model has been simulated over the period from 1994Q4 to 2000Q2, using the dynamic Gauss-Seidel method like the model for Version 1. Figure 2A and Figure 2B show the main results of the final test for Version 2. As can be seen from these two figures, the model performs particularly well for the expenditure variables (except in the case of the investment function and import function), for the price variables and for the balance of payments variables; but the unemployment rate (DESA) function and the nominal interest rate (SELIC) do not perform well. However, since the results of this final test suggest that this model generally performs well, we will carry specific policy simulations in Section 4.

4 SPECIFIC SIMULATION ANALYSIS

We attempted the following simulations during the period of 1994Q4-2000Q2. The three simulation cases are conducted using this model (Version 2). The exchange rate is an exogenous variable in the following three cases:

Case (1) NFSNO is held constant after 1994Q3.

Case (2) M2 is decreasing 10% from actual value after 1994Q3.

Case (3) SELIC is held constant after 1994Q3.

Next, we tried to analyze the role of the exchange rate as the "anchor" of the Real Plan. The Real Plan was a stabilization program first announced in December 1993, and then implemented in the following three sequential steps: 1) an emergency fiscal adjustment; 2) the elimination of the inflationary inertia, through the conversion of prices and salaries to a stable unit of account (the URV—Real Unit of Value); and 3) a monetary reform through the transformation of the URV into the new currency, the Real. The Real Plan was then introduced in July 1994 and the exchange rate was quickly appreciated thereafter, due to soaring capital inflows that followed the economic stabilization. This appreciation is pointed out as a major contribution to price stability in the beginning of the implementation of the last step. We conduct the following specific simulation, which focuses only on the exchange rate. In the Version 2 model, the exchange rate is an exogenous variable, but we estimate the function of the exchange rate using a two-period dummy during the period of 1994-2000 (see Appendix A).

Case (4) RATE is held constant after 1994Q3.

FIGURE 2A
RESULTS OF FINAL TEST FOR VERSION 2

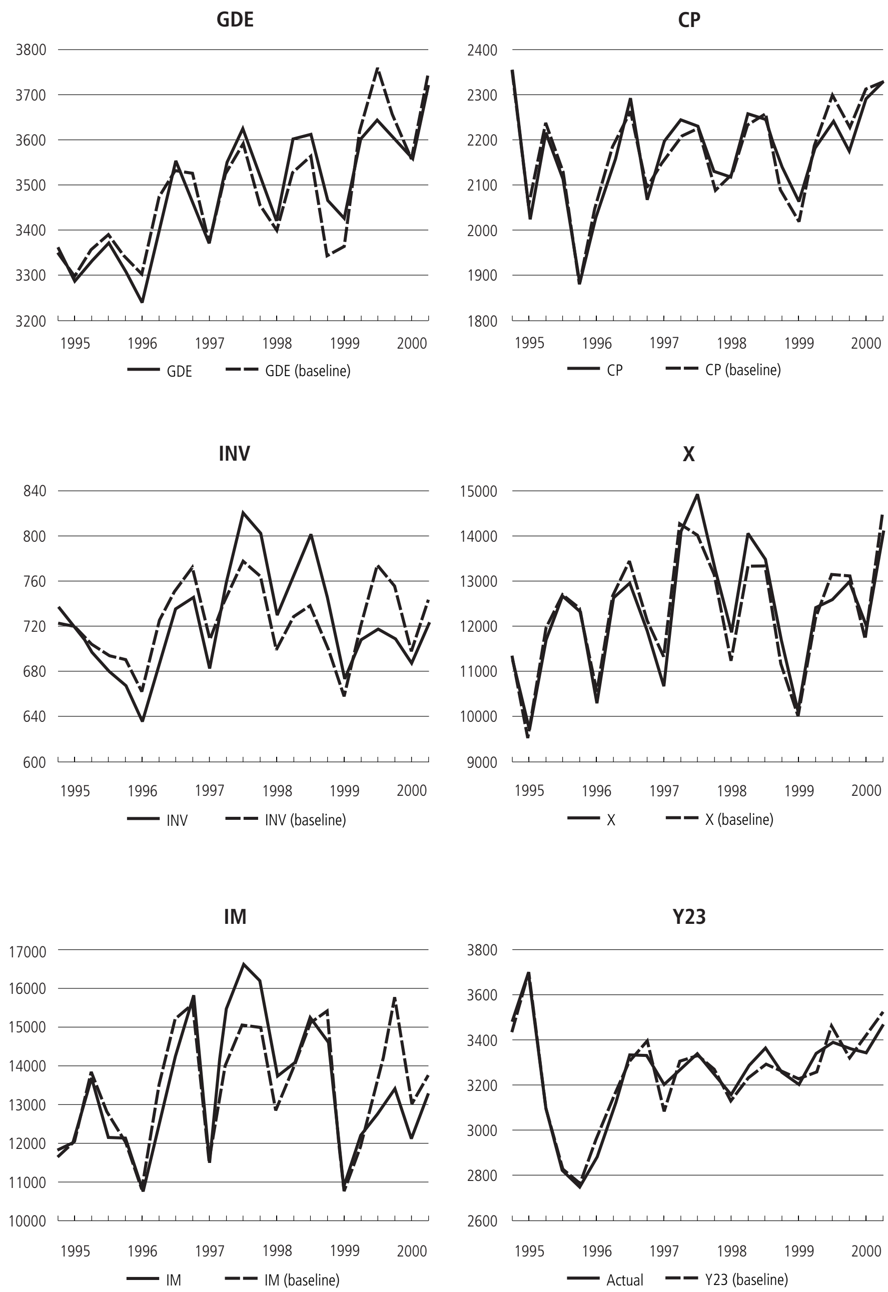
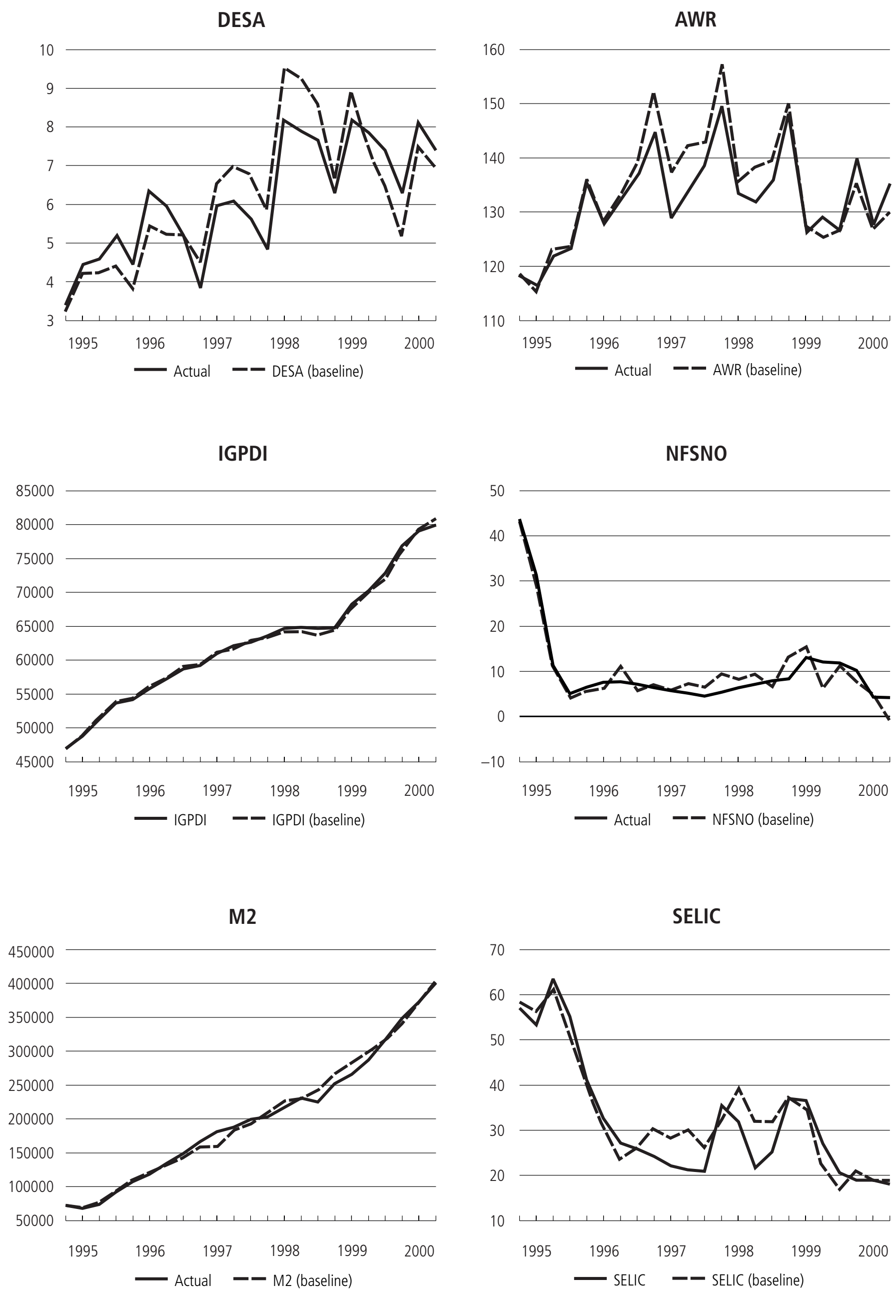


FIGURE 2B
RESULTS OF FINAL TEST FOR VERSION 2



We compared the results of this simulation on main macro variables with those of the final test, including the exchange rate function as endogenous.

Case (1): NFSNO increases. This implies the increase in NFSNO during this period. This causes the cyclical change of SELIC and M2 in Figure 3B, as well as both the decrease of GDE and the rate of capacity utilization (NUCI) in the 1995Q1-1997Q3 period and the increase in the 1997Q4-2000Q2 period in Figure 3A. Private consumption, investment, exports and imports follow similar patterns. The consumer price index is rapidly increasing. Thus, we conclude that this simulation shows the expected effects of fiscal expenditure policy.

Case (2): M2 decreases. This implies a tight monetary policy during this period. As the outcomes of tight monetary policy are effective by degrees, GDE and foreign currency reserve are decreasing slightly, and the CPI is down slightly in both Figure 4A and Figure 4B. Thus, we conclude that this simulation shows the expected effects of a tight monetary policy, even though the magnitude is weaker than expected.

Case (3): SELIC increases. This implies a higher SELIC during this period. That is, this is a tight monetary policy like in M2's case. Because the effect of this policy is large, this causes a decrease of M2, NFSNO and NUCI in Figure 5B. Thus, GDE, private consumption and investment are all decreasing rapidly in Figure 5A. The variables of the labor market follow a similar pattern. The consumer price index is also decreasing. Thus, we conclude that this simulation shows the expected effects of a tight monetary policy.

Case (4): RATE appreciation. This causes the decrease of GDE in this period. In particular, private consumption, investment and exports follow a similar pattern in Figure 6A. Furthermore, this policy also causes a rapid decrease in the consumer price index in Figure 6B, leading us to the conclusion that this policy in which RATE is held constant after 1994Q3 eliminates inflation. Thus, we conclude that this simulation shows the expected effects of the exchange rate policy.

FIGURE 3A
POLICY SIMULATION—NFSNO IS HELD CONSTANT
AFTER 1994Q3, CASE 1

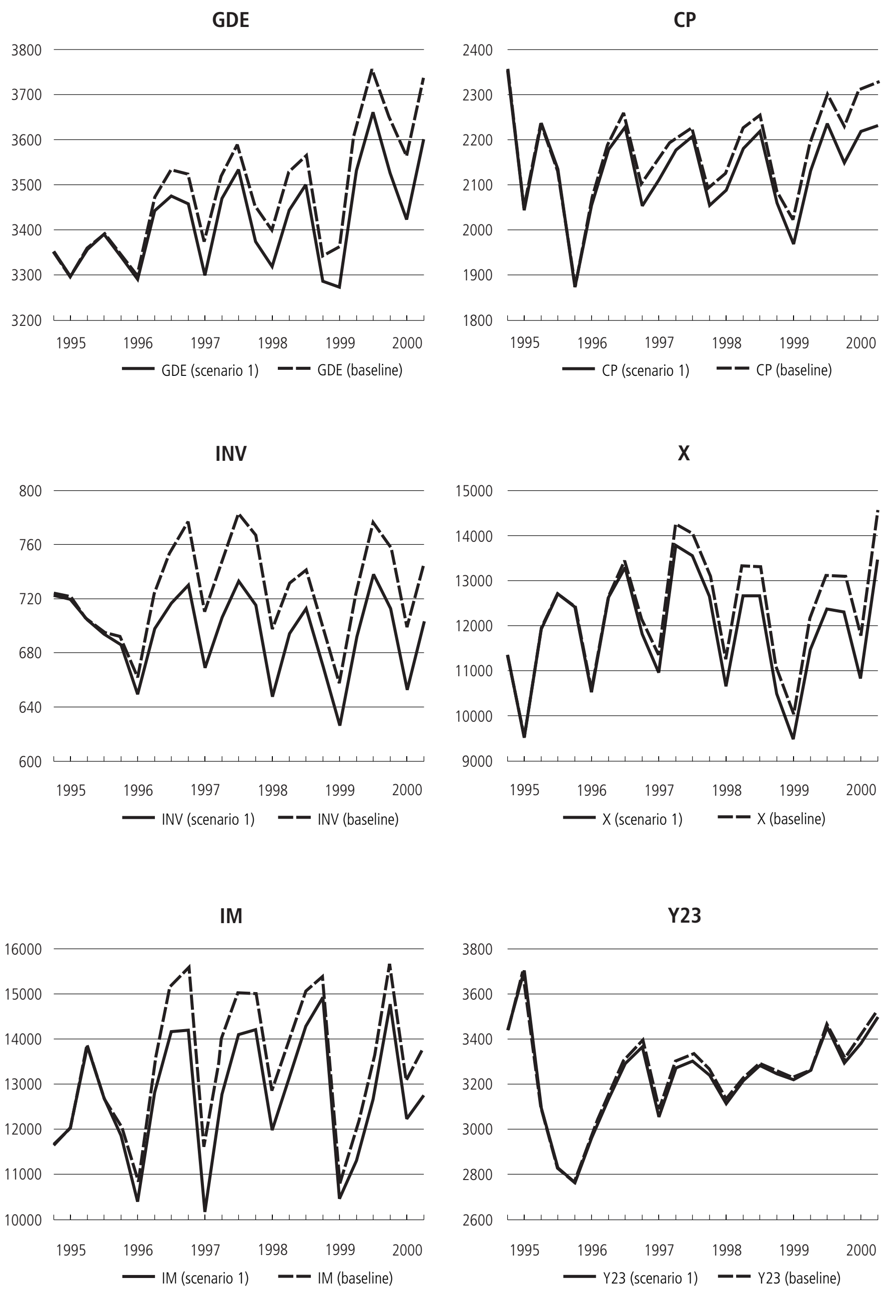


FIGURE 3B
POLICY SIMULATION—NFSNO IS HELD CONSTANT
AFTER 1994Q3, CASE 1

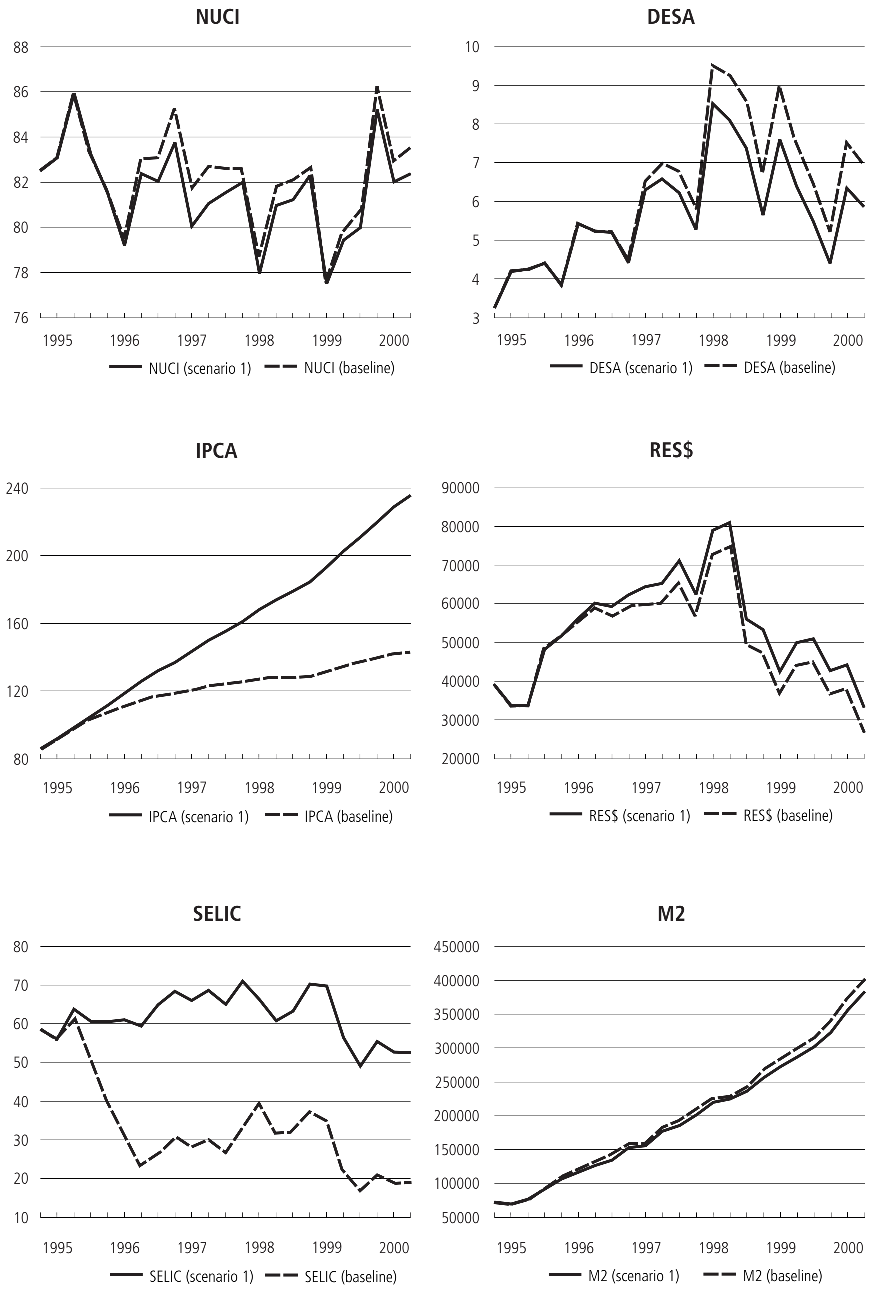


FIGURE 4A
POLICY SIMULATION—M2 IS DECREASING 10
PERCENT AFTER 1994Q3, CASE 2

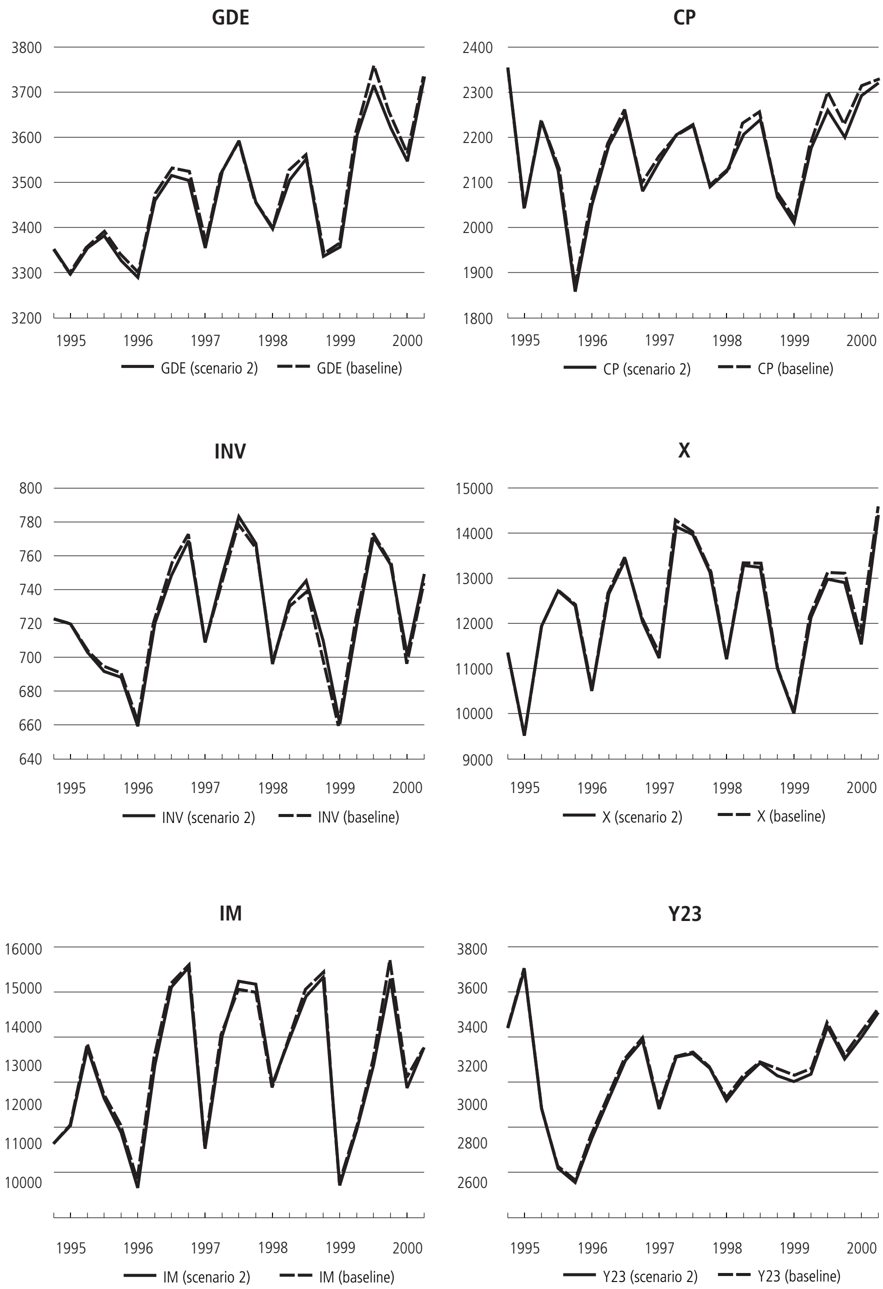


FIGURE 4B
POLICY SIMULATION—M2 IS DECREASING 10
PERCENT AFTER 1994Q3, CASE 2

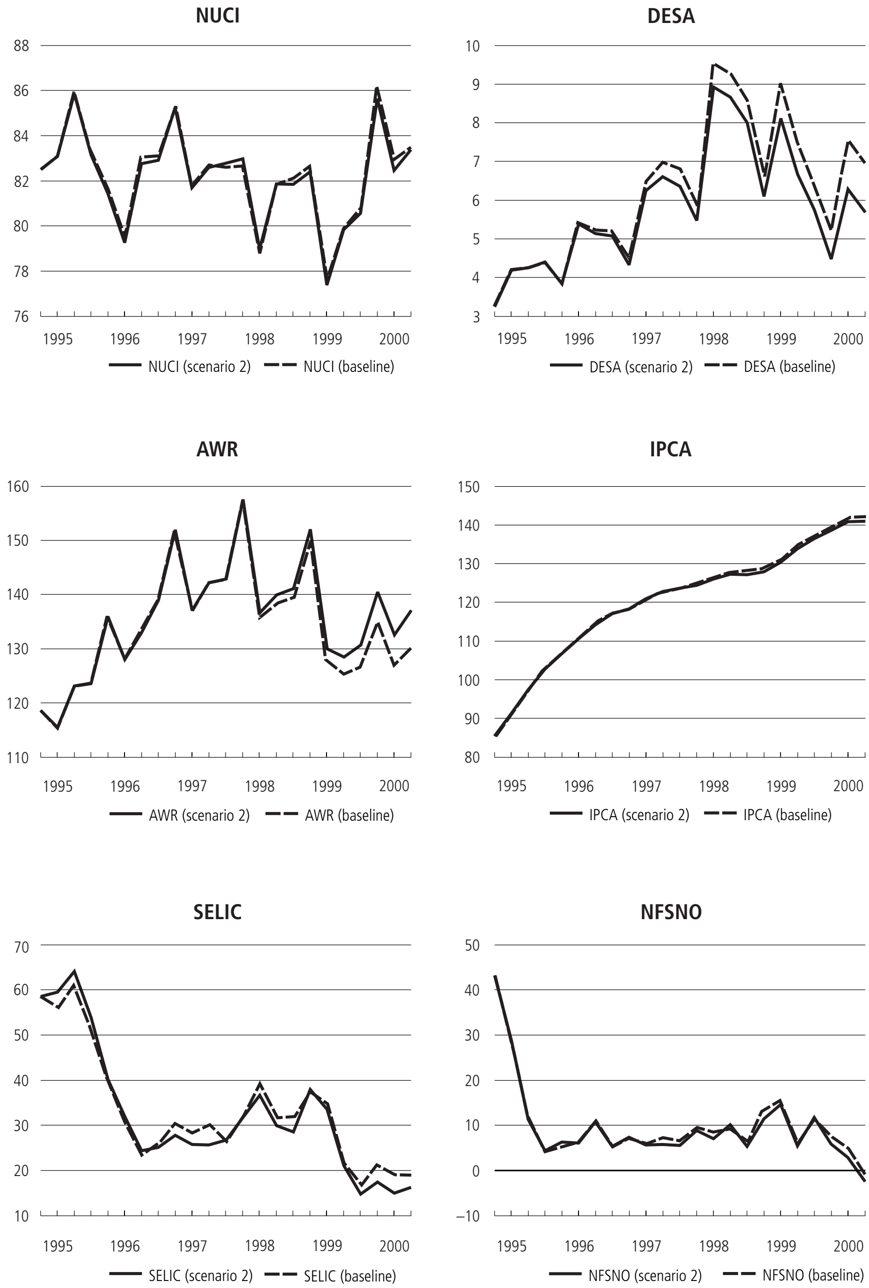


FIGURE 5A
POLICY SIMULATION—SELIC IS HELD CONSTANT
AFTER 1994Q3, CASE 3

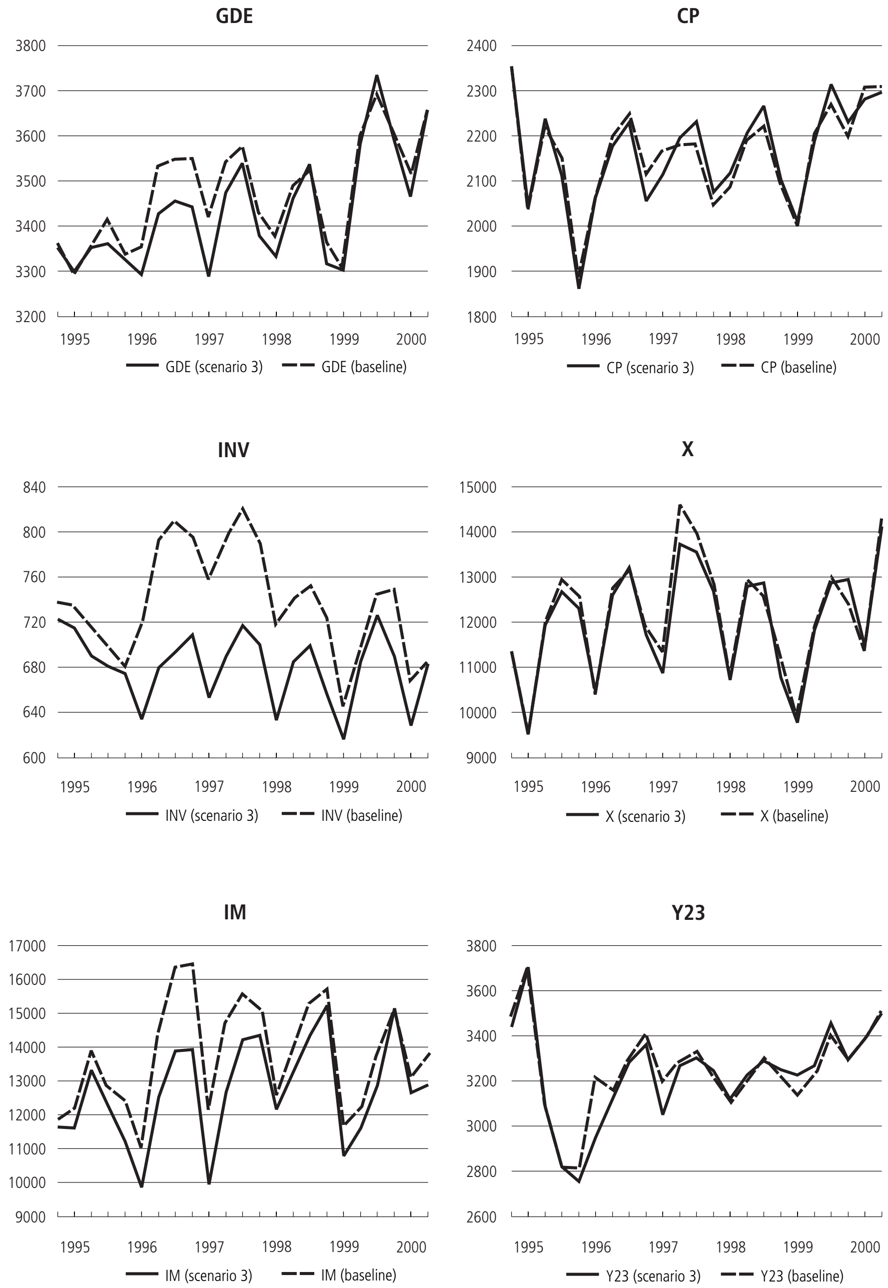


FIGURE 5B
POLICY SIMULATION—SELIC IS HELD CONSTANT
AFTER 1994Q3, CASE 3

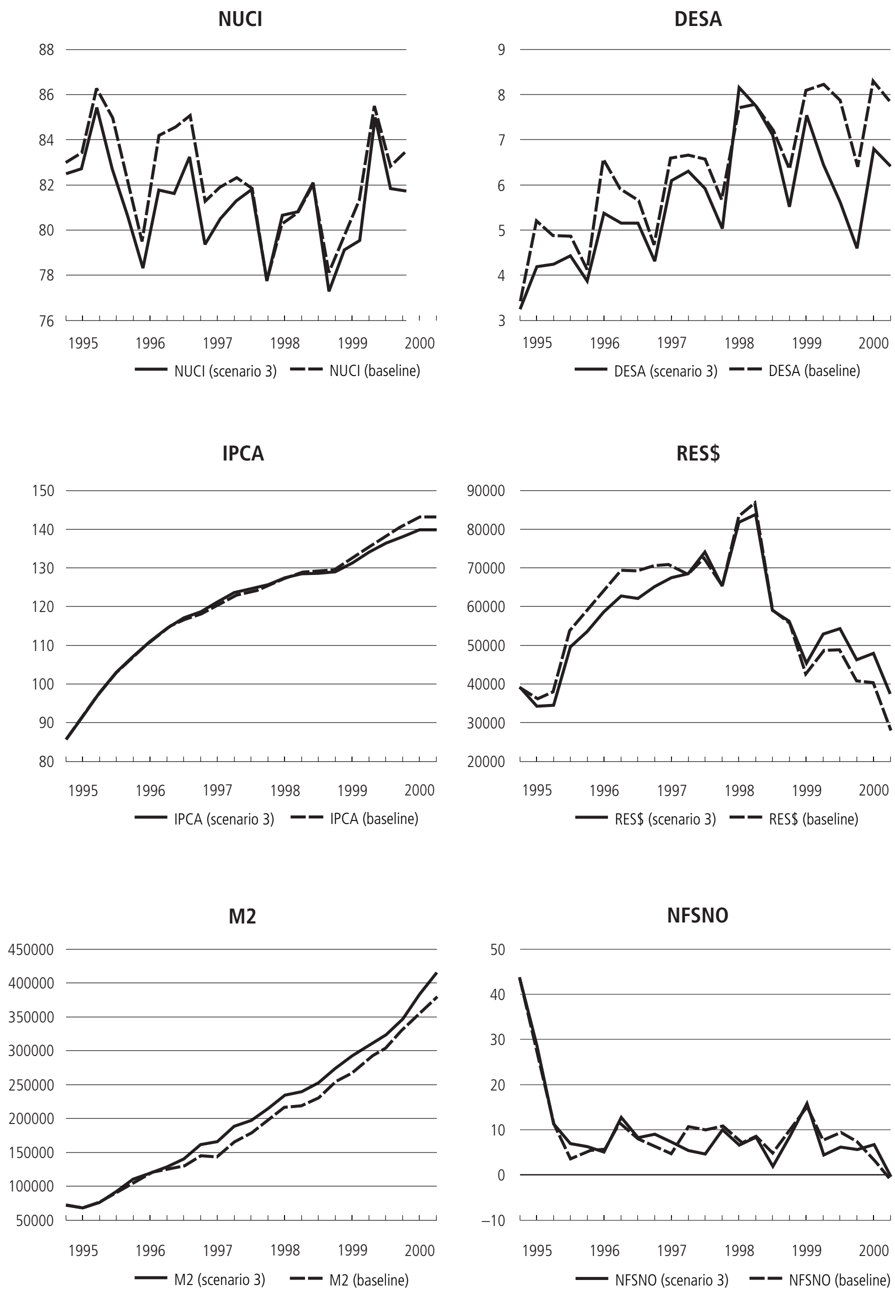


FIGURE 6A
POLICY SIMULATION—RATE IS HELD CONSTANT
AFTER 1994Q3, CASE 4

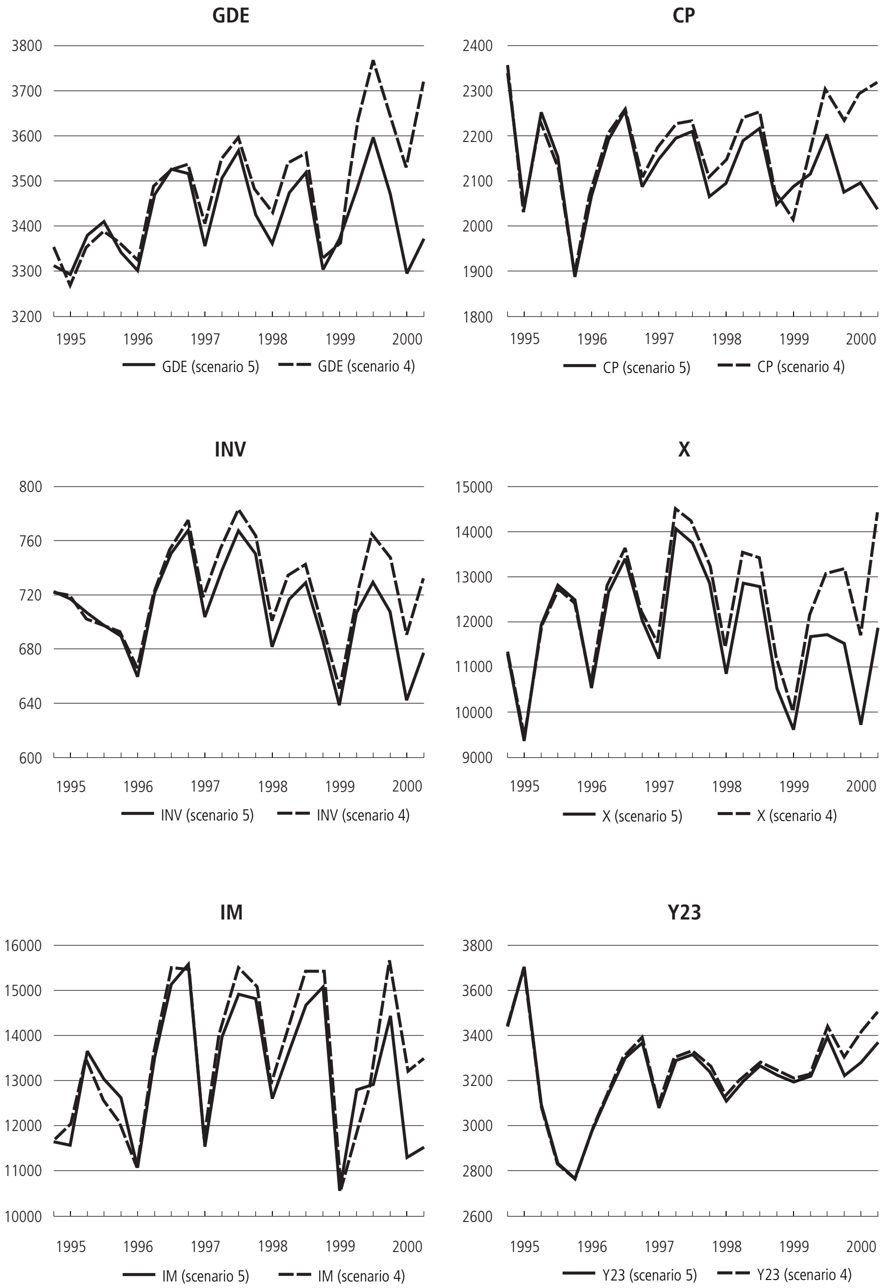
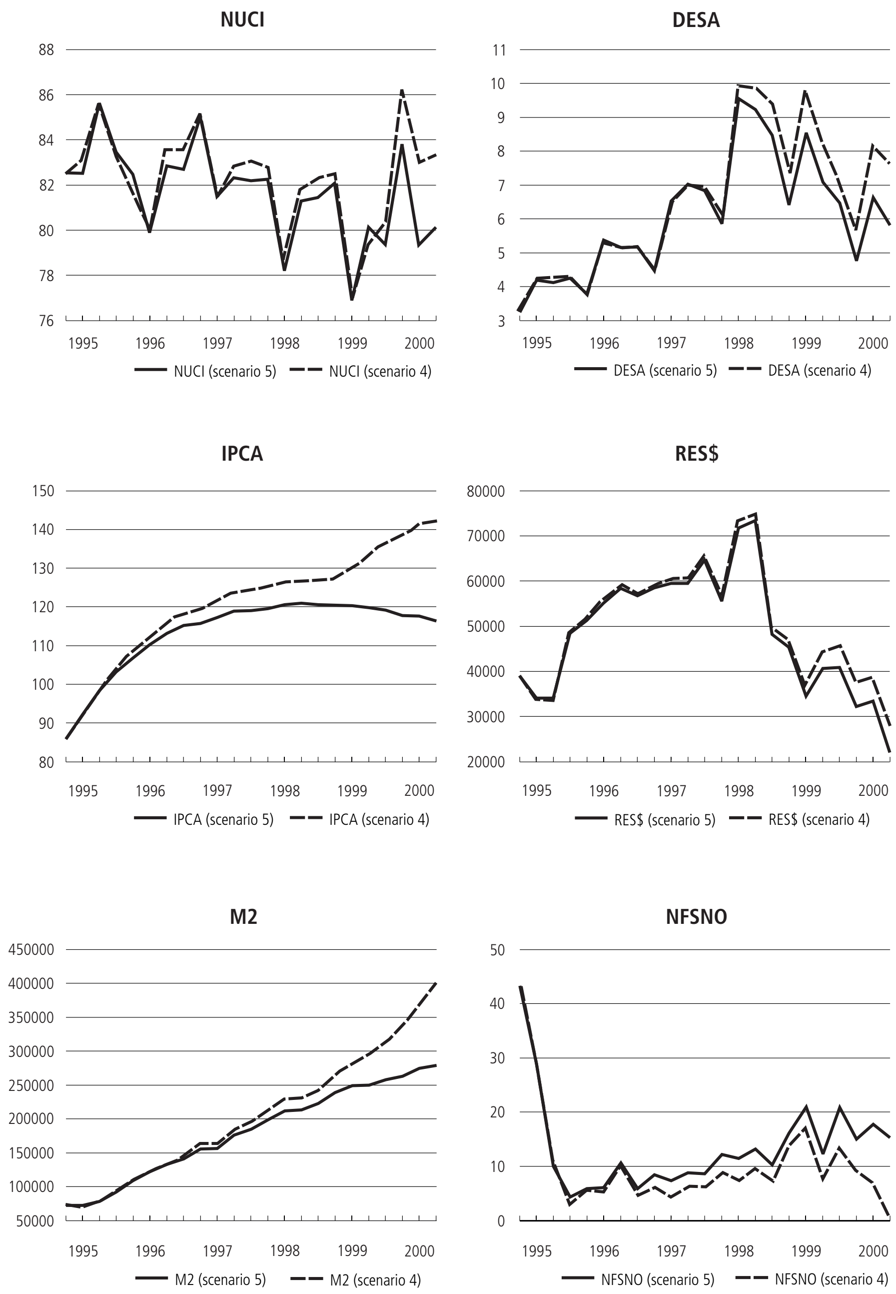


FIGURE 6B

POLICY SIMULATION—RATE IS HELD CONSTANT

AFTER 1994Q3, CASE 4



5 CONCLUSION

In this chapter, we first constructed a prototype quarterly econometric model for the Brazilian economy (1994Q4-2000Q2) with 26 endogenous variables, and found that this model performed well, with good final test results in Figure 1. We then estimated the reaction functions for the three variables (SELIC, M2 NFSNO), and found that this model with the three reaction functions (29 endogenous variables) performed well—see results of the final test in Figure 2. Finally, we undertook the following four simulations during the period of 1994Q4-2000Q2 using this model: Case (1) NFSNO is held constant after 1994Q3 in Figure 3, case (2) M2 is decreasing ten percent from the actual value after 1994Q3 in Figure 4, case (3) SELIC is held constant after 1994Q3 in Figure 5, and case (4) RATE is held constant after 1994Q3 in Figure 6. We conclude that these simulations show the expected effects of fiscal, monetary and exchange rate policies.

APPENDIX A

A Brazilian Quarterly Econometric Model (Versions 1 and 2)

A: Final Demand Sector

(1) Private Final Consumption Expenditure (CP)

$$CP/PTO = \underset{(5.03)}{0.1322} + \underset{(2.19)}{0.2903}*(YD(-1)/PTO(-1)) - \underset{(-3.16)}{0.0060}*(SELIC(-3)/SELIC(-4))$$

$$+ \underset{(1.62)}{1.11E{-}05}*(M2(-3)/IPCA(-3)) - \underset{(-1.28)}{0.0002}*(NFSNO(-1)) - \underset{(-2.69)}{0.0149}*(RATE/RATE(-1))$$

$$- \underset{(-1.13)}{0.0006}*(@TREND) + \underset{(6.46)}{0.0269}*(D94Q4) - \underset{(-3.26)}{0.0095}*(D95Q4)$$

$$+ \underset{(3.12)}{0.0067}*(@SEAS(1)) + \underset{(4.46)}{0.0115}*(@SEAS(2)) + \underset{(5.30)}{0.0091}*(@SEAS(3))$$

R^2 = 0.9305, RA^2 = 0.8609, *SE* = 0.0024, *SD* = 0.0063, *DW* = 2.51, F = 13.4

(2) Investment in Machinery and Equipment (INVM)

$$INVM/KR(-1) = \underset{(-2.44)}{-0.0138} + \underset{(1.89)}{0.0035}*(Y23(-1)/Y23(-2)) + \underset{(1.97)}{0.00014}*((NUCI(-3)+NUCI(-4))/2)$$

$$- \underset{(-2.47)}{0.0011}*(SELIC(-2)/SELIC(-3)) + \underset{(5.06)}{0.0040}*(SFDIR(-2)/SFDIR(-3))$$

$$+ \underset{(2.15)}{0.0005}*(IM(-2)/GDE(-2)) + \underset{(6.82)}{0.6534}*(INVM(-1)/KR(-2)) - \underset{(-2.52)}{0.0030}*(DESA(-3)/DESA(-4))$$

$$+ 0.0006*(D95Q1) - 0.0023*(@SEAS(1)) - 0.0011*(@SEAS(2)) - 0.0016*(@SEAS(3))$$

(0.81) (–4.07) (–1.80) (–1.90)

R^2 = 0.9421, RA^2 = 0.8841, *SE* = 0.0004, *SD* = 0.0010, *DW* = 1.71, F = 16.3

(3) Investment in Construction (INVC)

INVC/KR(–1) = –0.0106 + 0.0071*(GDP(–1)/GDP(–2))
(–1.34) (1.21)
+ 7.98E–05*((NUCI(–1)+NUCI(–2)+NUCI(–3))/3) – 0.00060*(SELIC(–1)/SELIC(–2))
(1.68) (–2.00)
+ 0.7584*(INVC(–1)/KR(–2)) – 0.0009*(D95Q2) – 0.0008*(D95Q3)
(7.18) (–3.32) (–2.66)
+ 0.00030*(@SEAS(1)) + 0.0012*(@SEAS(2)) + 0.0008*(@SEAS(3))
(1.21) (4.38) (3.70)
R^2 = 0.9233, RA^2 = 0.8703, *SE* = 0.0002, *SD* = 0.0006, *DW* = 2.00, F = 17.4

(4) Investment (INV)

INV=(INVM+INVC)/(1–0.026)

(5) Exports of Goods (X)

X/GDP(–1) = –14.390 + 12.110*(GDPUS(–1)/GDPUS(–2)) + 2.8653*(NUCI(–3)/NUCI(–4))
(–2.30) (1.97) (1.65)
+ 1.5081*(Y1/GDP(–1)) + 23337.2*(RATE(–2)/IGPDI(–2))
(2.40) (1.70)
+ 6.0812*((X(–1)+X(–2))/(KR(–1)+KR(–2))) + 0.3308*(D97Q2)
(3.21) (1.85)
– 0.4355*(@SEAS(1)) + 0.4911*(@SEAS(2)) + 0.4361*(@SEAS(3))
(–3.15) (3.58) (3.35)
R^2 = 0.9118, RA^2 = 0.8507, *SE* = 0.1465, *SD* = 0.3791, *DW* = 1.75, F = 14.9

(6) Imports of Goods (IM)

IM/GDP(–1) = –2.3921 + 5.2846*(GDE(–1)/GDE(–4)) – 290.75*(SELIC(–1)/IGPDI(–1))
(–1.50) (3.89) (–1.74)
+ 2.3209*(IM(–1)/(KR(–1)) + 0.4383*(RES$(–2)/KR(–2))
(1.97) (2.51)
– 27775.04*(RATE (–1)/IGPDI(–1)) – 0.6401*(D97Q1) – 0.5192*(@SEAS(1))
(–1.18) (–3.32) (–5.09)
+ 0.4848*(@SEAS(2)) + 0.2780*(@SEAS(3))
(3.53) (2.35)
R^2 = 0.9180, RA^2 = 0.8612, *SE* = 0.1655, *SD* = 0.4442, *DW* = 1.27, *F* = 16.2

(7) Net Exports (XMGSNF)

XMGSNF=(X–IM+SERNF$)*RATE*1000/IGPDI

(8) GDE

GDE=CP+CG+INV+XMGSNF

B: Supply and Capital Stock Sector

(9) GDP for Non–Primary Sector (Y23)

Y23/EMP(–1) = 0.0559 + 0.0505*((NUCI(–1)/100)*(KR(–1)/EMP(–1)))

(1.28) (2.18)

+ 0.0021*(M2(–1)/KR(–1)) + 0.0413*(SFDIR(–2)/SFDIR(–3))

(2.86) (6.42)

+ 0.0515*(D95Q1) – 0.0299*(D95Q3) – 0.0196*(D95Q4)

(11.8) (–6.42) (–4.30)

– 0.0088*(@SEAS(1)) + 0.0057*(@SEAS(2)) + 0.0100*(@SEAS(3))

(–3.40) (2.30) (3.62)

R^2 = 0.9616, RA^2 = 0.9350, *SE* = 0.0037, *SD* = 0.0145, *DW* = 2.57, F = 36.2

(10) GDP for Primary Sector

Y1=GDP–Y23

(11) Nominal GDP

GDPV=GDP*IGPDI

(12) Capital Stock

KR=KR(–1)+INV–DEPR

(13) Rate of Capacity Utilization (NUCI)

NUCI = 2.8631 + 41.574*(GDE(–1)/GDE(–4)) + 19.660*(Y23(–1)/EMP(–1))

(0.26) (5.79) (1.27)

+ 0.3934*(NUCI(–1)) – 1.6222*(SELIC(–1)/IPCA(–1)) + 0.8126*(FDIR/FDIR(–1))

(3.56) (–1.74) (3.05)

+ 2.0554*(D96Q1) – 2.3134*(D99Q3) – 3.4553*(@SEAS(1)) + 2.3790*(@SEAS(2))

(2.28) (–2.55) (–7.38) (3.48)

+ 0.9808*(@SEAS(3))

(1.70)

R^2 = 0.9288, RA^2 = 0.8694, SE = 0.6928, SD = 1.9171, DW = 1.89, F = 15.6

C: Income Sector

(14) Disposable Income

YD=(GDPV–TAX)/IGPDI

D: Labor Sector

(15) Rate of Unemployment (DESA)

DESA = –11.954 + 0.0262*(AWR(–2)) + 57.206*(GDE(–2)/EMP(–2))

(–2.02) (2.17) (1.49)

+ 5.8494*(KR(–2)/EMP(–2)) – 12.551*(NUCI(–1)/NUCI(–2))

(2.30) (–2.21)

+ 2.1985*(@SEAS(1)) + 1.5985*(@SEAS(2)) + 1.8633*(@SEAS(3))

(7.51) (4.35) (3.90)

R^2 = 0.9381, RA^2 = 0.9092, SE = 0.4470, SD = 1.4838, DW = 1.98, F = 32.5

(16) Employment

EMP=PTO*(1–DESA/100)

(17) Wage Rate (AWR)

LOG(AWR/AWR(–1)) = 0.4977 – 0.7851*LOG(EMP(–2)/EMP(–3))

(2.31) (–1.16)

+0.7276*LOG(NUCI(–1)/NUCI(–2)) – 0.0416*LOG((DESA(–3)+DESA(–4))/2)

(2.71) (–1.17)

+ 0.0601*LOG(IGPDI(–2)/IGPDI(–3)) + 0.0738*LOG(RATE(–2)/IPCA(–2))

(2.14) (2.01)

+ 0.4318*LOG(AWR(–2)/AWR(–3)) – 0.0421*(D95Q3) + 0.0601*(D96Q1)

(3.18) (–1.68) (1.94)

– 0.2039*(@SEAS(1)) – 0.0544*(@SEAS(2)) – 0.0715*(@SEAS(3))

(–12.1) (–3.35) (–2.22)

R^2 = 0.9639, RA^2 = 0.9278, *SE* = 0.0195, *SD* = 0.0725, *DW* = 2.44, *F* = 26.7

E: Price Sector

(18) General Price Index (IGPDI)

IGPDI/IGPDI(–1) = 0.8087 + 0.1085*(RATE/RATE(–1)) + 6487.7*(RATE(–1)/IGPDI(–1))

(8.62) (10.3) (16.1)

+ 0.0180*(M1/M1(–1)) + 0.0237*(AWR(–3)/AWR(–4)) + 0.2199*(GDE(–3)/GDE(–4))

(1.75) (1.41) (3.42)

– 0.0588*(KR(–1)/EMP(–1)) – 0.0020*(@TREND) – 0.0360*(D95Q4)

(–1.57) (–4.21) (–7.18)

– 0.0230*(D96Q4) – 0.0156*(@SEAS(1)) – 0.0152*(@SEAS(2)) – 0.0073*(@SEAS(3))

(–4.13) (–2.26) (–2.67) (–1.45)

R^2 = 0.9812, RA^2 = 0.9586, *SE* = 0.0039, *SD* = 0.0192, *DW* = 1.85, *F* = 43.4

(19) Consumer Price Index (IPCA)

IPCA/IPCA(–1)= 1.0209 + 0.0337*(RATE/RATE(–1)) + 3233.7*(RATE(–1)/IGPDI(–1))

(23.4) (3.63) (6.05)

+ 0.0392*(M2/M2(–1)) + 0.0003*((PIM(–3)+PIM(–4))/2) – 6.73E–07*(SELIC(–2))

(2.31) (1.11) (–1.39)

+0.0006*(NFSNO(–2)) – 0.0026*(@TREND) – 0.0130*(D96Q4)

(6.20) (–8.21) (–3.01)

+ 0.0063*(@SEAS(1)) +0.0040*(@SEAS(2)) – 0.0008*(@SEAS(3))

(2.37) (1.59) (–0.32)

R^2 = 0.9848, RA^2 = 0.9695, *SE* = 0.0038, *SD* = 0.0218, *DW* = 1.92, *F* = 64.6

F: Balance of Payments Sector

(20) Trade Balance (TB$)

TB$=X–IM

(21) Current Account Balance (CA$)

CA$=TB$+SER$+TUN$

(22) Foreign Direct Investment (FDI$)

FDI$ = 79844.3 + 16.9507*(GDE(–1)) – 143128.0*(GDPUS(–1)/GDPUS(–2))

(1.39) (3.85) (–2.53)

+ 7653.5*(RATE/RATE(–1)) + 0.2996*(FDI$(–1)) – 3709.5*(D95Q2)

(2.54) (1.81) (–2.30)

+ 66.988*(@SEAS(1)) + 3752.6*(@SEAS(2)) – 821.49*(@SEAS(3))

(0.08) (3.61) (1.05)

R^2 = 0.8857, RA^2 = 0.8203, *SE* = 1266.0, *SD* = 2986.8, *DW* = 2.15, *F* = 13.6

(23) Foreign Portfolio Investment(FPF$)

FPF$ – FPF$(–1) = – 4513.2 + 1435.8*(RATE) + 53.724*(SELIC–INTRUS)

(–1.85) (1.09) (1.51)

+ 7764.8*(D98Q1) – 11949.5*(D98Q3) – 8395.1*(D98Q4)

(3.81) (–5.74) (4.14)

+ 1268.6*(@SEAS(1)) + 1975.2*(@SEAS(2)) – 1547.4*(@SEAS(3))

(1.08) (1.74) (1.24)

R^2 = 0.8526, RA^2 = 0.7683, *SE* = 1849.1, *SD* = 3841.5, *DW* = 1.95, *F* = 18.6

(24) Capital Account Balance (CAP$)

CAP$=FDI$+FPF$+CAPOTH$

(25) Real Foreign Direct Investment (FDIR)

FDIR=FDI$*RATE*1000/IGPDI

(26) Accumulation of Real Foreign Direct Investment (SFDIR)

SFDIR=SFDIR(–1)+FDIR

(27) Balance of Payments (BP$)

BP$=CA$+CAP$

(28) Foreign Reserves (RES$)

RES$=RES$(–1)+BP$+RESE$

G: Reaction Function Sector

(29) Nominal Interest Rate (SELIC)

SELIC= – 24.434 – 0.2733*(BP$(–2)/BP$(–3)) – 822486.9*(RATE(–1)/IGPDI(–2))

(–0.34) (–1.31) (–3.70)

– 34.279*(M2(–1)/M2(–2)) + 0.0235*(GDE(–2)) + 0.3638*(NFSNO(–2))

(–1.55) (1.56) (2.60)

+34.618*(FDIR(–1)/SFDIR(–1))+ 0.6280*(SELIC(–1))

(1.68) (5.45)

–7.0579*(@SEAS(1)) – 4.9176*(@SEAS(2)) – 2.5570*(@SEAS(3))

(–2.48) (–1.84) (–0.84)

$R^2 = 0.9533$, $RA^2 = 0.9143$, $SE = 3.9730$, $SD = 13.574$, $DW = 2.52$, $F= 24.5$

(30) Money Supply (M2)

(M2/IGPDI(–1))/GDE(–1)

=0.0028 – 0.0002*(IPCA(–2)/IPCA(–3)) – 2.92E–05*(SELIC/SELIC(–2))

(3.80) (–6.24) (–0.67)

– 0.0024*(GDE(–1)/GDE(–2)) + 3.96E–09 *(CA$(–1)) – 1.60E–09*(CAP$(–1))

(–3.37) (0.64) (–1.31)

– 8.23E–05*(RATE(–1)/RATE(–2))+ 1.0108*(M2(–1)/IGPDI(–2)/GDE(–2))

(–1.02) (31.9)

– 7.24E–05*(@SEAS(1)) – 9.21E–05*(@SEAS(2)) + 1.87E–05*(@SEAS(3))

(–1.81) (–2.51) (0.59)

R^2 = 0.9928, RA^2 = 0.9867, *SE* = 3.41e – 05, *SD* = 0.0003, *DW* = 2.27, *F* = 164.8

(31) Public Sector Borrowing Requirements (NFSNO)

NFSNO=8.8478 – 0.0003*(BP$(–2)) – 0.0007*(IGPDI(–2))

(0.18) (–4.61) (–6.48)

+9.0740*(SELIC(–3)/SELIC(–4)) – 1.0489*(NUCI(–2)) + 429.52*(GDE(–2)/EMP(–2))

(5.43) (–2.92) (2.87)

+20.020*(Y23(–1)/Y23(–2))

(2.48)

– 0.0928*(@SEAS(1)) + 3.8260*(@SEAS(2)) – 2.8568*(@SEAS(3))

(–0.06) (1.91) (–1.39)

R^2 = 0.9591, RA^2 = 0.9308, *SE* = 2.4249, *SD* = 9.2168, *DW* = 2.15, *F* = 33.9

(option)

RATE=0.6155+0.3980*(D9498*(IPCA(–1)/IPCAUS(–1)))

(9.93) (8.01)

+ 0.9915*(D9900*(IPCA(–1)/IPCAUS(–1))) – 0.0963*(D94Q4) + 0.1055*(D98Q4)

(21.2) (–1.42) (1.59)

– 0.0410*(@SEAS(1)) – 0.0364*(@SEAS(2)) + 0.0126*(@SEAS(3))

(–1.07) (–0.96) (0.33)

R^2 = 0.9824, RA^2 = 0.9751, *SE* = 0.0589, *SD* = 0.3733, *DW* = 1.02, *F* = 135.2

APPENDIX B

List of Variables of the Quarterly Econometric Model (Versions 1 and 2)

AWR	Wage Rate	Index
BP$	Balance of Payments	Millions of US Dollars
CA$	Current Account	Millions of US Dollars
CAP$	Capital Account	Millions of US Dollars
CAPOTH$*	Other Foreign Investment (CAP$)	Millions of US Dollars
CG*	Government Final consumption	Millions of Reais, 1990 prices
CP	Private Final consumption	Millions of Reais, 1990 prices
DESA	Rate of Unemployment	Percent
DEPR*	Depreciation for Capital stock	Millions of Reais, 1990 prices
DiQj*	Dummy	1(when i year j quarterly), 0(other)
EMP	Employment	Millions of Persons
FDI$	Foreign Direct Investment	Millions of US Dollars
FDIR	Real Foreign Direct Investment	FDI$*RATE*1000/IGPDI
FPF$	Foreign Portfolio Investment	Millions of US Dollars
GDE	GDE	Millions of Reais, 1990 prices
GDP	GDP	Millions of Reais, 1990 prices
GDPV	Nominal GDP	Thousands of Reais
GDPUS*	GDP in the US	Millions of US Dollars, 1990 prices
IPCA	CPI	Index
IPCAUS*	CPI in the US	Index
IGPDI	General Price	Index %
IM	Imports of Goods	Millions of Reais, 1990 prices
INTRUS*	Nominal Interest Rate in US	Percent

INV	Investment	Millions of Reais, 1990 prices
INVC	Investment in Construction	Millions of Reais, 1990 prices
INVM	Investment in Machinery and Equipment	Millions of Reais, 1990 prices
KR	Capital Stock	Millions of Reais, 1990 prices
M1*	Narrow Money Supply	Millions of Reais
M2	Wide Money Supply	Millions of Reais
NFSNO	Necessity of Financial Sector	Percent
NUCI	Rate of Capacity Utilization	Index
PIM*	Prices for Import of Goods	Index
PTO*	Economic Active Population	Millions of Person
RATE*	Nominal Exchange Rate	Real per US Dollars
RES$	Foreign Currency Reserve	Millions of US Dollars
RESE$*	Error of Foreign Currency Reserve	Millions of US Dollars
SELIC	Nominal Interest Rate	Percent
SER$*	Service Balance	Millions of US Dollars
SERNF$*	Net Non-Factor Services	Millions of US Dollars
SFDIR	Accumulation of real Foreign Direct Investment	FDIR(94Q1)+.... +FDIR(2000Q2)
TAX*	Tax Revenue	Thousands of Reais
TB$	Trade Balance	Millions of US Dollars
TUN$*	Transfers	Millions of US Dollars
X	Exports of Goods	Millions of US Dollars
XMGSNF	Net Exports (Exports minus Imports of Goods)	Millions of US Dollars
Y1	GDP for Primary Sector	Millions of Reais, 1990 prices
Y23	Nominal GDP for Primary Sector	Millions of Reais, 1990 prices
YD	Disposable Income	Thousands of Reais, 1990 prices

*: exogenous variable

FIGURE A1
FLOWCHART OF THE BRAZILIAN QUARTERLY ECONOMETRIC MODEL (VERSION 1)

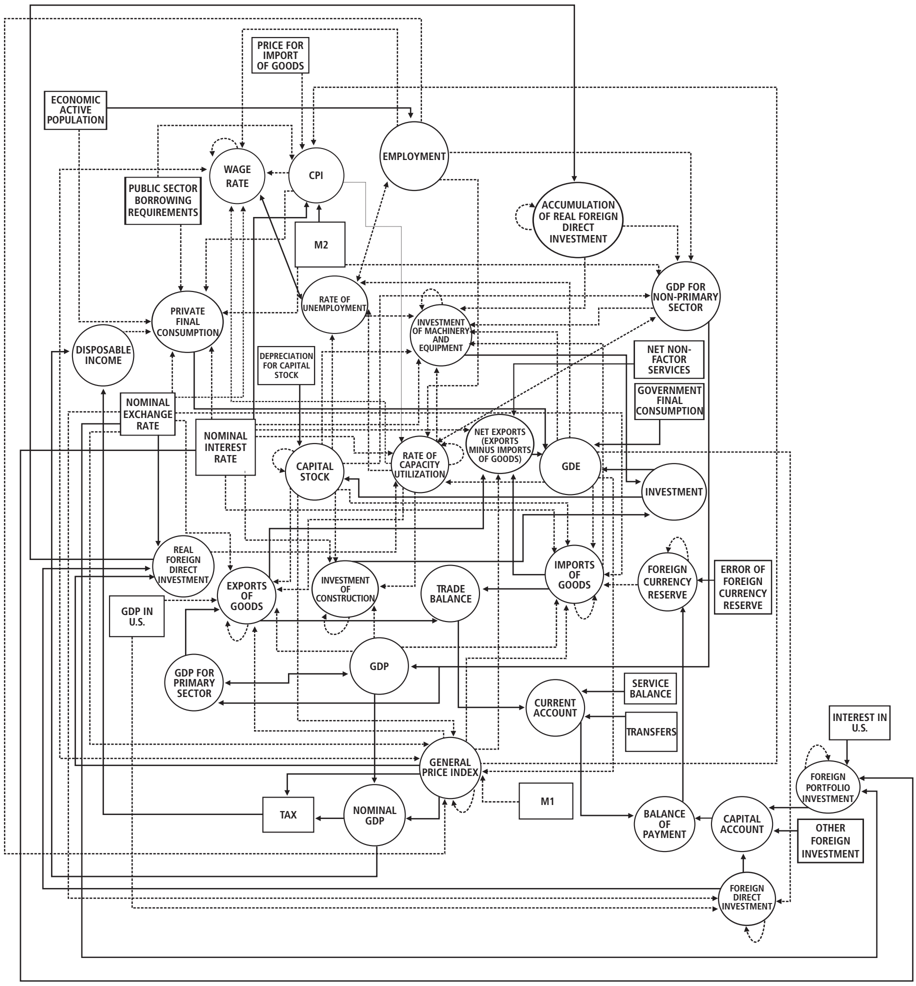
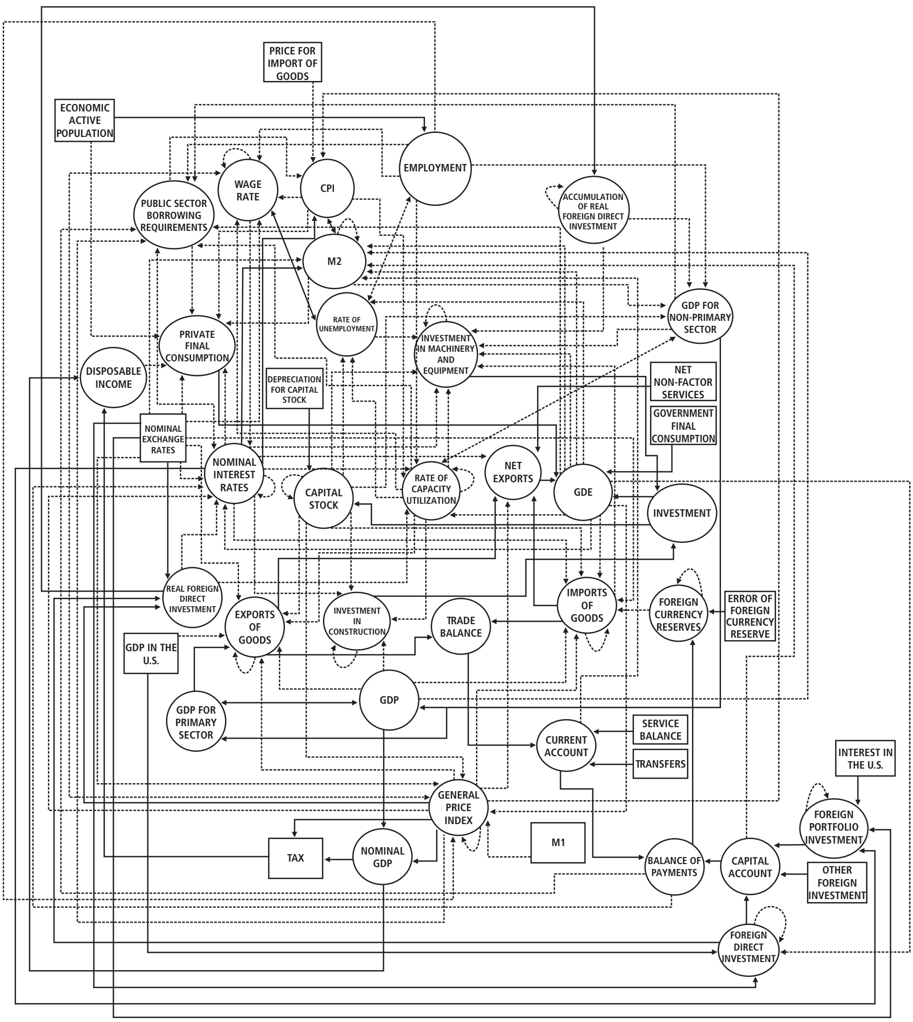


FIGURE A2
FLOWCHART OF THE BRAZILIAN QUARTERLY ECONOMETRIC MODEL (VERSION 2)



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CHAPTER 5

CONSTRUCTION OF A MONTHLY ECONOMETRIC MODEL

Takao Fukuchi

1 INTRODUCTION

This chapter attempts to construct a monthly econometric model for the recent Brazilian economy. The basic structure of the Brazilian economy has changed drastically from the past structure of the hyperinflation period. But when the basic economic structure is changing, the expected effects of fiscal and monetary policies, and the optimum policy mix to achieve the target set also change. It is therefore of crucial importance to understand the main features of this new economic structure, in order to be able to formulate policy packages that will foster sound economic growth in the future.

Thus, it would be useful to construct a *short-term* model on a monthly basis to clarify the current economic structure and quantitatively analyze the interaction between monetary and real aspects, as well as policy effects. On the other hand, there are a lot of monthly data readily available, such as exchange rate, interest rate, money supplies, various price indices, production index, exports and imports. So it would be worthwhile to collect all relevant data, to discover the possibility of constructing a monthly model and to analyze both the basic tendency and certain policy effects. However, the basic national account statistics are not yet fully prepared for the three aspects of the economy—expenditure, production and distribution—on an annual and quarterly basis. So I have decided to collect monthly data from various sources, and to combine them with expenditure and production side variables (consumption, investment, exports, imports; primary, secondary, tertiary sector GDP), which I have transformed from the quarterly basis to monthly, and have constructed a prototype model.

The structure of this chapter is as follows. Section 2 briefly summarizes the recent trends of the Brazilian economy in the observation period. Section 3 reports the results of the construction of the Version 1 Model. Section 4 reports the results of the extension to the Version 2 Model by estimation and inclusion of reaction functions. Section 5 shows the results of specific simulation studies. Section 6 explains the tentative construction of the decision model. Section 7 concludes the paper.

2 CURRENT TREND OF BRAZILIAN ECONOMY

After the Real Plan, the Brazilian economy went through a transitory period in which the government aimed to realize a sound economic growth while containing inflation within a controllable range. In this paper, I adopted the observation period of 37 months (June 1996-June 2000), which includes each of the 18 months before and after the devaluation of January 1999. In the first 18 months, there was a severe balance of payments crisis, and the foreign currency reserves decreased by a half due to a strong *short-term* capital flight. The exchange rate regime change and accompanying devaluation in January 1999 drastically changed the situation. In the latter 18 months, exports boosted and GDP increased rapidly in 2000. The trend of the real exchange rate is displayed in Table 1 (also refer to Figure 18).

TABLE 1
TRENDS OF NOMINAL AND REAL EXCHANGE RATES

(1) PERIOD	(2) EXCHANGE RATE	(3) IGPDI	(4) IPCA	(5) (2)/(3)	(6) (2)/(4)
1997.06	1.0769	0.9591	0.9731	1.1228	1.1066
1998.12	1.2087	1.0000	1.0000	1.2087	1.2087
1999.01	1.9832	1.0287	1.0070	1.9278	1.9694
1999.02	2.0648	1.0743	1.0176	1.9219	2.0290
1999.06	1.7695	1.1032	1.0396	1.6039	1.7020
1999.12	1.7900	1.2202	1.0894	1.4669	1.6431
2000.06	1.8000	1.2588	1.1072	1.4299	1.6257

Sources: Banco Central do Brasil, FGV and IBGE.

The real exchange rate, when deflated by the general price (IGPDI) or consumer price (IPCA) index, was only gradually depreciated by six to seven percent in two years (1997-1998). But the trade balance was generally negative in 1997-1998, suggesting that the exchange rate was gradually overvalued. To improve the balance of payments, the exchange rate was rapidly devalued in January-February 1999 by about 70 percent. This big devaluation greatly impacted all economic activities. Naturally, it fueled the export expansion, which had repercussion in various economic activities through various channels. The general price index (IGPDI) increased about 20 percent, while the consumer price (IPCA) increased by only 10 percent. The real exchange rate, deflated by IGPDI, increased by 26 percent, while the one deflated by IPCA by 20 percent. So the degree of the exchange rate *pass-through* was only about 28 to 37 percent (=20 or 26 divided by 70). Brazil had earlier had a widespread array of backward or forward indexation mechanisms. Therefore, a relatively small inflation and a low degree of *pass-through* indicates a big structural change in the economic dynamics.

Recently, in 2000, the Brazilian economy showed good recovery. The rate of unemployment peaked last February at 8.16 percent, but went down to 6.8 per cent in October, and 6.2 percent in November, the lowest level in the past three years. Increases of the minimum monthly salary to R$ 180 (US$ 92) may exert some pressure on private sector wages. Imports increased by 1.32 percent to US$ 55.8 billion, and exports increased by 14.7 percent to US$ 55.1 billion, so the trade deficit decreased from US$ 1.2 billion in 1999 to US$ 691 million. These favorable domestic and external issues benefited the international ratings of the Brazilian economy. Standard and Poor's raised the foreign currency rating of Brazil from B plus to BB minus, and its local currency rating from BB to BB plus. In 2001, the growth rate may reach 4 percent, while inflation is controlled, if without serious external disturbances.

So some important questions are:

(1) Why and how has the propensity to import increased quickly?

(2) Why have exports increased steadily?

(3) Why was the degree of *pass-through* rather low?

(4) Why did a dual development pattern (stagnated domestic sector and animated foreign sector activity) exist?

(5) How were the fiscal and monetary instruments (SELIC, M1, M2, NFSNO) changed with respect to important macroeconomic targets?

(6) How were these fiscal and monetary policies effective in absorbing the external shocks and achieving macroeconomic targets?

Thus, one of the main tasks for quantitative modeling is to sketch out the structure of this current transitory period, analyzing the mechanisms and functions of both the brake and the accelerator, and of fiscal and monetary policies. Another purpose of this modeling exercise is to check the consistencies between statistical indices from various sources, and to check the possibility of constructing a macro-model that makes a combined use of these various indices.

3 ESTIMATION OF MONTHLY ECONOMETRIC MODEL (VERSION 1)

The basic structure of the model is as follows. The whole model contains 21 endogenous variables: *expenditure-side* variables including consumption (CONS), investment (INV), exports (X) and imports (IM), and GDE; *production-side* variables including primary, secondary, tertiary GDP; real variables including the utilization index of the capital stock (NUCI), real wage (AWR), employment (EMP), unemployment rate (DESA); price variables such as the m consumer price index

(IPCA), wholesale price (IGPDI); the balance of payments variables (trade balance, current balance, balance of payments and foreign currency reserves).

The main differences compared with the previous modeling work [Fukuchi (September 2000)] are: (1) the estimation period includes the recent three years (June1997- June 2000). Some estimated equations use fairly long lags, so the data was prepared for five years (January 1996-December 2000). The data for July-December 2000 are utilized for simulation purposes. (2) The GDP of the primary sector was endogenously explained. (3) I changed the consumer price index to IPCA, because it is the official inflation target. (4) I explained the unemployment rate and wage rate, so the trend of the labor market is endogenously determined. (5) The balance of payments variables, such as the current account balance, the balance of payments and the foreign currency reserves, are endogenously explained so that the effects of devaluation through the change in the balance of payments and foreign currency can be adequately tracked. (6) The overall fitting was improved by applying the new criterion.

In all of the estimated equations, the explaining variables in principle do not contain any current endogenous variables, so OLS estimations do not incur heavy simultaneity errors, except the production function and the import function. I set the estimation criteria as follows: (1) all explained variables on the left-hand-side are deflated by a suitable variable to eliminate the steady trend. In this way, I tried to avoid the possible bias caused by spurious correlation, which can occur from the existence of common trends between explained and explaining variables. (2) I required the determination coefficient to be higher than 0.95 so as to secure a good fitting at a single equation estimation, and all t-values bigger than 1.0 so as to secure the explaining power of each explaining variable. (3) I required all MAPEs in the last five months to be less than 10 percent so as to secure a sufficiently good fitting. (4) I decided not to employ any dummy variables, because they contribute to improving the fitting, but it is difficult to assign them reasonable explanations. Instead of using dummy variables, I added the special term, which is a linear combination of foreign portfolio investment, FiFPF$, to the i-th equation. I interpret that (FPF$) manifests the expectation about the movements of the Brazilian economy, so that the influences of the changing expectation of various economic entities can be expressed by functions of FPF$.

LIST OF VARIABLES

Endogenous Variables (21):

(Symbol)	(Name)	(unit)
GDE:	GDE	(R$ 1 billion)
GDP:	GDP	(R$ 1 billion)
GDPN:	Per Capita GDP	(R$ 1.000)
Y1:	GDP of Primary Sector	(R$ 1 billion)
Y2:	GDP of Secondary Sector	(R$ 1 billion)
Y3:	GDP of Tertiary Sector	(R$ 1 billion)
CONS:	Consumption Expenditure	(R$ 1 billion)
INV:	Investment	(R$ 1 billion)
X:	Exports	(R$ 1 billion)
IM:	Imports	(R$ 1 billion)
KR:	Capital Stock	(R$ 1 billion)
NUCI:	Capacity Utilization Rate Index	(index)
DESA:	Rate of Unemployment	(percent)
EMP:	Employment	(US$ 1 million)
AWR:	Wage Rate	(index)
IPCA:	Consumer Price Index	(index)
IPGDI:	General Price Index	(index)
TB$:	Trade Balance	(US$ 1 million)
CA$:	Current Account Balance	(US$ 1 million)
BP$:	Balance of Payments	(US$ 1 million)
RES$:	Foreign Currency Reserves	(US$ 1 million)

Exogenous Variables (18)

(Symbol)	(Name)	(unit)
BPE$:	Error Term of Balance of payments	(US$ 1 million)
CAP$:	Capital Balance	(US$ 1 million)

DPI_Y:	Ratio of Internal Debt to GDP	(percent)
DPE_Y:	Ratio of External Debt to GDP	(percent)
DUMDEC:	December Dummy	(1 in December)
FPF$:	Portfolio Foreign Investment	(US$ 1 million)
GDPUS:	GDP of the U.S.A.	(US$ 1 trillion)
KFDI:	Real Stock of Foreign Direct Investment	(R$ 1 billion)
M1:	Narrow Money Supply	(R$ 1 billion)
M2:	Wide Money Supply	(R$ 1 billion)
FDI$:	Foreign Direct Investment	(US$ 1 million)
PFP$:	Foreign Portfolio Investment	(US$ 1 million)
POIL$:	Oil Price	(US$ per barrel)
POP:	Population	(1 million)
PTO:	Economical Active Population	(1 million)
SELIC:	Interest Rate	(percent)
RATE:	Exchange Rate	(real per dollar)
SERF$:	Service Balance	(US$ 1 million)
T:	Time Trend	(January 1995=1)

Monthly Model of Brazilian Economy (June 1997-June 2000: 37 samples)
[Version 1: Fiscal & Monetary Instruments (SELIC, M1, M2, NFSNO) are exogenous]

(E-1) Consumption Expenditure (CONS)

(CONS)/(POP)(–1)*100=471.36–6.084*(GDE)(–1)/(POP)(–1)+0.006647*((GDE)(–)
(0.49) (–1.52) (1.54)
/(POP)(–))^2-4.447*(SELIC)(–1)/(SELIC)(–5)+1680E03*(NFSNO)(–)/(KR)(–1)
(-3.13) (4.27)
+0.0003432*(M2)(–2)/(IPCA)(–2)-0.0001969*(M2)(–4)/(IPCA)(–4)
(3.44) (-2.03)
–6.663*(DESA)(–1)+1867*(POP)–1)/(POP)(–2)–119.5*(DES)(–1)/(GDE)(–1)

(-5.61) (8.24) (-2.95)

–16.34*(RATE)(–1)/(RATE)(–2)–22.55*(RATE)(–1)/(RATE)(–7)

(–3.18) (–4.46)

–154.6*(IPCA)(–4)/(IPCA)(–13)-333.0*(IGPDI)(–1)/(IGPDI)(–2).

(–2.59) (–3.40)

–22.30*(POIL$)(–1)/(POIL$)(–3)+F1(FPF$)+u

(–4.07)

R^2=0.9657, RA^2=0.9315, *SE*=2.434, *SD*=9.305, *DW*= 2.70, *F*=28.21

(E-2) Investment Expenditure (INV)

(INV)/((KR)(–1))*1000=42.053+6.923*(GDP)(–1)/(GDP)(–7)+0.08971*(NUCI)(–9)

(2.49) (1.95) (1.73)

–0.02224*((SELIC)(–8)–(IPCA)(–8)+(IPCA)(–9))+59.18*(M2)(–2)/KR(–2)

(–1.14) (9.58)

+63.55*(IM)(–1)/(GDE)(–1)+464.1*(IM)(–2)/(KR)(–2)–0.7709*(DESA)(–1)

(3.21) (3.60) (-2.80)

–46.94*(IGPDI)(–1)/(IGPDI)(–2)–146.4*(KFDI)(–1)/(KR)(–1)+F2(FPF$)+u

(–3.07) (–16.65)

R^2 = 0.9911, RA^2 = 0.9877, *SE* = 0.5880, *SD* = 5.3190, *DW* = 1.57, *F* = 291.63

(E–3) Capital Stock (KR)

(KR) = (1–0.005)*(KR)(–1) + (INV)

(E–4) Exports (X)

(X)/((KR)(–7))*E04=–1531.97+0.4202*(GDPUS)(–3) –1.298*(NUCI)(–7)

(–1.96) (1.87) (–1.88)

–38.11*(GDE)(–8)/(GDE)(–12)+140.4*(Y1)(–7)/(Y1)(–8)

(–1.09) (1.86)

+344.78*(RATE)(–1)/(IGPDI)(–1) +15.42*(RATE)(–4)/(IGPDI)(–4)

(7.02) (2.00)

+38.28*(RATE)(–7)/(RATE)(–10)+1121*(IM)(–10)/(KR)(–11)
(3.51) (1.36)
+220.5*(KR)(–7)/(KR)(–12) –1721*(KFDI)(–6)/(KR)(–6)
(1.70) (–2.38)
+2.651*(POIL$)(–7)+F4(FPF$)+u
(3.15)

R^2=0.9678, RA^2 = 0.9390, SE = 4.51, SD = 18.28, DW = 2.64, F = 33.61

(E-5) Imports (IM)

(IM)/(KR)(–7))*(IGPDI)/(RATE)*1000=–7.692+0.7653*(SELIC)(–1)/(SELIC)(–3)
(–1.34) (3.03)
+1.050*(SELIC)(–4)/(SELIC)(–9)+ 29.63*(RES$)(–10)/(KR)(–10)
(4.47) (2.81)
+18.60*(M2)(–3)/(KR)(–3)+1.813*(POIL$)(–4)/(POIL$)(–7)
(2.23) (2.38)
–2.126*(RATE)(–1)+1.785*(RATE)(–10)–0.06680*(NUCI)(–11)
(–4.09) (1.73) (-1.30)
–6.781*(INV)(–2)/(INV)(–13)+207.7*(INV)(–11)/(KR)(–11)
(–2.90) (4.89)
+8.409*(IGPDI)(–4)/(IGPDI)(–11)+F5(PFP$)+u
(2.36)

R^2 = 0.9930, RA^2 = 0.9861, SE = 0.328, SD = 2.785, DW = 2.62, F = 143.25

(E-6) GDE

(GDE) = (CONS)+(INV)+(X) – (IM)

(E-7) GNP

(GNP) = (GDE)

(E-8) Per Capita GDP (GDPN)

(GDPN) = (GDP)/(POP)

(E-9) Capacity Utilization Rate (NUCI)

(NUCI)/(GDP)*(KR)(–1) = 198.71+0.6183*(NUCI)(–1)/(GDE)(–1)*KR(–2)

(0.47) (5.03)

–9076*(EMP)(–1)/(KR)(–1)+11.96*(SELIC)(–1)/(SELIC)(–3)

(–2.63) (1.37)

+880.3*(IPCA)(–1)/(IPCA)(–7)–5.693*(PTO)(–7)/(POP)(–7)

(3.28) (-2.03)

+39.59*(RATE)(–1)/(RATE)(–5)-152.1*(IM)(–1)/(Y2)(–2)+F9(PFP$)+u

(2.03) (–1.07)

$R^2 = 0.9854$, $RA^2 = 0.9812$, $SE = 16.64$, $SD = 121.53$, $DW = 2.01$, $F = 236.2$

(E-10) GDP of Primary Sector (Y1)

(Y1)/(KR)(–7)*1000 = –32.03+34.03*(M2)(–7)/(KR)(–7)+0.5031*(IM)(–7)/(IM)(–10)

(–2.50) (10.75) (1.72)

+213.6*(INV)(–7)/(KR)(–8)+14.64*(GDE)(–1)/(GDE)(–2)

(11.53) (4.38)

+4.008*(CONS)(–1)/(CONS)(–7)+20.72*(IPCA)(–12)/(IGPDI)(–12)

(2.39) (3.95)

+3.838*(KFDI)(–7)/(KR)(–6)–0.1509*(PTO)(–3)/(POP)(–3)

(7.01) (-2.31)

–0.7595*(X)(–1)/(X)(–12)+u

(–2.29)

$R^2 = 0.9935$, $RA^2 = 0.9914$, $SE = 0.2480$, $SD = 2.681$, $DW = 1.80$, $F = 464.1$

(E-11) GDP of Secondary Sector (Y2)

(Y2)/(KR)(–7)*E03 = 46.36+73.80*(M2)(–1)/(KR)(–1)+107.6*(M2)(–5)/(KR)(–5)

(3.01) (6.19) (6.34)

–751.4*(INV)(–2)/(KR)(–3)+0.1149*(GDE)(–1)/(POP)(–1)

(–4.49) (5.94)

–0.002324*(GDE)(–7)/(POP)(–7)+3.618*(RARE)(–1)/(IPCA)(–1)

(–1.36) (3.78)

–1.610*(T)+u

(–18.48)

R^2 = 0.9963, RA^2 = 0.9955, SE = 0.81, SD = 12.08, DW = 1.55, F = 1141.4

(E-12) GDP of Tertiary Sector (Y3)

(Y3) = (GDP) – (Y1) – (Y2)

(E-13) Rate of Unemployment (DESA)

(DESA) = 245.64+2.281*(AWR)(–2)/(AWR)(–3)+0.7192*(GDE)(–5)/(EMP)(–5)

(4.35) (2.13) (1.69)

+0.1279*(PTO)(–2)/(POP)(–2)–2.206*(KFDI)(–4)/(KFDI)(–8)

(2.47) (-3.19)

+0.1404*(KR)(–2)/(EMP)(–2)–243.9*(KR)(–2)/(KR)(–3)

(1.40) (–4.77)

+0.4154*(RATE)/(RATE)(–2)–0.2178*(T)+F13(FPF$)+u

(1.05) (–5.69)

R^2 = 0.9667, RA^2 = 0.9479, SE = 0.1685, SD = 0.7389, DW = 2.66, F =51.44

(E-14) Employment (EMP)

(EMP) = (PTO)*(1–(DESA)/100)

(E-15) Wage Rate (AWR)

(AWR)/(AWR)(–1)=6.2102-3.914*(EMP)(–1)/(EMP)(–2)+0.007597*(NUCI)(–1)

(4.41) (–3.39) (7.04)

+0.005443*(NUCI)(–2)+0.003689*(NUCI)(–7)–0.02369*(DESA)(–1)

(3.38) (3.63) (-6.68)

+0.005075*(DESA)(–7)–0.5197*(IPCA)(–1)/(IPCA)(–7)

(2.36) (-3.90)

+0.02456*(RATE)(–1)/(RATE)(–3)+0.006686*(GDE)(–1)/(POP)(–1)

(1.61) (2.59)

–0.007378*GDE)(–2)/(POP)(–2)–0.7183*(GDE)(–1)/(EMP)(–1)

(–2.88) (–2.72)

+0.7802*(GDE)(–2)/(EMP)(–2)–0.1300*(GDE)(–3)/(EMP)(–3)

(2.90) (–2.96)

–0.2225*(FDI$)(–1)/(KFDI)(–2)–0.7495*(AWR)(–1)/(AWR(–2)

(–2.68) (–6.90)

–0.5798*(AWR)(–2)/(AWR)(–12)+0.02069*(DUMDEC)+u

(–6.93) (2.54)

$R^2 = 0.9759$, $RA^2 = 0.9544$, $SE = 0.007582$, $SD = 0.03553$, $DW = 2.39$, $F = 45.39$

(E-16) Consumer Price Index (IPCA)

(IPCA)/(IPCA)(–2)*E03=1165.22+15.91*(RATE)(–1)

(4.45) (6.40)

+5.464*(RATE)(–2)/(RATE)(–8)+16.02*(M1)(–1)/(M1)(–4)

(1.83) (2.22)

–72.88*(M2)(–1)/(M2)(–8)+149.7*(POP)(–1)/(POP)(–10)

(–5.20) (1.67)

-0.1080*(SELIC)(–7)–0.1327*(SELIC)(–12)+

(–2.46) (–1.85)

+0.4201*((NFSNO)(–4)–(NFSNO)(–5))+4.665*(POIL$)(–1)/(POIL$)(–12)

(1.31) (2.16)

–268.5*(CPIUS)(–1)/(CPIUS)(–3) +F16(FPF$)+u

(–1.15)

$R^2 = 0.9517$, $RA^2 = 0.9131$, $SE = 2.0459$, $SD = 6.9421$, $DW = 2.35$, $F = 24.65$

(E-17) General Price Index (IGPDI)

(IGPDI)/(IGPDI)(–1)*E03 = 435.94+29.18*(RATE)/(RATE)(–1)
(1.79) (4.25)
+75.81*(RATE)(–1)/(RATE)(–2)+12.98*(RATE)(–1)/(RATE)(–3)
(6.56) (2.08)
+41.58*(RATE)(–2)/(IGPDI)(–2)+20.43*(M1)/(M1)(–1)
(5.06) (2.20)
+26.20*(M1)(–1)/(M1)(–2)-1.003*((DPI_Y)(–1)+(DPE_Y)(–1))
(2.18) (–3.66)
+12.97*(POIL$)(–4)/(POIL$)(–9)+372.0*(POP)(–1)/(POP)(–2)
(4.10) (1.55)
+0.3533*(AWR)(–1)–0.5450*(NUCI)(–6)+F17(FPF$)+u
(1.85) (-2.20)

$R^2 = 0.9532$, $RA^2 = 0.9268$, $SE = 2.725$, $SD = 10.078$, $DW = 2.38$, $F = 36.09$

(E-18) Trade Balance (TB$)

(TB$) = ((PX)(X)–(PIM)(IM))/(RATE)

(E-19) Current Balance (CA$)

(CA$) = (TB$)+(SERF$)

(E-20) Balance of Payments (BP$)

(BP$) = (CA$)+(CAP$)

(E-21) Foreign Currency Reserves (RES$)

(RES$) = (RES$)(–1)+(BP$)+(BPE$)

(FPF$-function)

F1(FPF$) = –0.1700*(FPF$)(–1)/(FPF$)(–4)+0.1532*(FPF$)(–1)/(FPF$)(–7)

(–2.54) (1.89)

–0.2938*(FPF$)(–3)/(FPF$)(–6)+0.2253*(FPF$)(–4)/(FPF$)(–11)

(–3.70) (2.24)

F2(PFP$)=0.03906*(FPF$)(–1)/(FPF$)(–3)

(3.27)

F4(FPF$)=-0.0001868*(FPF$)(–2)+0.2331*(FPF$)(–1)/(FPF$)(–4)

(–2.54) (1.89)

–0.6587*(FPF$)(–1)/(FPF$)(–12)–0.4950*(FPF$)(–4)/(FPF$)(–13)

(–3.70) (2.24)

+0.3020*(FPF$)(–7)/(FPF$)(–10)

(1.26)

F5(FPF$)=–1.31E–02*(FPF$)(–1)/(FPF$)(–2)–1.28E–02*(FPF$)(–1)/(FPF$)(–5)

(–1.45) (-1.87)

–1.73E-02*(FPF$)(–1)/(FPF$)(–6)+6.80E–02*(FPF$)(–1)/(FPF$)(–11)

(–1.81) (4.19)

–6.20E–02*(FPF$)(–1)/(FPF$)(–12)-3.15E-02*(FPF$)(–4)/(FPF$)(–14)

(-3.63) (–2.31)

+2.41E-04*(FPF$)(–5)-1.31E-04*(FPF$)(–6)

(3.56) (–1.45)

F9(PFP$)=-0.7125*(FPF$)(-1)/(FPF$)(–2)

(–1.98)

F13(FPF$)=5.282E-05*(FPF$)(–1)–6.433E–05*(FPF$)(–3)+1.076E–04*(FPF$)(–5)

(–1.09) (–1.75) (1.29)

+3.921E–05*(FPF$)(–7)+1.155E–05*(FPF$)(–8)

(1.29) (4.42)

F16(FPF$)=0.001089*(FPF$)(–1)+0.0007560*(FPF$)(–2)

(3.70) (2.08)

–0.3902*(FPF$)(–4)/(FPF$(–11)–0.1429*(FPF$)(–5)/(FPF$)(–12)

(–5.30) (–6.81)

+0.1014*(FPF$(–4)/(FPF$)(–8)—0.2487*(FPF$(–3)/(FPF$(–8)

(2.69) (–3.33)

F17(FPF$) = –0.1717*(FPF$)(–1)/(FPF$)(–2)+0.07641*(FPF$)(–1)/(FPF$)(–5)

(–1.79) (1.27)

Note: R and RA are the multiple correlation coefficients before and after the correction of the degree of freedom; SE and SD are respectively the standard deviation of the equation error and of the explained variable. DW is the Durbin-Watson statistic.

The number in parenthesis is the t-value. The value in the parenthesis after the variable shows the number of lags.

Along the estimation, I took special care to avoid any spurious relations, which could be caused by the existence of secular trends of the left-hand side variable. Table 2 shows the results of the first-order Dicky-Fuller equations with and without the trend for the explained variables. As the t-value of the estimated coefficient of the lagged variable exceeded 2.0 whether in (1) or (2), the null-hypothesis of zero coefficients (the existence of the unit root) was rejected by these simple tests.

TABLE 2
RESULTS OF DICKY-FULLER TEST

Left-hand Side Variable	(1) With trend	(2) Without trend
(CONS)/(POP)(–1)	(–) 3.23	(–) 2.85
(INV)/(KR)(–1)	(–) 4.28	(–) 5.84
(X)/(KR)(–7)	(–) 4.28	(–) 5.56
(IM)*(IGPDI)/(RATE)/(KR)(–7)	(–) 2.39	(–) 1.53
(NUCI)/(GDE)*(KR)(–1)	(–) 2.44	(–) 1.74
(Y1)/(KR)(–7)	(–) 21.77	(–) 19.99
(Y2)/(KR)(–7)	(–) 16.42	(–) 16.63
(IPCA)/(IPCA)(–2)	(–) 2.98	(–) 2.94
(IGPDI)/(IGPDI)(–1)	(–) 3.65	(–) 3.35
(DESA)	(–) 1.19	(–) 2.05
(AWR)/(AWR)(–1)	(–) 6.83	(–) 6.93

Note: The Dicky-Fuller first order equation is calculated as follows for a *left-hand* side variable (X): $\Delta X=a+bX(-1)+c(Time)+u$. The figures in *Table 2* show the T-values of coefficient (b).

Based on the results of the single estimation, first I constructed a 21-equation model which treats M2 and exchange rate (RATE) as exogenous, and thus consists of (E-1)-(E-17) and (E-20)-(E-23). I implemented the final test for 37 months (June 1997-June 2000), and calculated the mean absolute percentage error (MAPE,%) for the last 10, 5 and 3 months. The results are shown in Table 3.

Table 3 shows good results from the 37 months of the final test for all endogenous variables. The MAPE of all endogenous variables were kept at less than 10 percent; and in the final three months, MAPES of 12 variables were less than 5 percent even though relatively large disturbances occurred at the beginning of 1999. Thus the model was sufficiently able to explain the changes of variables.

TABLE 3
MAPE OF FINAL TEST AND DETERMINATION COEFFICIENT

Variable	Last 10 months	Last 5 months	Last 3 months	Det. coefficient
CONS	1.7170	2.1530	2.6848	0.9657
INV	4.7635	6.1986	7.3106	0.9911
X	6.3957	6.7847	8.9949	0.9678
IM	8.0980	9.4397	9.7861	0.9930
GDE	2.6030	3.1284	4.4214	—
GDPN	2.6030	3.1284	4.4214	—
NUCI	1.8455	1.6869	1.3864	0.9854
KR	2.3637	3.2163	3.6365	—
Y1	3.6762	3.9170	4.7357	0.9935
Y2	2.6499	2.0732	1.7590	0.9963
Y3	5.3348	5.9994	7.7204	—
IPCA	0.4022	0.4531	0.5205	0.9517
IGPDI	0.5467	0.7214	0.8284	0.9532
AWR	2.7382	2.6642	1.4394	0.9759
EMP	0.6834	0.6952	0.6122	—
DESA	8.2327	8.6818	7.9502	0.9667
RES$	1.6759	2.0282	2.8079	—

Source: Calculated by author. MAPE for balance of payment variables (TB$, CA$, BP$) are not listed, because they can take zero values, so MAPEs are meaningless.

The causal ordering map of the model is as follows. There are three groups of exogenous variables: (1) overseas variables including the oil price in dollars (POIL$), GDP of the U.S.A. (GDPUS), consumer price of the U.S.A. (CPIUS), foreign direct investment (FDI$), portfolio investment (FPF$), real stock of FDI (KFDI), exchange rate (RATE); (2) domestic and other variables including population (POP), economically active population (PTO), employment (EMP), unemployment rate (DESA), industrial production index (IPI), wage rate (AWR), time (T); (3) monetary and fiscal variables including narrow money (M1), wider money (M2), money market interest rate (SELIC), fiscal expenditure (DES), fiscal revenue (REC), ratio of external debt over GDP (DPE/Y), primary fiscal requirement (NFSPPR), nominal fiscal requirement (NFSNO).

There are four groups of endogenous variables: (1) price variables including general price (IGPDI), consumer price (INPC), export price (PX), import price (PIM); (2) expenditure side variables including investment (INV), consumption (CONS), export (X), import (IM), GDE; (3) production side variables including primary sector GDP (Y1), secondary sector GDP (Y2), tertiary sector GDP (Y3), per capita GDP (GDPN), capital stock (KR), capacity utilization rate (NUCI); (4) balance of payments variables including trade balance (TB$), current balance (CA$), balance of payments (BP$), and foreign currency reserves (RES$).

In principle, all of the estimating equations contain only predetermined variables. The price variables [consumers price (IPCA), wholesale price (IGPDI)], and the expenditure variables [(consumption (CONS), investment (INV), exports (X), imports (IM)] are explained by the three groups of exogenous variables and lagged endogenous variables. Then, the GDE is determined by summing up these expenditure items. By definition, GDP is equal to GDE. On the other hand, the production function determines GDP based on employment, capital stock multiplied by capacity utilization rate, and other variables that influence the value-added ratio. So the capacity utilization rate index (NUCI) is determined by the GDE-GDP identity and by the production function. The GDP of the primary and secondary sectors come from structural equations, and the GDP of the tertiary sector is obtained as a residual. The capital stock and the per capita GDP are trivially calculated using their definitions. The trade balance (TB$) is defined by the dollar value of exports minus imports. Then the current balance (CA$) and balance of payments (BP$) are defined, and, finally the foreign currency reserves (RES$), including the error term of the balance of payments (BPE$), is defined.

The fiscal and monetary variables exert various effects on the real variables and the price variables. I interpret that M1 is related to market transactions and to inflation, while M2 measures financial deepening. So, the influences of money supplies are two-fold: narrow money supply (M1) influences domestic prices (IGPDI, INPC) and consumption expenditure (CONS), while the wide money supply (M2) expresses the supply of working capital, and influences investment, exports, imports, Y1 and Y2, and also to export and import prices.

Figures 1 to 11 show the trends of actual and fitted values of each endogenous variable based on the relevant structural equation. The result of the final test for all the endogenous variables will be explained in Chapter 6.

Consumption function: Figure 1 shows the trend of consumption expenditure (CONS). There were *short-term* or seasonal cycles in 1997 and 1998, while the cycle of 1999 was modified by a downfall in February 1999. As the levels end-of-year (December; 48,60,72) are roughly similar, there does not exist a discernible increasing trend. In equation (E-1), the per capita consumption was explained by 15 variables, including GDP growth rate, increment of price growth, real money supply, population growth, unemployment rate and fiscal expenditure variables. The linear and squared terms of per capita GDP have negative and positive signs, and suggest a marginally increasing propensity to consume. The final test nicely traced the actual trend, except for an overestimation at the end.

Investment function: Figure 2 shows the trend of investment (INV). The (E-2) equation explains investment over capital stock or investment growth rate with the 11 explaining variables. The GDP growth rate, import ratio and M2 supply exert a positive influence, while the real interest rate, unemployment rate, FDI stock ratio and general price growth exert negative effects. The positive influence of the capacity utilization rate may imply a lagged effect of demand growth. The investment showed a decreasing trend in 1997-1998. After the devaluation, it still stagnated at a low level, and made a quick recovery in 2000, returning to the level of 1997. The final test result was good, except for the overestimation in 2000.

Export function: Figure 3 shows the export trend. In equation (E-4), exports, which are normalized by the capital stock, depend on increments of the GDP of the USA. for positive growth, as well as on lagged imports, which represent supply of intermediate goods or working capital, and on oil price growth. Meanwhile, the capacity utilization rate and GDE growth exert negative effects because the potential supply to the export sector decreases. Also, FDI growth exerts a negative effect, perhaps because many FDI are domestic market oriented. In this equation, a variation of the exchange rate exerts a strong positive effect on exports, as expected. As there is a time lag of about seven to eight months between the contract decision and actual delivery, many variables are lagged by seven to eight months. In the past, there was a mildly decreasing trend in 1997 and 1998. After the devaluation of January-February 1999, exports jumped up, and doubled in 12 months. As the nominal and real exchange rates were devaluated by 70 or 50-60 percent, such a jump of 100 cannot be easily predicted if only through the price effect of the exchange rate devaluation. So the jump was caused not only by a favorable price effect of devaluation, but also by other favorable conditions.

FIGURE 1
RESULT OF ESTIMATION OF CONSUMPTION (CONS)

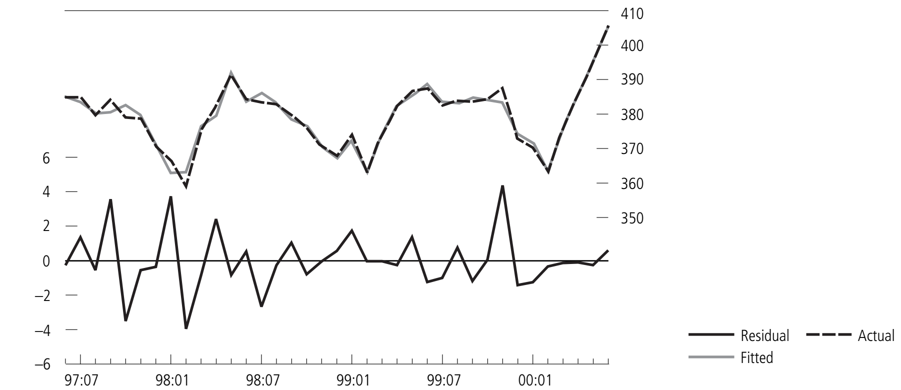


FIGURE 2
RESULT OF ESTIMATION OF INVESTMENT (INV)

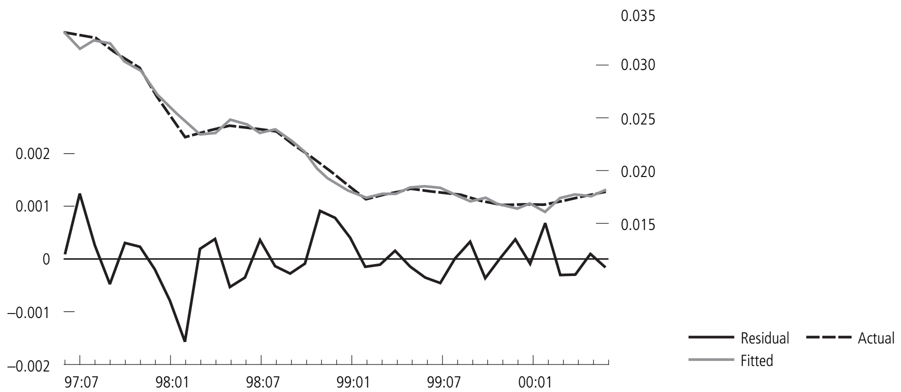
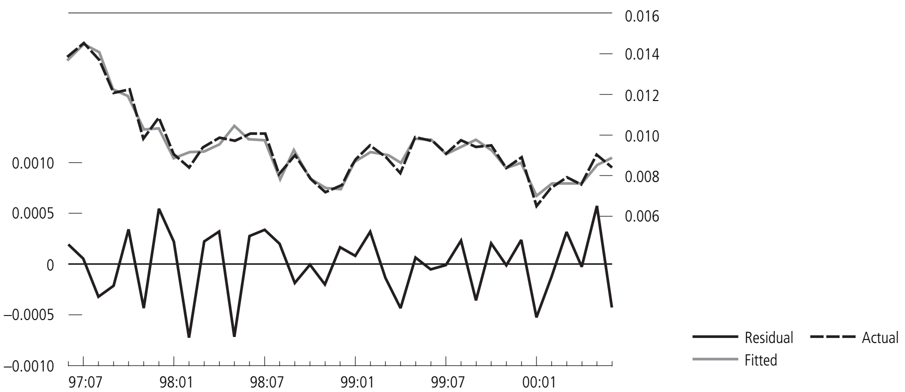


FIGURE 3
RESULT OF ESTIMATION OF EXPORTS (X)



Import function: Figure 4 shows the trend of import. In equation (E-5), dividing by capital stock also normalizes import. The import capital ratio positively relates to money supply (M2), foreign currency holdings, oil price growth and wholesale price growth, as expected. The exchange rate exerts *short-term* and *medium-term* negative effects, but exerts a positive effect overall. The investment growth exerts a negative effect through an increase in the supply capacity, but with an eleven month lag the growth generated exerts a positive effect perhaps through an increase in the demand of capital goods imports. SELIC growth produces a positive effect, perhaps because it may imply an increasing domestic production cost or create an expectation of balance of payments crisis and thus cause an import decrease. The basic characteristic of the import trend in 1997-2000 is a steady upward trend. In the two years between January 1997 and December 1999, imports increased by 2.34 times. Imports increased by 64 percent in January 1997-December 1998, and also by 42 percent in 1999 after a rapid devaluation in January-February 1999. Such a steadily increasing trend cannot be adequately understood because a rapid devaluation should exert a strong pressure to cut down imports. The propensity to import (import over GDP) was 4.91 percent in January 1997, 7.97 percent in December 1998, and 10.91 percent in December 1999; and it was relatively low by international standards. So we can assess that the Brazilian economy is currently in the process of openingup. Such a basic structural trend dominates and overcomes the negative impacts of devaluation. The trade balance (dollar exports minus dollar imports) recorded a deficit of US$ 978 million in 1999 even after a big devaluation.

Capacity utilization rate function: Figure 5 shows the trend of the capacity utilization rate (NUCI). There is a cyclical pattern in 1997 and 1998. In 1999, there was a big downfall in January-February, but after that the trend returned to its usual pattern, and to the same level at the end of the period. The final test result traced the actual trend fairly well, except for the overestimation at the end. The capacity utilization rate (NUCI) was determined by the GDP production function, (E-9), and the GDE-GDP identity. So the good fit of NUCI implies a good fit of the production function and of the GDE. The production function explained the GDP with the effective capital stock (capital stock multiplied by capacity utilization rate), employment, growth of the economically active population (PTO), imports, consumer price variation, exchange rate and SELIC. The additional variables (SELIC, imports, ratio of economically active population, price growth) represent shift factors. The fact that the capacity utilization rate remained stable implies that the effective capacity supply and demand basically matched at the end of the observation period. This can be a factor of low inflation pressure, and of a low degree of *pass-through*.

FIGURE 4
RESULT OF ESTIMATION OF IMPORTS (IM)

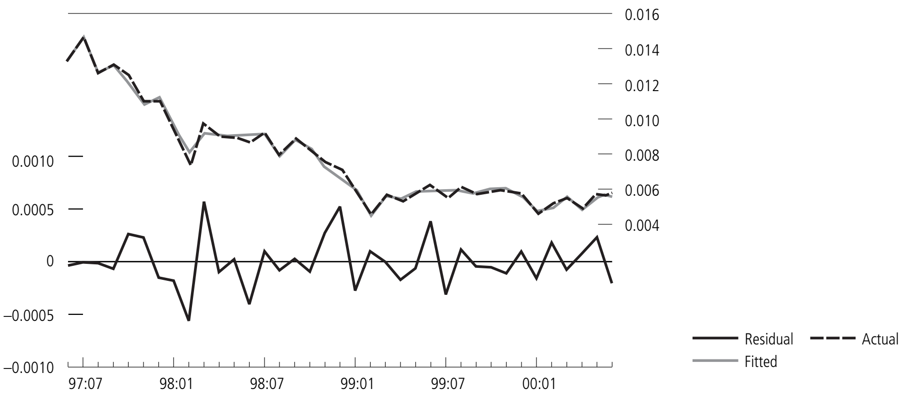
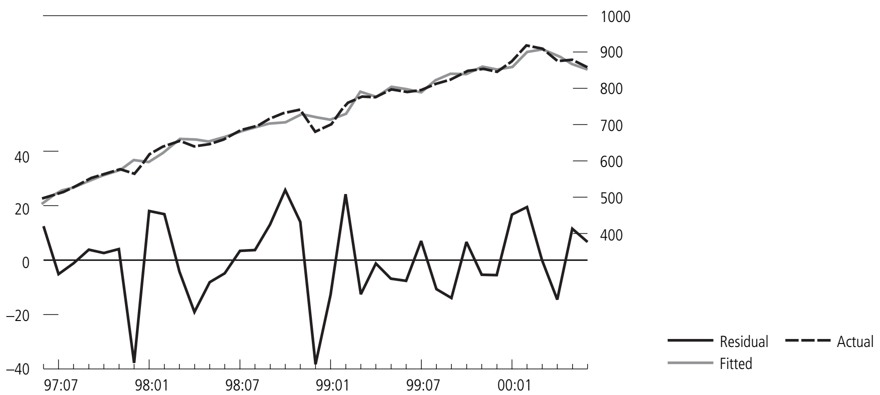
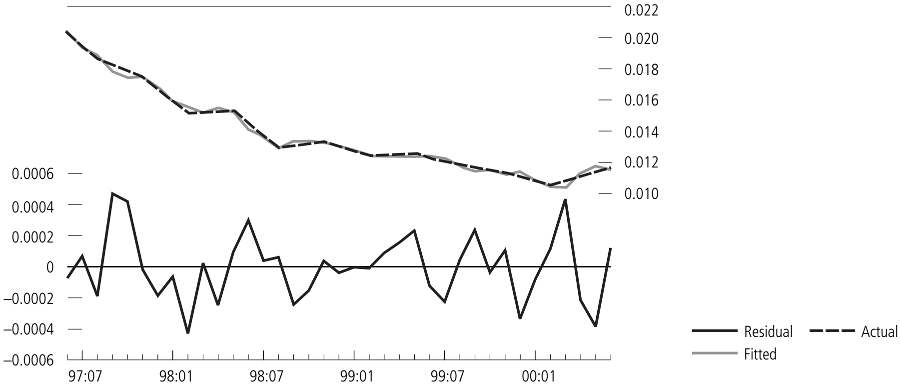


FIGURE 5
RESULT OF ESTIMATION OF RATE OF CAPACITY UTILIZATION (NUCI)



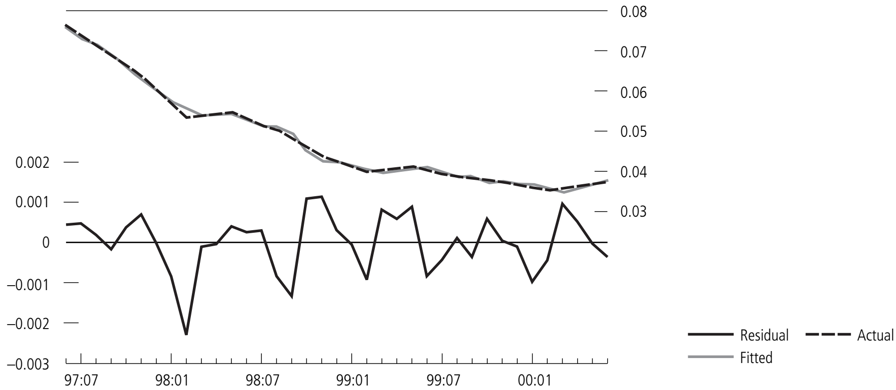
Y1 function: Figure 6 shows the trend of the GDP of the primary sector (Y1). It showed a rather stable stagnant trend in 1997 and 1998. In 1999, it leveled up, perhaps due to the rapid devaluation and accompanying export growth, and showed a rapid growth in 2000. The GDP of the primary sector (Y1) was explained by (E-10), which considered supply side factors like capital stock, import, the economically active population ratio, money supply and investment growth, and demand factors like consumption growth, export growth, consumer price growth and GDE growth. The FDI stock ratio exerts a positive effect. The final test result traced the movement well, except for an overestimation at the end.

FIGURE 6
RESULT OF ESTIMATION OF GDP OF PRIMARY SECTOR (Y1)



Y2 function: Figure 7 shows the trend of the GDP of the secondary sector (Y2). Equation (E-11) explained the actual trend by some supply side factors such as capital stock and money supply (M2), and demand factors such as per capita GDP. The real exchange rate also exerts a positive effect. The recent investment growth exerts a negative effect, perhaps due to an import increase. The time trend has a negative effect, which may represent a shift of the industrial structure. In the first 18 months, the trend was decreasing, and ended up decreasing by more than ten percent in 1997-1998. The rapid devaluation of January-February 1999 could not rapidly animate this sector, and the level was stagnated in 1999. Only after the time lag of one year, it started a rapid growth in 2000. The final test traced this trend well, except for an overestimation at the end.

FIGURE 7
RESULT OF ESTIMATION OF GDP OF SECONDARY SECTOR (Y2)



IPCA and IPGDI functions: Figures 8 and 9 show the evolution of consumer prices (IPCA) and general prices (IGPDI), both of which show stable increasing trends that were accelerated greatly after the drastic devaluation of January-February 1999. The consumer price trend was heavily influenced by the wholesale price trend. In equation (E-17), the change of the general price index (IGPDI) is explained by 12 variables: positively influenced by changes in money supply, exchange rate, oil price, population growth and real wage, and by debt ratios, the time trend, and the ratio of the economically active population; and negatively influenced by the capacity utilization rate and fiscal debt ratios. Among them, the influence of the exchange rate dominates to explain a steep increase in 1999. In equation (E-16), the growth rate of the consumer price (IPCA) is influenced positively by the level and growth of the exchange rate, M1 growth, growth of oil price, population growth, and increment of the public sector borrowing requirements (NFSNO); and it is negatively influenced by SELIC and M2 growth. The growth of CPI in the U.S. exerts a weak negative influence. It may mitigate the positive influence of the exchange rate. The low coefficients of the exchange rate describe a low exchange rate *pass-through* after January 1999. The money supply (M2) has positive and negative signs respectively, representing the contrasting effects of *short-term* demand in increasing effect and *long-term* supply in enhancing effect. As a whole, the actual trends of two prices were very well traced by a single equation estimation and also by the final test.

FIGURE 8
RESULT OF ESTIMATION VARIATION OF CONSUMER PRICE (IPCA)

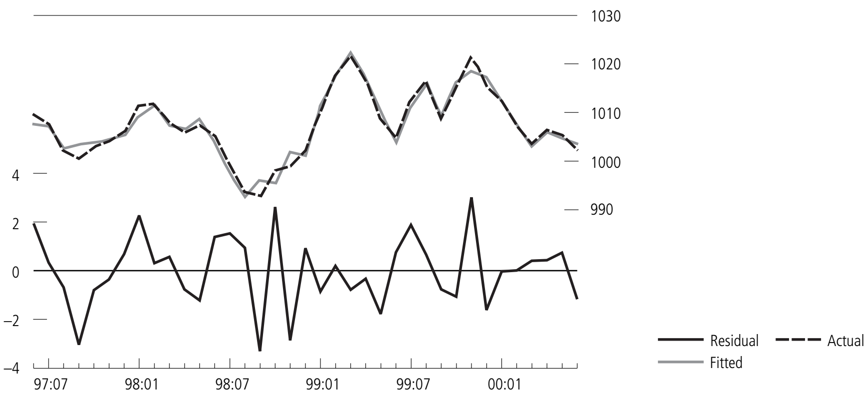
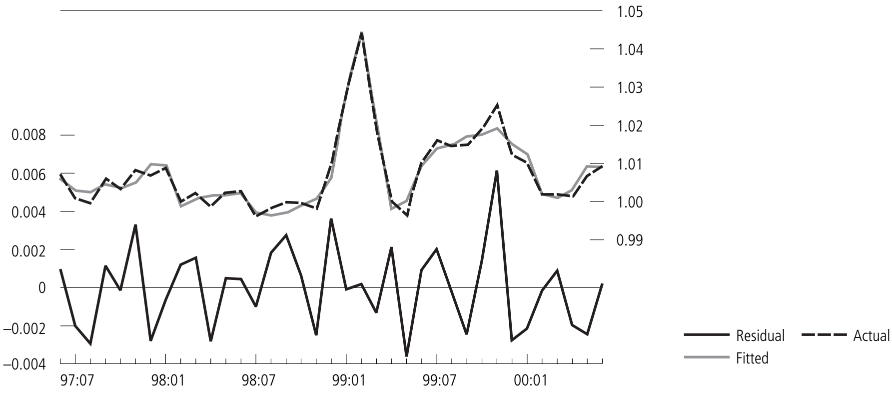
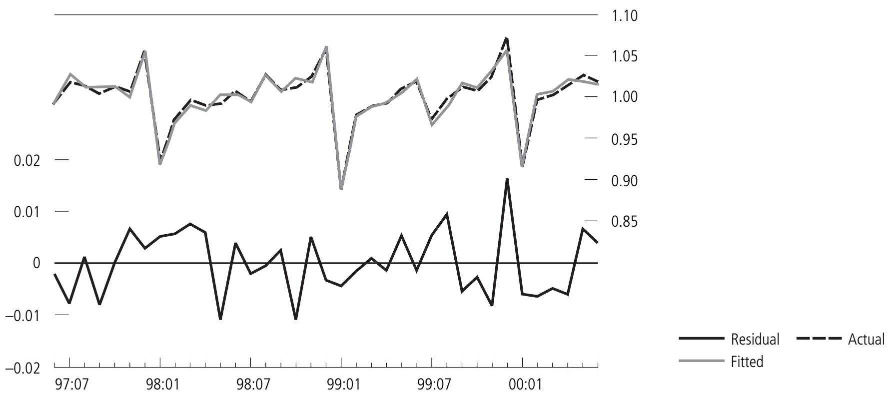


FIGURE 9
RESULT OF ESTIMATION OF WHOLESALE PRICE (IGPDI)



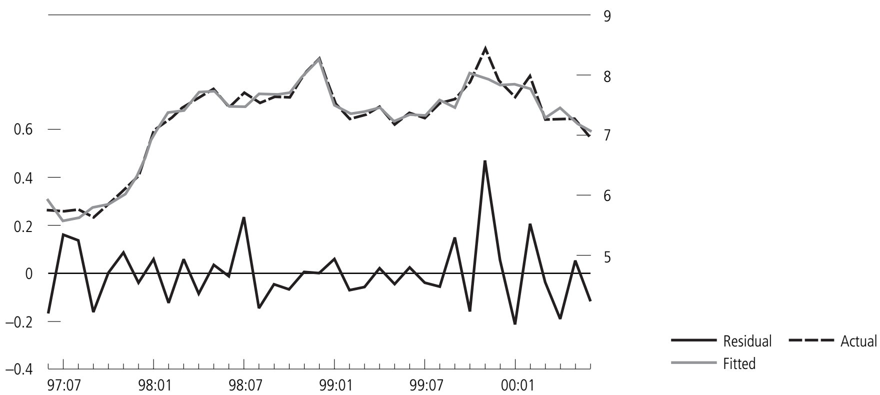
AWR function: Figure 10 shows the trend of the real wage index (AWR). It shows a jump every December because of bonus payments. In (E-15), this is explained by the December dummy (DUMDEC) with a positive coefficient. Wage change is also influenced positively by the capacity utilization rate and by the exchange rate, and negatively by employment growth, price growth, lagged value and FDI growth. The influences of the unemployment rate and the labor productivity (GDP over employment) are cyclically changing. The linear and second terms of per capita GDP have positive and negative signs. The real wage shows a cyclical downward trend until the devaluation, and then an increasing trend. By (E-15), the trend of wage is *well-traced*, except for some cyclical errors.

FIGURE 10
RESULT OF ESTIMATION OF WAGE RATE (AWR)



DESA function: Figure 11 shows the trend of the unemployment rate (DESA). It drastically increased from 5.5 percent to eight percent in 1997-1998. After the devaluation, it stagnated at around 7.5 percent, then once again increased to eight percent, and decreased to seven percent in 2000. In (E-13), the unemployment rate (DESA) is influenced positively by the wage rate growth, population growth, exchange rate growth, the capital intensity of labor (KR/EMP) and labor productivity (GDP/EMP), and negatively by FDI stock growth, capital stock growth, and time trend. The single-equation estimate traced the actual trend well, but the final test result was underestimated by about one percent in 1999-2000. Contrasting trends exist in the labor market: a recent decreasing trend in the unemployment rate and a quick recovery and growth of the level of employment, and on the other end, a stagnant trend of real wage. But the wholesale price increased by 25 percent, and the consumer price increased by 11 percent after the devaluation. So the nominal wage did increase by these rates, while the real wage was roughly constant in 1997-2000. As a whole, the Brazilian labor market is still characterized by the existence of abundant unskilled labor supply. So the increase of employment in the modern sector did not result in a sharp increase of the real wage level.

FIGURE 11
RESULT OF ESTIMATION OF UNEMPLOYMENT RATE (DESA)



The results of the final test were relatively good in terms of MAPE. But the observations above suggest that the final test errors were relatively large for Y1, Y2, and Y3 especially in 2000. Conventional wisdom might suggest the introduction of dummy variables because the various non-economic shocks are conceivable in such a period of big devaluation. But I did not employ any dummies against this conventional wisdom. So the results might show the limit of estimation and explanation without dummies. In a sense, a part of the remaining disturbances are the cost of this strategy. I confirmed the workability of the monthly model based on the final test. Various simulation experiments were implemented. Their results are compared with those of other models. The results are reported in Chapter 6.

4 EXTENSION OF MONTHLY MODEL (VERSION 2)

In the previous section, four variables (SELIC, M1, M2, NFSNO), which are the main fiscal and monetary instruments, were treated as exogenous. The government changes these instruments to achieve the *short-term* and *long-term* economic targets, while considering important restraints. So when these variables are regressed on economic variables, including major target variables, the coefficients would manifest the attitude or reaction of the government in manipulating the instruments. In certain political situations, the attitude of the government would change abruptly. So the nature of the reaction function is fragile, and its estimation is usually very difficult. In this section, I first report the results of the estimation of the reaction functions separately. Then, I enlarge the Version 1 Model to the Version 2 Model incorporating these additional functions.

Monthly Model of Brazilian Economy (June 1997-June 2000: 37 samples)
[Version 2: Fiscal & Monetary Instruments (SELIC, M1, M2, NFSNO) are endogenous]

(E-1)-(E-21) same as Version 1.

(E-22) SELIC (SELIC)

(SELIC) = 299.06–1.589E–04*(RES$)(–2)–55.77*(M2)(–1)/(M2)(–2)
(3.84) (–1.82) (–1.86)
–23.69*(RATE)/(RATE)(–1)+7.348*(RATE)/(RATE)(–12)
(–3.65) (2.97)
–9.492*(RATE)(–2)/(RATE)(–15)+9.265*(RATE)(–4)/(RATE)(–7)
(–1.86) (1.53)
–296.0*(IPCA)(–1)/(IPCA)(–7)+103.8*(GDE)(–4)/(GDE)(–12)
(–4.67) (5.13)

–2.103*(NFSNO)(–7)+17.12*(POIL$)(–1)/(POIL$)(–3)
(–3.11) (2.55)
+6.691*(POIL$)(–5)/(POIL$)(–9)+36.92*(FDI$)(–3)/(KFDI)(–4)
(1.33) (1.35)
+ F22(FPF$)+u

R^2 = 0.9572, RA^2 = 0.9144, *SE* = 2.5535, *SD* = 8.7321, *DW* = 2.99, *F* = 22.38

(E–23) Narrow Money Supply (M1)

(M1)/(GDE)(–1)/(IPCA)(–1)=2.850+6.722E-06*(BP$)(–6)
(4.56) (6.11)
+2.657*(IPCA)(–1)/(IPCA)(–7)–8.266*(IPCA)(–1)/(IGPDI)(–5)
(2.99) (–6.93)
+1.199*(GDE)(–4)/(POP)(–4)+4.367*(GDP)(–7)/(POP)(–7)
(3.15) (11.92)
+0.01793*(NFSNO)(–2)–0.01002*(NFSNO)(–8)
(7.01) (–2.88)
+0.001219*(SELIC)(–1)+0.001248*(SELIC)(–10)
(1.90) (2.03)
–0.02348*(RATE)/(RATE)(–4)+0.1299*(RATE)(–1)/(RATE)(–12)
(–1.02) (6.31)
+0.01224*(POIL$)(–7)/(POIL$)(–13)+0.08284*(POIL$)(–2)/(POIL$)(–7)
(7.44) (2.43)
+F23(FPF$)+u

R^2 = 0.9789, RA^2 = 0.9525, SE = 0.01238, SD = 0.05683, DW = 2.82, F = 37.13

(E–24) Wide Money Supply (M2)

(M2)/(GDE)(–1)/(IPCA)(–1) = 4.6082+3.409*((SELIC(–1)–(IPCA)(–1)+(IPCA)(–2))
(4.95) (1.62)

–5.974*(SELIC)(–7)–6.517*(GDE)(–1)/(GDE)(–2)
(–1.68) (–5.11)
+1.936*(GDE)(–1)/(GDE)(–4)+0.3041*(RATE)/(RATE)(–1)
(3.95) (2.03)
+8.050E–05*(CA$)(–2)+1.790E-05*(CAP$)(–2)
(3.06) (4.60)
+0.9525*(M2)(–1)/(GDE)(–2)/(IGPDI)(–2)+F24(FPF$)+u
(28.36)

R^2 = 0.9894, RA^2 = 0.9847, *SE* = 0.05740, *SD* = 0.4653, *DW* = 1.61, *F* = 212.76

(E–25) Public Sector Borrowing Requirements (NSFNO)

(NFSNO) = –156.68+5.701*(GDE)(–1)/(GDE)(–8)+0.08941*(SELIC)(–1)
(–6.48) (2.18) (6.02)
+152.4*(IPCA)(–1)/(IPCA)(–2)+1.350E-05*(RES$)(–1)
(6.29) (1.00)
–0.5109*(POIL$)(–2)+3.732*(RATE)+4.484*(RATE)(–1)
(–20.69) (4.44) (5.22)
+F25(FPF$)+u

R^2 = 0.9937, RA^2 = 0.9881, *SE* = 0.3418, *SD* = 3.1377, *DW* = 2.80, *F* = 177.25

F22(FPF$) = –1.836E-05*(FPF$)(–2)–1.628*(FPF$)(–5)
(4.62) (–5.91)
+9.118E–04*(FPF$)(–1)/(FPF$)(–8)+1.298E–03*(FPF$)(–1)/(FPF$)(–12)
(1.20) (1.99)
–1.641E-03*(FPF$)(–2)/(FPF$)(–15)–1.031E-03*(FPF$)/(FPF$)(–4)
(–1.81) (–3.89)

F23(FPF$) = 1.836E–05*(FPF$)(–2)–1.628E-05*(FPF$)(–5)

(4.62) (-5.91)

–1.031E–03*(FPF$)/(FPF$)(–4)+1.298E–03*(FPF$)(–1)/(FPF$)(–12)

(–3.89) (1.99)

–1.641E-03*(FPF$)(–2)/(FPF$)(–15)+9.118E–04*(FPF$)(–1)/(FPF$)(–8)

(–1.81) (1.20)

F24(FPF$) = –2.704E–05*(FPF$)(–2)–2.112E–05*(FPF$)(–3)–1.850E–05*(FPF$(–4)

(–2.54) (–2.14) (–1.60)

F25(FPF$) = 2.080E–04*(FPF$)(–6)+3.634E–04*(FPF$)(–7)

(2.70) (5.32)

–3.774E–04*(FPF$)(–10)–0.01088*(FPF$)(–1)/(FPF$)(–5)

(–6.70) (–1.58)

-0.04553*(FPF$)/(FPF$)(–2)+0.05043*(FPF$)(–3)/(FPF$)(–6)

(–4.90) (4.08)

+0.02603*(FPF$)(–2)/(FPF$)(–13)+0.02290*(FPF$)(–4)/(FPF$)(–7)

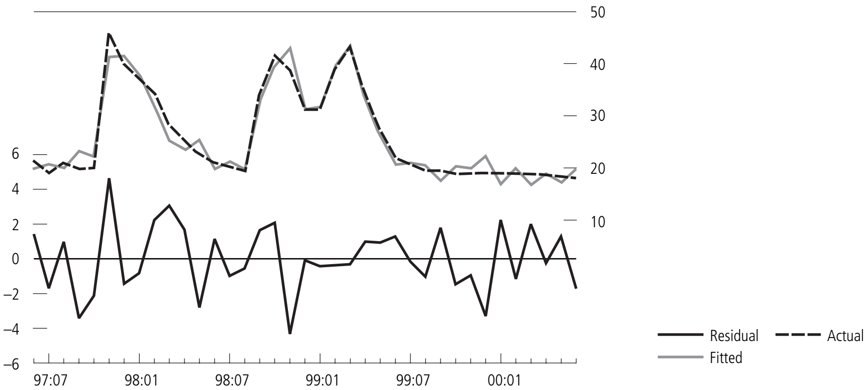
(1.59) (1.37)

+0.03957*(FPF$)(–5)/(FPF$)(–14)+3.924E-03*(FPF$)/(FPF$)(–6)

(2.61) (1.24)

SELIC function: Figure 12 shows the trend of the SELIC. It shows two big peaks in the forty-seventh and forty-eighth months (November-December 1997), and also in the fifty-eighth and fifty-ninth and in the sixty-second and sixty-third months (October-November 1998 and February-March 1999). In (E-22), the SELIC is positively influenced by GDE growth, FDI growth and oil price, and negatively influenced by M2, foreign currency reserves, IPCA growth and NFSNO. Therefore, when the GDE growth is high and the economy is overheated, the SELIC goes up. When the nominal public sector borrowing requirements (NFSNO) increase, the SELIC goes down. These are understood as reasonable reactions of the Central Bank. An M2 increase will negatively influence the SELIC through a market pressure. But the reaction of the SELIC to balance of payments, exchange rate change, and IPCA growth are more complex, because their coefficients have different signs according to the number of lags. The sum of the coefficients of reaction to balance of payments is negative, so when the surplus increases due to short-term capital inflows, the SELIC tends to be lower. When the SELIC is explained by these 18 variables, the result of a single-equation estimation nicely traces the actual trend, as shown in Figure 12. But when the reaction functions are included, the final test causes some cyclical errors in the last 12 months. It seems that a consistent explanation of big peaks and the constancy in the last 12 months is very difficult, not to mention the possibility of a structural change or break after the summer of 1999.

FIGURE 12
RESULT OF ESTIMATION OF SELIC



Banco Central do Brasil (2001) picks up four major issues and fields for discussion: (1) aggregate demand; (2) aggregate supply; (3) international economy; and (4) prices. The equation (E-22) basically covered these four fields using 13 explaining variables.[1] In (E-22), the SELIC increases with the growth rates of GDE, FDI and oil prices, and decreases when the public sector borrowing requirements ratio (NFSNO), the foreign currency reserves (RES$) and the money supply (M2) growth. The response to an inflationary trend is complex: the SELIC decreases when the growth of IPCA is high, while it responds to the exchange rate with changing signs over time. The actual trend of the SELIC is complex, including two peaks and constancy in the last 12 months. It was fairly well traced by the reaction function. But in the last 12 months, the error term showed a fluctuating

1. M2 growth corresponds to aggregate money (1.3 in Inflation Report), FDI$ and FPF$ correspond to investment (1.4), NFSNO refers to the public sector borrowing requirement (1.5), RES$ corresponds to the balance of goods and services (1.7) of aggregate demand. GDE growth represents aggregate supply (2.4). Oil price (3.5) and exchange rate refer to the international economy. IPCA growth refers to prices (4.2).

movement. The big contrast between big peaks and constancy made the consistent explanation quite difficult to accept. Table 1 shows the decomposition of the SELIC change into the influences of nine explaining variables multiplied by their coefficients. Big changes are mainly explained by the following variables.

- A large increase of 11.6 % in October 1998 (month 57): IPCA (3.3%), GDE (3.0%), FPF$ (2.8%), FDO (1.5%).

- A big drop of 15.4 % in December 1998: FPF$ (8/0%), M2 (3.0%), FDI (2.0%), POIL$(1.1%).

- Increases in January-March 1999 of 21.5%: FPF$, exchange rate, M2, IPCA, GDE, POIL$ (by order of sum of absolute % changes).

- Drops in April and June 1999 of 19.1%: GDE (8.5%), exchange rate (5.7%), IPCA (5.1%), oil price (4.0%), M2 (3.2%), RES$(2.4%).

Therefore, many variables played major roles interchangeably in different months. But according to Table 4, the net inflow of short-term capital (FPF$) played important roles in creating big peaks. The effect of the exchange rate devaluation was also drastic. IPCA, GDE, M2, NFSNO and POIL$ also exerted strong effects in certain months.

M1 function: Equation (E-23) explains the trend of M1. The ratio of real M1 to GDP is positively influenced by per capita GDP, balance of payments, SELIC, public sector borrowing requirements (NFSNO), M2 growth and oil price growth. Changes in the exchange rate, IPCA and in short-term capital inflow have impacts in different directions along time. In Figure 13, the relative stagnation after devaluation and a quick increase in 2000 are adequately explained.

M2 function: The equation (E-24) explains the ratio of the real stock of M2 to the GDE. It is positively influenced by the real SELIC, the exchange rate change, the current account balance, the capital account balance and its lagged value, and negatively influenced by IPCA growth, GDE growth and short-term capital inflow. As shown in Figure 14, the estimated values traced the actual trend fairly well.

The trend of M2 to GDE basically shows a steady growth, while the one of M1 to GDE shows a relatively volatile cyclical growth. As shown above, both are well explained by major macroeconomic target variables such as the economic growth rate, balance of payments, inflation rate and other economic factors. The reaction patterns are fairly complex, but based on these different reaction coefficients, two trends are well-traced in the final test, except for the cyclical errors of M1 in 2000.

TABLE 4
DECOMPOSITION OF SELIC CHANGE

VA	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
M	RES$	M2	IPCA	GDE	NFS	RATE	FDI	POLI	FPF$	SEL
43	(–)0.5	(–)4.7	0.1	1.2	1.0	(–)0.0	(–)0.8	(–)1.4	0.6	(–)4.5
44	0.2	8.4	3.9	1.2	0.9	(–)0.1	0.2	(–)1.1	(–)4.3	9.3
45	(–)0.4	(–)2.6	0.7	3.6	0.3	0.1	(–)1.9	0.9	(–)4.3	(–)3.6
46	(–)0.3	0.8	0.6	(–)0.0	(–)0.6	(–)0.1	0.5	0.1	2.6	3.5
47	0.3	(–)8.0	1.2	1.7	0.9	0.0	(–)0.2	1.5	10.4	7.8
48	1.3	6.3	2.6	1.1	0.2	(–)0.0	(–)0.1	0.3	(–)4.8	6.9
49	(–)0.0	1.5	(–)0.4	0.8	1.5	(–)0.0	1.3	(–)2.9	(–)1.3	0.6
50	(–)0.1	(–)2.4	(–)1.8	1.9	0.5	0.0	(–)1.9	(–)2.4	(–)1.2	(–)7.4
51	0.3	0.1	(–)1.8	(–)2.0	1.4	(–)0.0	0.4	1.5	(–)2.6	(–)2.8
52	(–)0.8	(–)0.6	0.9	(–)5.1	(–)4.0	0.0	(–)1.0	0.9	5.0	(–)4.5
53	(–)1.6	3.9	0.4	(–)5.8	0.4	(–)0.0	0.3	1.5	3.7	2.9
54	(–)0.8	(–)5.8	(–)1.6	0.8	(–)1.0	0.0	(–)0.9	0.6	2.3	(–)6.6
55	0.3	3.0	(–)0.6	(–)0.3	3.4	(–)0.0	1.3	(–)2.0	(–)0.7	4.4
56	(–)0.1	(–)1.6	2.0	3.0	(–)3.9	(–)0.1	(–)0.4	0.4	(–)7.1	(–)7.8
57	(–)0.6	0.9	3.3	3.0	(–)0.4	0.1	1.5	0.9	2.8	11.6
58	0.8	3.7	0.5	0.2	(–)2.9	(–)0.0	(–)0.5	0.8	4.0	6.5
59	4.0	(–)2.8	1.6	(–)0.3	1.9	(–)0.0	1.6	0.6	(–)5.1	1.5
60	0.4	(–)3.0	(–)0.1	(–)0.5	(–)1.0	0.1	(–)2.2	(–)1.1	(–)8.0	(–)15.4
61	0.1	(–)1.6	3.1	3.2	(–)1.0	(–)10.0	1.0	(–)2.9	15.6	7.5
62	(–)0.7	5.7	(–)2.1	(–)1.8	(–)2.9	14.7	(–)1.5	3.1	(–)7.3	7.1
63	1.5	(–)2.4	(–)3.5	(–)1.7	0.9	(–)4.0	0.4	1.9	13.8	6.9
64	0.3	1.6	(–)3.8	(–)3.6	(–)0.5	(–)4.1	(–)1.0	0.9	1.9	(-)8.2
65	0.3	(–)0.7	(–)1.1	0.9	1.3	7.5	2.2	3.7	(–)12.7	1.4
66	(–)2.1	1.6	(–)1.3	(–)4.9	(–)0.7	1.6	(–)1.7	(–)3.1	(–)0.3	(–)10.9
67	(–)0.4	(–)5.4	(–)2.3	2.9	0.7	(–)2.7	(–)0.3	(–)3.8	3.7	(–)7.7
68	0.6	5.7	(–)1.6	5.6	(–)7.0	(–)6.5	(–)0.1	3.4	6.1	6.0
69	(–)0.1	(–)6.1	(–)0.1	3.0	(–)4.1	1.4	0.4	4.1	(–)3.7	(–)5.1
70	0.1	3.4	2.6	(–)0.4	2.7	0.7	0.8	(–)0.8	(–)14.7	(–)5.6
71	(–)0.0	0.3	(–)3.3	(–)0.4	0.6	1.0	(–)0.7	(–)1.4	7.2	3.3
72	0.7	(–)1.6	(–)1.2	2.6	0.4	0.6	(–)0.1	(–)0.9	0.4	0.9
73	(–)0.3	3.6	0.2	(–)4.8	(–)3.6	(–)5.8	(–)0.3	0.1	5.4	(–)5.6
74	1.3	(–)0.2	0.3	6.8	2.2	1.3	0.0	(–)0.2	(–)4.0	7.6
75	(–)0.3	(–)3.3	1.4	(–)4.6	0.4	0.2	0.2	0.4	(–)0.1	(–)5.6
76	(–)0.4	(–)0.2	1.9	(–)4.2	(–)0.0	4.5	(–)0.0	(–)0.6	(–)1.1	(–)0.2
77	(–)0.5	4.6	2.0	(–)6.1	3.1	0.7	(–)0.4	(–)3.9	1.9	1.4
78	1.7	(–)7.6	2.1	1.4	0.9	(–)1.6	0.0	0.9	0.0	(–)2.2

Note: VA (variable),M (month:42 = June 1997; 78 = June 2000): Definition of variables are: (1) = (–)0.0001589*(RES$) (–2), (2) = (–)55.77*(M2)(–1)/(M2)(–2), (3) = (–)296.0* (IPCA(–1)/(IPCA(–7), (4)=103.8*(GDE) (–4)/(GDE)(–12), (5) = (–)2.103*(NFSNO)(–7), (6) = (–) 23.69* (RATE)/(RATE (–1) + 7.348* (RATE)/(RATE) (–12) –9.492* (RATE) (–2)/(RATE) (–15) +9.265* (RATE) (–4)/(RATE) (–7), (7) = 36.92* (FDI) (–3)/(FDI) (–4), (8) = 17.12* (PoIL$) (–1)/(PoIL$) (–3) + 6.691* (PoIL$) (–5)/(PoIL$) (–9), (9) = (SELIC) – (SUM of (1) (–8)), (10) = (SELIC): figures in the table shows the increment from the previous month.

NFSNO function: Figure 15 shows the trend of the nominal public sector borrowing requirements (NFSNO), which exhibits three different phases: a steady increase in 1997-1998, an elevated peak and gradual decrease in 1999, and a constantly low level in 2000. In (E-25), NFSNO is influenced positively by GDE

FIGURE 13
RESULT OF ESTIMATION OF NARROW MONEY SUPPLY (M1)

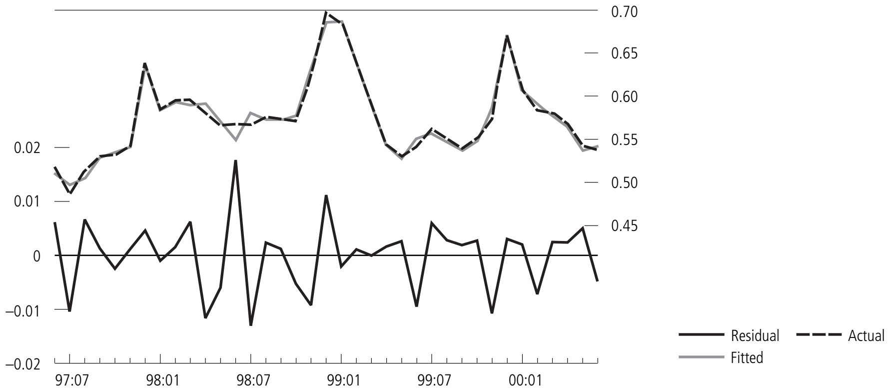


FIGURE 14
RESULT OF ESTIMATION OF WIDE MONEY SUPPLY (M2)

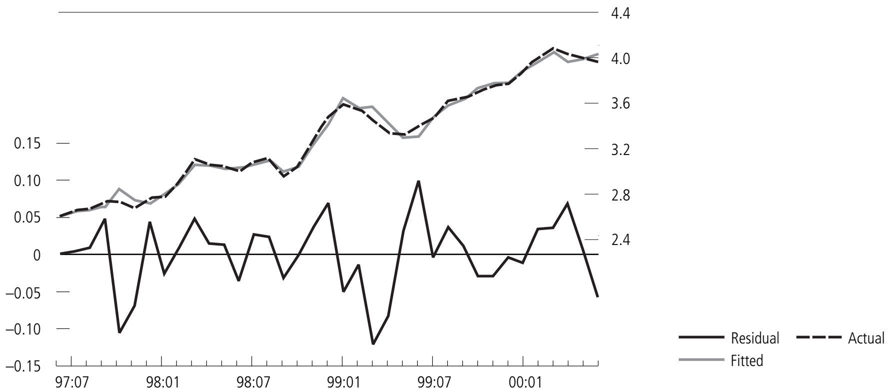
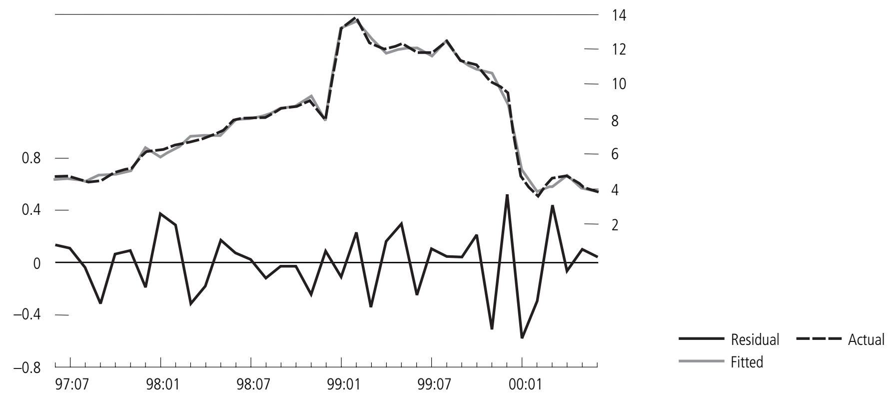


FIGURE 15
RESULT OF ESTIMATION OF PUBLIC SECTOR BORROWING REQUIREMENTS (NFSNO)



and consumption growth, price (IPCA and IGPDI) growth, foreign currency reserves, SELIC and the capacity utilization rate, and negatively by per capita GDP, M2, exchange rate change, current balance and oil prices. The ratio of external and internal debt to GDP also has positive effects. The last effect and the positive effect of SELIC are easily understood as the natural consequences of the increasing burden of interest payment. But other effects are understood to manifest the governmental reaction to the economic trend. The final test traced the actual trend well, except for the cyclical errors in 2000.

The results of the final test of the extended Version 2 Model are summarized in Table 5.

By including the reaction functions and extension of the Version1 Model into the Version 2 Model, the final test results deteriorated, especially for the year 2000. The SELIC and NFSNO recorded high levels before coming down to low levels in 2000. Therefore, the relatively big MAPE of the SELIC and NFSNO are partly due to these special trends, and can be understood as being within tolerable ranges.

TABLE 5
RESULT OF FINAL TEST AFTER ENDOGENIZATION OF INSTRUMENTS

Variables Instruments	Last 10 months	Last 5 months	Last 3 months
SELIC	26.2917	33.8567	30.2246
M1	8.3925	12.9129	16.4512
M2	4.6490	5.6395	5.4079
NSFNO	27.5334	38.9577	40.1237
OTHERS			
CONS	3.0026	3.7181	5.0557
INV	5.4800	8.6304	10.8046
X	6.8043	8.7443	10.0385
IM	12.8451	11.4702	14.7920
GDE	3.0261	3.6995	5.5186
GDPN	3.0261	3.6995	5.5186
NUCI	2.7133	2.9846	3.5362
KR	1.6863	2.4566	2.9055
Y1	6.3008	6.2992	8.2165
Y2	7.0256	7.7522	8.7592
Y3	5.9114	6.5984	8.5596
IPCA	0.6687	0.8989	0.8618
IGPDI	0.8446	1.2058	1.7312
AWR	3.7856	4.7522	4.4236
EMP	0.6899	0.6155	0.5187
DESA	8.2433	7.6922	6.7752
RES$	2.3929	2.9856	3.8816

Source: Calculated by author.

The chronological process of the structural changes of the Brazilian economy after the hyperinflation period is an interesting theme. Fiorencio and Moreira (1999) discussed the exchange rate pass-through in different regimes based on their VAR model, which included INPC, SELIC and the exchange rate, and defined the degree of indexation by the maximum eigenvalue. They showed that the degree decreased drastically after the Real Plan and was stable up to the beginning of 1999. The final test result in Table 3 suggests that the movement of the private economy can be well described by the Version 1 Model. But the result of the final test in Table 5 is worse than the one of Table 3. So there may exist a possibility of structural change in the reaction functions of the public sector.

5 SPECIFIC SIMULATION STUDIES

I tried following simulations for the sixty-first to the seventy-eight periods (January 1999-June 2000). The simulation cases (1)-(5) are calculated by the Version 2 Model, while case (6) is calculated by the Version 1 Model, in which all instruments are treated as exogenous variables. The exchange rate is an exogenous variable in all cases.

Case (1). NFSNO is held constant after January 1999.

Case (2). M2 is held constant after January 1999.

Case (3). M1 is held constant after January 1999.

Case (4). SELIC is held constant after January 1999.

Case (5). RATE is held constant after January 1999.

Case (6). RATE is held constant after January 1999. All instruments are exogenous.

The figures in Table 6 indicate the rates of divergence of simulated figures from the final test values in the seventy-eighth period (after 17 months) by the Version 2 Model.

TABLE 6
TRENDS OF NOMINAL AND REAL EXCHANGE RATES

Case	Case (1)	Case (2)	Case (3)	Case (4)	Case (5)	Case (6)
GDE	7.69	(–)19.26	0.04	4.99	(–)21.83	0.49
Y$/N	7.69	(–)19.26	0.04	4.99	(–)21.83	0.49
RES$	(–)1.15	7.96	0.76	(–)3.79	(–)0.00	(–)2.59
IPCA	(–)0.51	9.10	0.23	(–)1.49	(–)5.28	(–)9.18
INV	10.24	(–)61.80	(–)0.34	6.82	(–)64.80	(–)16.19
X	(–)4.25	(–)6.63	0.41	(–)2.70	(–)14.31	(–)5.53

From four simulation cases, (1)-(4), we can analyze the comprehensive effects of an independent change of an instrument, and its inducing changes of other instrumental variables.

Case (1). NFSNO is constant after January 1999. This implies decreases of the NFSNO in the sixty-first through the seventy-second periods, and big increases in the seventy-fifth through seventy-eighth periods. The byproduct of this fiscal stance is a higher SELIC and cyclical changes of M1 and M2. Based on these negative and positive stances of fiscal expenditure policy, the GDE decreased in the sixty-third to sixty-ninth periods, and increased in the seventy-fifth to seventy-eighth periods. The capacity utilization rate, real wages, employment, consumption and import follow similar patterns. The foreign currency reserves decreased slightly. Basically, this simulation revealed the effects of fiscal expenditure policy as expected.

Case (2). M2 is constant after January 1999, reflecting a very restrictive money supply policy (note that M2 increased rapidly in the period). M2 is a major source of money supply for private sector activities. The major byproduct is a big decrease in SELIC, M1 and NFSNO. The GDE, capacity utilization rate and investment decreased by 19 percent, 11 percent and 61 percent in the seventy-eighth period, respectively, and the rate of unemployment increased by 24 percent. Exports decreased, while imports showed cyclical changes. The wholesale price index (IGPDI) decreased, while the consumer price index increased slightly, which is a result of various changes of instruments (for example, decrease of SELIC).

Case (3). M1 is constant after January 1999. The trend of M1 is rather cyclical. So this assumption implies an increase in the sixty-first through sixty-ninth periods, and the decreases in the seventieth through seventy-second periods. It induced the accompanying change of M2, inverse changes of SELIC, and a cyclical change of NFSNO. By these changes, GDE, consumption, investment, exports, imports and foreign currency reserves showed cyclical changes.

Case (4). SELIC is constant after January 1999. This implies that SELIC decreased in the sixty-third period, but increased in the sixty-sixth through seventy-eigth periods. It induced the increasing trends of NFSNO, M2 and M1. Thus, the overall effects to the private sector economy are the sum of the effects of these changes. GDE, consumption, investment and the capacity utilization rate showed gradual increasing trends, while the variables of the labor market (DESA, AWR, EMP) and trade (exports, imports) showed cyclical trends. The overall growth of the real economy is positive, but the effects on balance of payments and foreign currency holdings are deteriorating.

Let us compare the following three cases in detail:

a) Devaluation strategy (final test case). The exchange rate was devaluated at January 1999. All instruments (NFSNO, M1, M2, SELIC) took actual values.

b) Intermediate strategy [case(6)]. All instrumental variables took actual values. Only the exchange rate was assumed constant after January 1999.

c) Fixed-exchange-rate strategy [case(5)]. The exchange rate was held constant after January 1999, and all instrumental variables changed endogenously according to their reaction functions.

Table 7 denotes the changes of important endogenous variables in the sixty-ninth (after eight months) and seventy-eighth periods (after 17 months).

Therefore, *a*) describes the actual manipulation of the exchange rate and instruments and the corresponding trend of the economy. *c*) describes the case of holding constant the exchange rate after January 1999, the corresponding manipulation of other instrumental variables and of the economic trend. *b*) is between these two. So when we ask the question, "To compare the devaluation strategy and the fixed-exchange-rate strategy after January 1999, which one was better for protecting the Brazilian economy in the actual circumstance of a quick foreign investment outflow and related economic and social instability?", the comparison between (*a*) and (*c*) will give us a comprehensive answer, and case (*b*) could serve to decompose the difference. Main observations are:

1. The devaluation strategy, which was actually adopted, was better than the intermediate strategy, and much better than the fixed-exchange-rate strategy based on the change GDE, and its major components (consumption, investment, export). When the exchange rate was held constant and instrumental variables were changed from their actual paths, GDE, consumption, investment and exports decreased by 21, 16, 64 and 14 percent in the seventy-eigth period respectively. IPCA

TABLE 7
COMPARISON OF DEVALUATION AND FIXED EXCHANGE RATE STRATEGIES

Case	Case (5)	Inst. endogenous	Case (6)	Inst. exogenous
Period	69th	78th	69th	78th
GDE	(–)10.90	(–)21.83	(–)1.78	0.49
Y$/N	41.77	16.42	56.93	49.64
RES$	(–)7.11	0.00	(–)6.13	(–)2.59
IPCA	(–)1.43	(–)5.28	(–)4.73	(–)9.18
CONS	(–)2.88	(–)16.25	3.69	2.11
INV	(–)37.48	(–)64.80	(–)15.40	(–)16.19
X	(–)46.69	(–)14.31	(–)50.75	(–)5.53

Source: Calculated by author. Figures are in percentage decreased by five percent in the seventy-eigth period. So the price stability target was better achieved. However, this is a result of a big decrease in the GDE. The foreign currency reserves, RES$, the target of the balance of payments, did not show any significant changes in the seventy-eigth period, although the GDE decreased greatly. So it is clear that the maintenance of a constant exchange rate greatly damaged the competitiveness of Brazilian exports. Considering all these factors, we can conclude that the exchange rate regime change and the accompanying devaluation strategy made up the best strategy among the set of possible manipulation of instruments.

2. The cost of an intermediate strategy, in which only the exchange rate changed relative to the path actually observed. Therefore, the divergence of case (6) simply describes the independent effect of a constant exchange rate. From Table 7, the main effect is the collapse of international competitiveness and accompanying decrease of exports to a half, as well as the related decrease of investment by 15 percent.

3. The additional cost of manipulation of instruments. The difference between case (5) and case (6) shows that the big downfall of economic activities occurred based on the further adjustment of instruments.

The basic three targets of macroeconomic policy are growth (increase of GDP), price stability (decrease of IPCA), and balance of payments equilibrium (increase of RES$). In case (5) or (6), the sum of GDP in the sixty-first and seventy-eighth periods and the foreign currency reserves (RES$) decreased as compared to the final test. The decrease of the IPCA is due in part to the decrease of the GDP. Therefore, we can also conclude that the devaluation strategy was better than the maintenance of the fixed exchange rate based on the comprehensive judgment of basic targets.

According to Bodansky *et al* (2000), the basic framework of implementing an Inflation targeting in Brazil was as follows. (1) Output gap (h) is determined by fiscal stance (NFSNO) and others. (2) Rate of inflation (π) is determined by h, foreign price and exchange rate (e). (3) Balance of payments (BP) is determined by h, π and the interest rate (SELIC). Thus instruments were assigned to targets as follows: a fiscal instrument to the growth target, the exchange rate to price stability and SELIC to balance of payments equilibrium. Based on the modeling exercise, the observation period (June 1996-June 2000) is divided into three sub-periods.

a) Successful Real Plan period (June 1996-Summer 1998). NFSNO is squeezed to control the fiscal debt, thus resulting in increases of the output gap.

The exchange rate was maintained as fixed, so it successfully restrained the possible inflationary trend. SELIC was adjusted to control the balance of payments deficit. Thus the package of neo-classical combination (a fiscal instrument targeting growth and the SELIC targeting the balance of payments) along with a fixed exchange rate, meant to sustain price stability, worked successfully to achieve the political goals of the Real Plan.

b) Transitory break period (Autumn 1998-January 1999). The implicit trend of the overvaluation of the exchange rate became explicitly apparent, and this recognition induced an expectation of devaluation, and a strong short-term capital flight. Finally the fixed exchange rate regime was abolished in January 1999, and the exchange rate was immediately devalued nearly 100 percent. This quick devaluation and accompanying spurt of SELIC stopped the big capital flight, and resolved the balance of payments crisis.

c) Relative stable period (January 1999-June 2000). A big exchange rate devaluation animated the export, and contributed to economic recovery. After the exchange rate became flexible, it became a market determined endogenous variable. So the SELIC became more heavily attached to the price stability target. The inertia of a big devaluation dominated through this sub-period, in which price stability and economic recovery were observed.

After the adoption of a floating regime, the SELIC is expected to work not only for price stability, but also for the balance of payments equilibrium by influencing capital transactions. Meanwhile, it is rather difficult for NFSNO to change because of the existence of big fiscal debt. This shortage of instruments or overburden on the SELIC will render the policy handling after 2001 very difficult, and can be one of the causes of stagflation after 2001. This is an interesting and important research topic for future study. Other simulation studies based on the Version 2 Model will be reported in Chapter 6.

6 TRIAL CONSTRUCTION OF DECISION MODEL

Variables in an econometric model can be classified as endogenous and exogenous variables. The former can be interpreted as political target variables and irrelevant variables. The latter can be interpreted as instrument variables and non-policy variables. By eliminating irrelevant variables, an econometric model can be reduced to a decision model, which describes the interrelationships between targets and instruments in a compact way. In this section, I took up three political targets (growth, balance of payments, price stability) and four instruments (M1, M2, NFSNO, SELIC), and constructed a compact decision model. The results were as follows. The target variables are specified as the per capita GDP in dollars (Y$/N), balance of payments (BP$) or foreign currency reserves (RES$) and IPCA. The result is as follows. I estimated two equations of Y$/N and BP$ anew to construct the decision model, and combined them with definitions of GDE and foreign currency reserves. The instrument reaction functions are the same with the Version 2 Model.

Decision Model of Brazilian Economy (June 1997-June 2000: 37 samples)

(Target Function)

(T-1) Per Capita Monthly GDP in US$ (Y$/N)

(Y$/N)=2482.98–0.2868*((SELIC)(–1)–(IPCA)(–1)+(IPCA)(–2))

(6.75) (–1.69)

–0.2251*((SELIC)(–7)–(IPCA)(–7)+(IPCA)(–8))

(–1.42)

+4.303*(M2)(–1)/(IPCA)(–1)–2.239*(NFSNO)(–7)

(5.87) (–1.63)

–235.2*(RATE)/(RATE)(–1)–225.1*(RATE)(–1)/(RATE)(–5)

(–19.81) (–22.83)

–168.8*(RATE)(–5)/(IPCA)(–5)–34.30*(POIL$)(–3)/(POIL$)(–5)

(–16.40) (–3.53)

+25.98*(KFDI)(–1)/(KFDI)(–12)–1499*(GDPUS)(–1)/(GDPUS)(–4)

(5.57) (–4.24)

+F1(PFP$)+u

$R^2 = 0.9976$, $RA^2 = 0.9955$, $SE = 3.9667$, $SD = 59.6684$, $DW = 1.93$, $F = 478.02$

(T-2) Per Capita Monthly GDP (in R$) (GDPN)

(GDPN) = (Y$/N)*(RATE)

(T-3) GDE(GDE = GDP)(GDE)

(GDE) = (GDPN)*(POP)

(T–4) Balance of Payments (BP$)

(BP$) = –466228.9+214.0*(SELIC)(–2)+88.72*(SELIC)(–3)+416.9*(SELIC)(–9)
(–6.03) (6.89) (2.51) (9.18)
+196.24*(SELIC)(–10)+117.8*(SELIC)(–14)-626.7*(NFSNO)(8)
(5.03) (3.34) (–1.46)
+945.9*(NFSNO)(–9)+1119*(NFSNO)(–14)+6837*(RATE)(–4)
(4.95) (5.17) (4.15)
+18050*(RATE)(–8)+8926*(RATE)(–8)/(RATE)(–12)
(5.77) (4.77)
–23370*(POIL$)(–1)/(POIL$)(–7)+836.4*(POIL$)(–3)
(–6.59) (3.82)
+256.8*(POIL$)(–7)+231.5*(POIL$)(–9)+6942*(KFDI)(–2)/(KFDI)(–13)
(1.98) (1.73) (6.82)
+361500*(GDPUS)(–4)/(GDPUS)(–13)+F4(FPF$)+u
(4.93)

$R^2 = 0.9913$, $RA^2 = 0.9792$, $SE = 657.42$, $SD = 4566.34$, $DW = 2.82$, $F = 81.99$

(T-5) Foreign Currency Reserves (RES$)

(RES$) = (RES$)(–1)+(BP$)+(BPE$)

(T-6) Consumers Price (IPCA): same as (E-16)

(Instrument Reaction Function)

(I-1) Interest Rate (SELIC): same as (E-22)

(I-2) Narrow Money Supply (M1): same as (E-23)

(I-3) Wide Money Supply (M2): same as (E-24)

(I-4) Ratio of Public Sector Borrowing Requirements to GDE (NSFNO): same as (E-25)

Per capita GDE function: In Figure 16, the per capita GDE in dollars (Y$/N) showed a negative trend until the end of 1996, then quickly dropped at the beginning of 1997 and gradually recovered. In (T-1), it is negatively influenced by the real interest rate, which is the nominal interest rate (SELIC) minus the increment of consumer prices (IPCA), PSBR ratio (NFSNO), nominal exchange rate (RATE) change, real exchange rate and oil price change. It is positively influenced by the money supply (M2) and by an increase of foreign capital stock (KFDI). GDE is determined by definition. The actual trend is fairly well-traced, including a drop in January 1999, a steady recovery in dollar terms, and a quick recovery in Real.

Balance of payments function: In Figure 17, the balance of payments displayed volatile changes in the observation period. It recorded big peaks in the Spring of 1996, and twice in 2000, and a big valley in to Autumn of 1996. In (T-4), the balance of payments (BP$) is positively influenced by the interest rate (SELIC), exchange rate (RATE), growth of foreign capital and GDP of the USA. The PSBR ratio (NFSNO) and the oil price (POIL$) of different months have changing signs, and create cyclical influences. As shown in Figure 17, the estimated values do fairly well in tracing the actual cyclical movement, including a quick drop at the end of 1998, and the following steady recovery. The estimated foreign currency reserves (RES$) also nicely traced the actual sharp decline after 1998.

I calculated the final test for 37 months (42-78). The mean absolute percentage error (MAPE) of the endogenous variable is shown in Table 8.

As for the private sector economy, the MAPE for the GDE and IPCA are fairly good, but the result for foreign currency holdings created systematic errors. As for the instruments, MAPE for M2 is fairly small, while MAPE for M1, SELIC and NFSNO are quite big. These high values of MAPE are partly due to the special trends of quick decreases to low levels in 2000. Considering these results, the construction of the decision model still needs further improvement, especially regarding the balance of payments.

Exchange rate function: In the decision model, we treated the exchange rate (RATE) as an exogenous variable. (1) But as shown in Figure 18, I discovered a single equation (S-1) that nicely explained the trend of the exchange rate quite well in the observation period based on (non-FDI) short-term capital inflow (FPF$), consumer price changes, foreign currency reserves, current account balance, SELIC, GDE growth, LIBOR of the USA., real wage change, oil price change and public sector borrowing change. (2) There is an interesting question about the nature and stability of the equation's coefficients because the exchange

FIGURE 16
RESULT OF ESTIMATION OF Y$/N

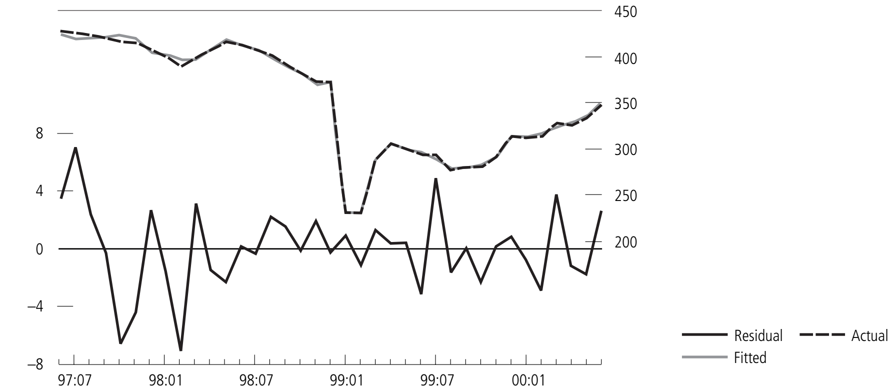


FIGURE 17
RESULT OF ESTIMATION OF BALANCE OF PAYMENTS (BP$)

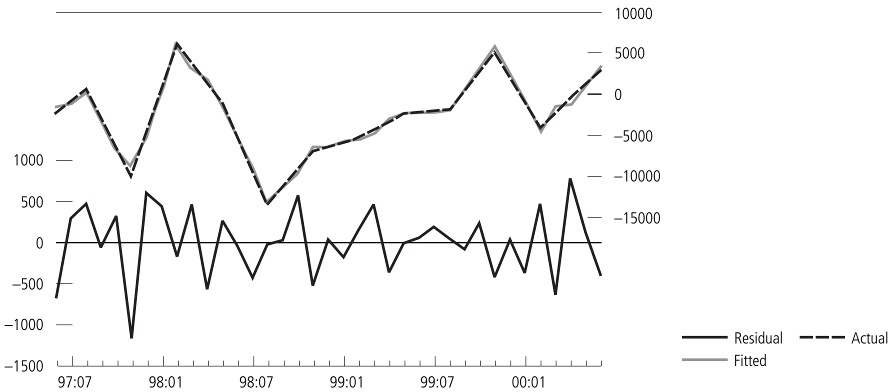


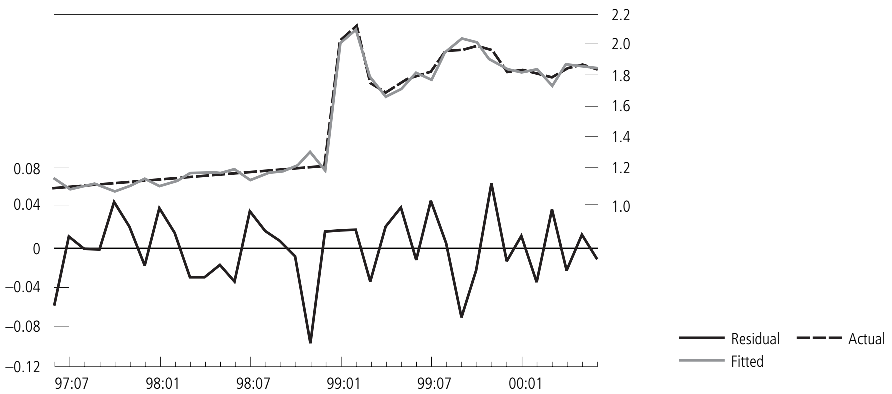
TABLE 8
RESULT OF FINAL TEST (42-78 MONTHS)

Variables	MAPE (Last 10 months)	MAPE (Last 5 months)	MAPE (Last 3 months)	Determination COEFFICIENT
Target				
Y$/POP	2.894	3.580	3.098	0.9976
GDE	2.894	3.580	3.098	(Definition)
GDE/POP	2.894	3.580	3.098	(Definition)
BP$	—	—	—	0.9913
RES$	31.524	35.471	40.204	(Definition)
IPCA	0.806	1.085	1.441	0.9517
Instruments				
SELIC	48.396	42.260	42.067	00.9572
M1	12.171	15.960	18.111	0.9789
M2	4.912	6.690	6.278	0.9894
NSFNO	48.172	42.260	42.067	0.9937

Source: Calculated by author. MAPE of balance of payment (BP$) is not shown because it can take zero value, so MAPE is meaningless.

rate regime changed from a band system to a freely floating system in January 1999. So the nature of the exchange rate equation is a mixture of a governmental reaction function to implement the rate according to political targets, and a behavioral equation to reflect market tendencies. The negative coefficients of the growth rates of AWR and IPCA might reflect the governmental attitude to mitigate the inflationary trend by evaluation. Also, because this is a short-term model, the expectation behavior must strongly influence some coefficients. The influence of oil price is complex, but as shown in Figure 18, this equation successfully explained the quick depreciation in January 1999. (3) I could not incorporate this exchange rate equation into the model and get reasonable results in the final test. The incorporation of the exchange rate equation is another important issue for the future.

FIGURE 18
RESULT OF ESTIMATION OF EXCHANGE RATE (RATE)



(S-1) Exchange Rate (RATE)

$(RATE)=11.99-1.024*(GDE)(-4)/(GDE)(-8)-0.08368*(SELIC)(-2)/(SELIC)(-7)$

(11.26) (–4.33) (–2.32)

$-0.02621*(RES\$)(-2)/(IM)(-2)+0.2104*(CA\$)(-1)/(CA\$)(-2)$

(–4.28) (5.99)

$+5.162*(LIBORUSA)(-1)/(LIBORUSA)(-2)-3.628*(AWR)(-1)/(AWR)(-13)$

(9.31) (–8.76)

$-9.899*(IPCA)(-3)/(IPCA)(-12)-0.3978*(NFSNO)(-1)/(NFSNO)(-7)$

(–9.91) (–7.72)

–0.8713*(POIL$)(–1)/(POIL$)(–3)+0.5539*(POIL$)(–1)/(POIL$)(–7)
(–8.94) (10.00)
+FS1(FPF$)+u

$R^2 = 0.9905$, $RA^2 = 0.9852$, $SE = 2.045$, $SD = 0.04366$, $DW = 2.15$, $F = 185.82$

FS1(FPF$) = –0.005322*(FPF$)(–1)/(FPF$)(–2)–6.63E–05*(FPF$(–5)
(–5.32) (–9.78)
–3.18E–05*(FPF$)(–6)
(–4.88)

In August (–$4.139B) and September (–$5.776B) of 1998, the net short-term capital inflow (FPF$) recorded large negative balances. The large short-term capital outflow might have represented foreign investors expectations: (1) the increasing tendency of the overvaluation of the exchange rate would damage the international competitiveness, worsen the current balance and decrease the foreign currency holdings, so (2) the government would devaluate the exchange rate in the near future. Actually, a large devaluation (accompanied by the regime change) happened in January 1999 and corrected the overvaluation of the exchange rate. In a sense, the large capital outflow signalled a severe macroeconomic imbalance which urged for correction. A large capital outflow implies a worsening in the confidence of international investors, so it is a bad sign. But if such a warning sign is quickly noticed, and effective countermeasures are taken, the government could actually improve the situation, turning a minor setback into a major advantage.[2]

To clarify this point, I conducted an experiment, in which I assumed that the capital flight in the Autumn of 1998 was cut by a half, and changed the absolute values of the short-term capital outflow accordingly (–$2.069B, –$2.888B) as shown in Figure 19, and recalculated the values of the exchange rate. Table 9 shows the ratio of the new value of the variable to the final test value. The decrease in the capital outflow in August-September 1998 lessened the devaluation of the exchange rate in January 1999, by making the exchange rate increase to 1.8 instead of R$ 2 per dollar. But as Table 9 shows, the trend of the exchange rate is quite

2. I thank Dr. Octávio A. F. Tourinho (IPEA) for his useful comment on this point. "So, the incidence of large capital outflow to the economy indicates that a minor setback can turn into a major advantage if tactfully treated".

TABLE 9
EFFECTS OF DECREASE OF FOREIGN CAPITAL OUTFLOW

VARIABLES	1-3, 99	4-6, 99	7-9, 99	10-12, 99	1-3, 2000	4-6, 2000
SELIC	0.943	0.972	1.125	0.937	1.223	0.971
RATE	0.915	0.990	1.003	0.995	0.996	1.004
M2	1.004	0.980	1.039	1.027	1.004	0.991
M1	1.073	1.130	1.146	1.146	1.205	1.023
RES$	1.186	0.997	1.013	0.769	0.703	0.890
IPCA	0.998	0.999	1.001	0.998	0.992	0.996
NFSNO	0.974	0.974	1.012	0.902	0.931	1.266
GDE	1.063	1.026	1.018	1.020	0.998	0.994
Y$/POP	1.156	1.037	1.016	1.025	1.002	0.990

similar after January 1999, so the necessary adjustment (devaluation) happened anyway. But such a delayed adjustment created a social cost in 18 months. Compared with the final test value, the foreign currency reserves (RES$) decreased by 11 percent, while the GDE and IPCA decreased by little. The deviation of SELIC and also of NFSNO show cyclical movements. So, when judged by a combination of growth, price stability and balance of payments targets, an elimination of the large capital outflows actually damaged total welfare. In other words, the large capital outflows in August-September 1998 forced a large devaluation by the government in January 1999; but based on such prompt adjustment, the government was able to avoid a larger decrease of national welfare.

7 SUMMARY AND CONCLUSION

The main purpose of this chapter was to confirm the possibility of the construction of a monthly econometric model. I collected monthly data from various sources. I also converted the quarterly series of national income statistics to a monthly basis. Combining this monthly data, I constructed a Version 1 monthly econometric model (June 1997-June 2000) for the private sector with 21 endogenous variables and 18 exogenous variables. I paid special attention to separate secular trends from the left-hand explained variables by normalization to avoid spurious correlation. I did not use any dummy variables, but used the portfolio foreign investment (or its combinations) to manifest the changing expectations to the current trend of the Brazilian economy. The OLS estimation showed good final test results, in which the MAPE of all endogenous variables were controlled at less than ten percent after repeating the calculation 36 times.

Then I estimated the reaction functions for four important monetary and fiscal instrumental variables (SELIC, M1, M2, NFSNO). By incorporating these reaction functions, I constructed a Version 2 Model. Although the MAPE of

SELIC and NFSNO are relatively high due to volatile changes in late periods, the final test showed that the movement of the private sector is still nicely traced by this extended model.

Brazil abolished the fixed exchange rate regime and adopted the flexible exchange rate regime in January 1999. This resulted in a big devaluation of Real by nearly 100 percent. Was such a devaluation strategy desirable or not? Could the accompanying changes of instrumental variables mitigate the deteriorating effects of shock? The simulation studies based on Version 1 and Version 2 models showed that the devaluation strategy was better than the maintenance of the fixed exchange rate regime. The continuation of the fixed exchange rate regime would result in the collapse of the private sector, with a drop of the GDE by 21 percent in 17 months, even though the instruments are fully accommodated based on reaction functions. A big short-term capital outflow like the one in August-September 1999 is a bad because it implies a deterioration of investor confidence. But without such a big capital outflow, the government could not opt for quick actions (including the exchange rate regime change and devaluation), so the national welfare would deteriorate even further. In Brazil's case, a big capital outflow acted as a useful warning for the government act smartly enough to respond quickly.

I tried to construct a decision model with four target variables (GDE, IPCA, BP$, RES$), four instruments (SELIC, M1, M2, NFSNO) and nine exogenous variables, which compactly describes the mutual over-time interrelationships between targets and instruments. There are many interesting studies of such target-instrument interaction based on the VAR framework. But the number of variables is usually smaller and the fit with the actual trend is not rigorously confirmed. The monthly decision model offers an alternative framework to supplement these two points, although the current decision model still needs further improvement in fitting.

A simple simulation by the decision model clarified that a large short-term foreign capital outflow in Autumn 1998 contributed positively to improving the national welfare. The big outflow of short-term capital per se is not a blessing. But it urged a quick response, a big devaluation, and this prompt action protected the economy from a greater loss.

The overall results showed the feasibility of the construction of a monthly econometric model and the usefulness of related simulation studies. Naturally, there are many important points subject to further improvement. The current models treat two important variables as exogenous: the exchange rate (RATE) and the short-term capital net inflow (FPF$). After these two variables are successfully and endogenously explained, the resulting enlarged decision model could better serve to describe the changes of instrument variables and to assess their effectiveness in more detail. A preceding study is an Indonesian monthly model [Fukuchi 2000*a*, 2001). Also, I admit that the object of fiscal policy is not confined to three macroeconomic targets. Therefore, the additional components, such as the preparation of a better infrastructure, must be additionally considered in order to fully assess a fiscal instrument. As the changes of targets and instruments were very volatile in the observation period, the possibility of structural changes must be further checked.[3]

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FUKUCHI, T., TOKUNAGA, S. Simulation analysis of exchange rate dynamics: the case of Indonesia. *The Developing Economies*, v. 37, n. 1, p. 35-58, 1999.

3. The chronological process of the structural changes of the Brazilian economy after the hyperinflation period is an interesting theme for modeling work. Fiorencio and Moreira (1999) discussed the exchange rate pass-through in different regimes based on their VAR model including INPC, SELIC and the exchange rate, and defined the degree of indexation by the maximum eigenvalue. They showed that the degree of indexation decreased drastically after the Real Plan and was stable until the beginning of 1999.

CHAPTER 6

STOCHASTIC SIMULATIONS AND MULTIPLIER ANALYSIS

Mamoru Obayashi

1 INTRODUCTION

The purpose of this chapter is to analyze the dynamic properties of the three macro econometric models of the Brazilian economy described in the previous chapters. To do so we have applied stochastic simulation as a tool for assessment, following Hukkinen and Viren (1999). These simulations have allowed us to understand the forecasting performance of each macroeconometric model and its robustness to stochastic shocks.

A lot of criticism exists on the standard approach to macroeconometric modeling. Firstly, the forecasting performance of large "structural" macroeconometric models has been poor even though such models are generally found to be useful. Secondly, the theoretical foundations of the models have not accounted satisfactorily for some theoretical developments, such as the introduction of rational expectations. Thirdly, the econometric procedures have not been adequate, for example by ignoring implications of cointegration and so on. Lastly, the models have not been sufficiently tested and their overall performance has not been adequately evaluated.

This last point is important. Formal econometric testing has been conducted mostly on individual estimated equations, but only on a few occasions has the overall performance of the model been formally evaluated.

A common practice in testing the models is to calculate their mean absolute percentage errors (MAPE) or root mean squared errors (RMSE). Obviously, if either the MAPEs or RMSEs are close for two different models, it will be difficult to distinguish their relative merits. At the same time, even if some MAPEs are smaller than others, it will be impossible to conclude that the models with the lower MAPEs contain more information.

To be precise, there are two types of MAPE/RMSE tests: within sample MAPEs and outside sample MAPEs. If one had enough data, one could divide the sample into two parts: a sample period for estimation and a sample period for the evaluation of forecasting performance. Unfortunately, due to the lack of sufficiently long time series, macroeconometric models usually use most of the sample for estimation, leaving very little room for out of sample tests. This is particularly true in the case of the three macroeconometric models for the Brazilian economy that we have considered, which had to use up all of the samples for estimation, thus making it impossible to calculate outside MAPEs.

After obtaining a reasonable model with MAPEs, there are two possible tests for analyzing the model. One is stochastic simulation and the other is multiplier analysis. By applying stochastic simulation, we can analyze the behavior of the model's endogenous variables in response to random shocks. In order to analyze the model's response to changes in the exogenous variables, we use multiplier analysis.

2 RESULTS OF THE STOCHASTIC SIMULATIONS

We should note that the models passed the so-called "final tests", which means that these models are good approximations to the real economy, assuming that the error terms of each estimated equation are not considered. From these results, we can safely proceed to the stochastic simulations.

The stochastic simulations are carried out as follows. First, we run a within-sample simulation called "the final test" as a dynamic deterministic simulation. The solution is the baseline. The MAPEs are then calculated based on the actual data and baseline solution.

In a stochastic simulation, the equations of the model are solved so that they have residuals that are randomly drawn. In this case, the model generates a set of outcomes for the endogenous variables in every run. We obtain a distribution of outcomes by solving the model many times using different draws for the random components in the model, then calculating statistics over all of the different outcomes. One thousand repetitions are generally adequate to obtain reasonable values.

We select the size of the confidence interval given by the upper and lower bounds; the 95 percent confidence interval with a weight of 2.5 percent in each tail will be appropriate.

At each observation of a stochastic simulation, a set of independent random numbers are drawn from the standard normal distribution, then these numbers are scaled to match the desired variance-covariance matrix of the system. These variances are calculated from the model equation residuals. For the set of observations that will be used when estimating the variance-covariance matrix of the model residuals, we use the estimation sample.

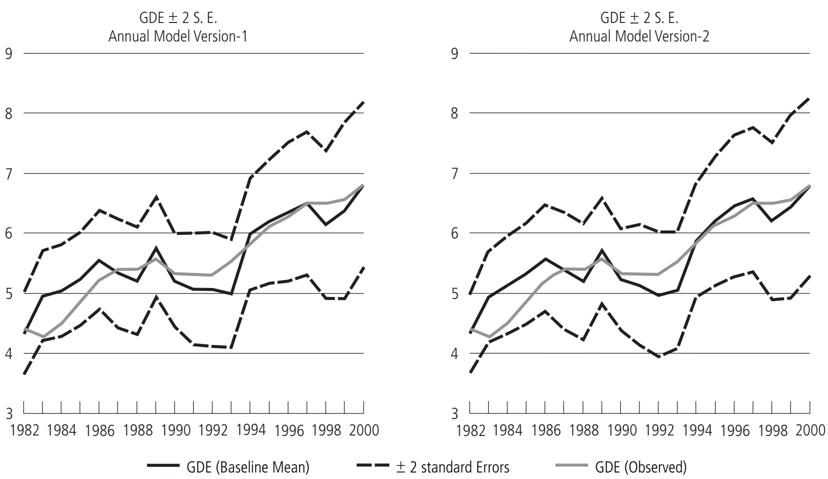
All endogenous variables are shocked at the same time. Obviously, a lot of volatility results. Depending on the model characteristics, the model may fail to run one thousand times due to the explosive paths. We selected the maximum sample period, which is capable of running one thousand stochastic simulations for each model.

There are shocks to the stochastic equations and shocks to exogenous variables. Shocks to the endogenous equations are a straightforward application of stochastic simulation. The three diagrams that follow show the results of the 1,000 runs of each model, applying randomly chosen error terms for each estimated equation.

The three models have different periodicities, and a straightforward comparison is not possible. For each data frequency, we distinguish two versions: Version 1 and Version 2. Version 1 does not include monetary variables and fiscal variables, such as monetary aggregates, interest rates and the exchange rate (depending on the model). Version 2 treats these variables as endogenous.

Figure 1 shows the results of Annual Model Version 1 and Version 2. In each diagram, the baseline as the path of average of one thousand runs, the actual path of the series and the bound of confidence interval of two standard errors are drawn.

FIGURE 1
STOCHASTIC SIMULATIONS OF THE ANNUAL MODEL
[GROSS DOMESTIC EXPENDITURE (GDE), R$ TRILLIONS 1980 PRICES]



The paths of the baseline and actual Gross Domestic Expenditures (GDE) do not diverge. In addition to that, the variances increase through time but they are not explosive. The result of Annual Model Version 2 is quite similar to Version 1, though the path of the average of simulations appears to be slightly different.

Figure 2 shows the results of the Quarterly Model. Note that the models run successfully only for the shorter sample periods rather than the estimated sample periods, in the case of Version 1 from the fourth quarter of 1997 to the second quarter of 2000 and in the case of Version 2 from the fourth quarter of 1998 to the second quarter of 2000. The variances of Version 1 are not explosive but Version 2 exhibits explosive variances.

Figure 3 shows the results for the Monthly Model. Version 1 runs successfully through the estimated sample periods. Note that Version 2 runs successfully only for the shorter sample period rather than the estimated sample period: July 1999 to June 2000. The path of the average of one thousand runs and the actual GDE do not diverge in the case of Version 1 at earlier stages, but at later stages of the simulations it diverges. In addition to that, the standard errors of the model are expanding in the case of Version 2.

As a general observation for the Version 1, the lower the data frequencies are, the more robust the models. Because the observations included are relatively stable, but the exception is the Quarterly Model. As regards the differences in versions,

FIGURE 2
STOCHASTIC SIMULATIONS OF THE QUARTERLY MODEL
[GROSS DOMESTIC EXPENDITURE (GDE), R$ MILLIONS, 1990 PRICES]

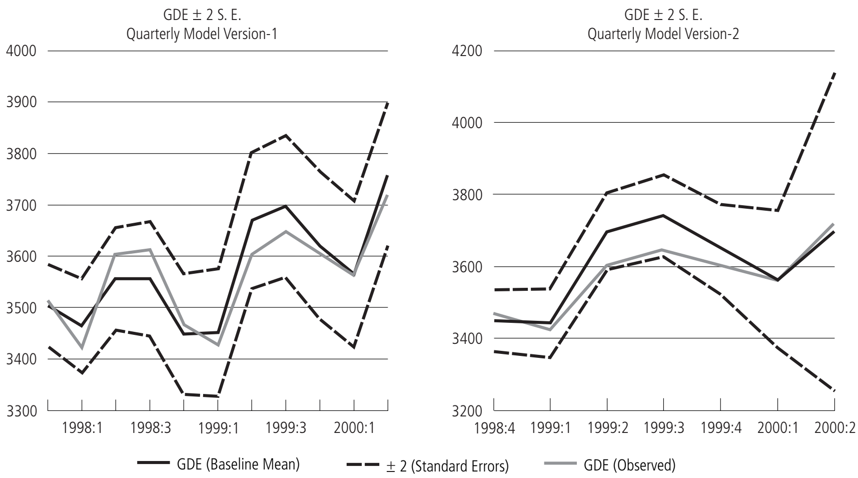
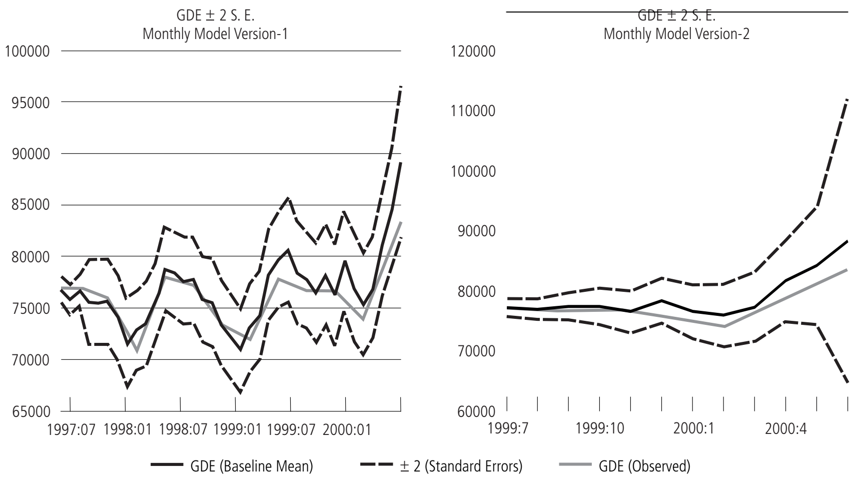


FIGURE 3
STOCHASTIC SIMULATIONS OF THE MONTHLY MODEL
[GROSS DOMESTIC EXPENDITURE (GDE), R$ MILLIONS]



the variances of Version 2 of the models increase at higher rates over the simulation period. For the sources of these paths of GDE we need to investigate individual paths of endogenous variables.

In the following part, we pick up several variables of our interest that cause problems in simulations in order to observe the characteristics of the models.

In the case of the Annual Model Version 1, it is evident that the price variables are the sources of instability because the sample includes inflationary periods. Figure 4 shows IPCA consumer price index. Because these variables have larger and expanding variances as compared to other variables, they make the model unstable. Eventually they drive the model into a region in which it is not defined.

In the case of the Annual Model Version 2, the variances of price variables are explosive as well. Furthermore, the M2 money supply displays an exploding pattern, as depicted in Figure 5.

As for the Quarterly Model Version 1, it is stable for a certain period but it cannot run successfully for the entire sample period. The model structure requires further improvements. It runs only from the fourth quarter of 1997 to the second quarter of 2001. In particular, the variances of AWR real wage rate are explosive as shown in Figure 6.

Regarding the Quarterly Model Version 2, the model runs for a shorter period than Version 1. Hence many variables have explosive variances but the original

FIGURE 4
STOCHASTIC SIMULATIONS RESULTS: ANNUAL MODEL VERSION-1
[IPCA, CONSUMER PRICE INDEX, 1990=100)

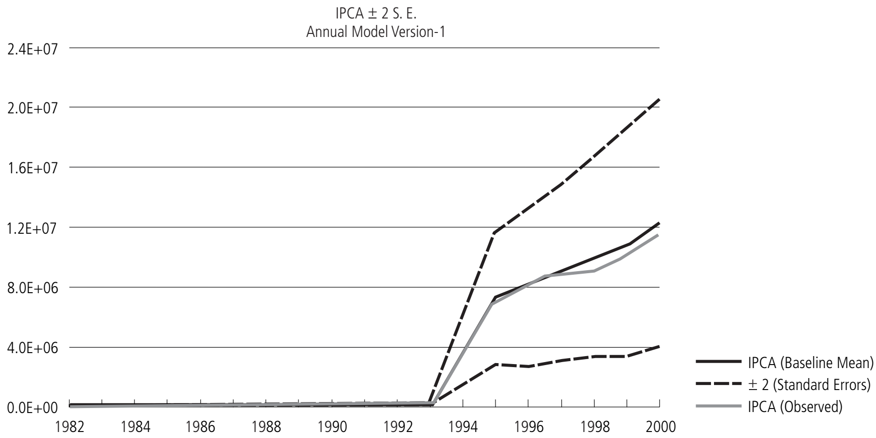
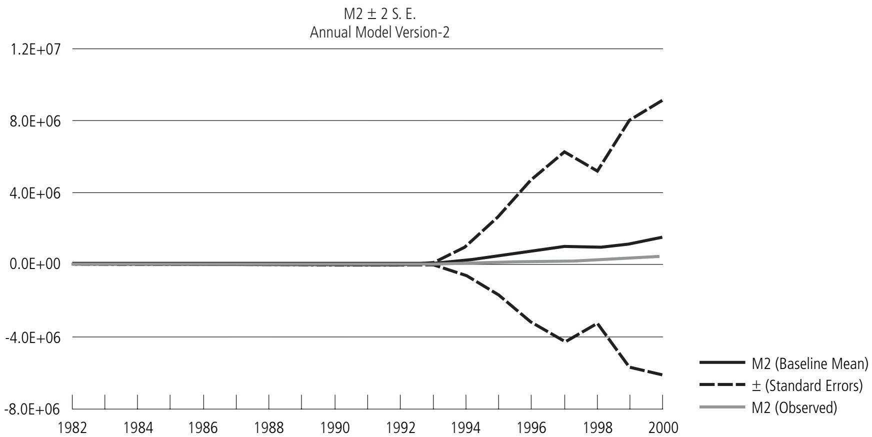


FIGURE 5
STOCHASTIC SIMULATIONS RESULTS: ANNUAL MODEL VERSION-2
[MONEY SUPPLY M2, R$ MILLIONS]



sources seem to be the real wage rate AWR, investment INV, unemployment DESA and money supply M2. Figure 7 shows investment INV.

As regards the Monthly Model Version 1, the model is relatively stable as compared to Version 2. There are two patterns of standard errors: the one is expanding and the other is large but not expanding. INV (investment), X (exports) and IM (imports) belong to the former case, while AWR (real wage rate), DESA

FIGURE 6
STOCHASTIC SIMULATIONS RESULTS: QUARTERLY MODEL VERSION-1
[AWR REAL WAGE RATE, INDEX NUMBER]

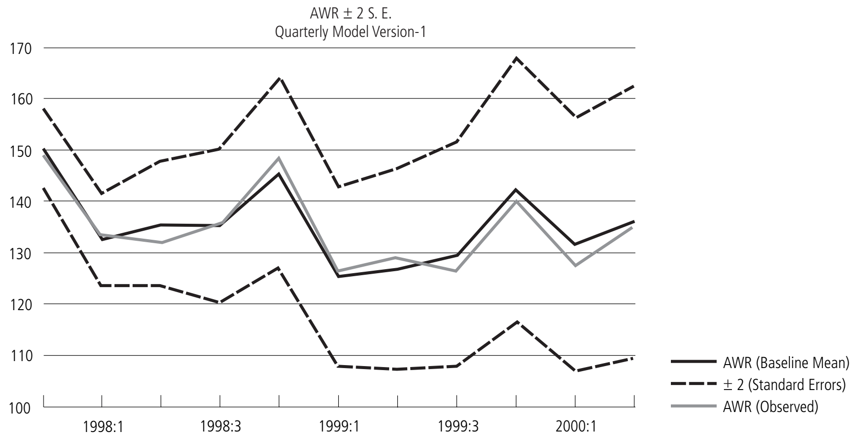
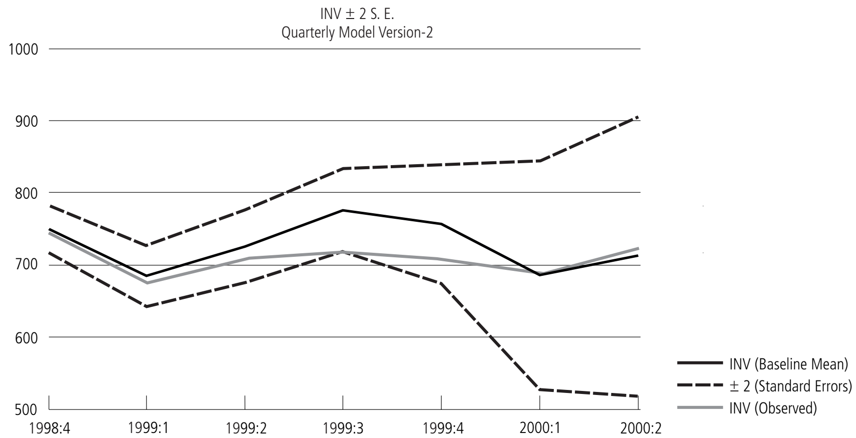


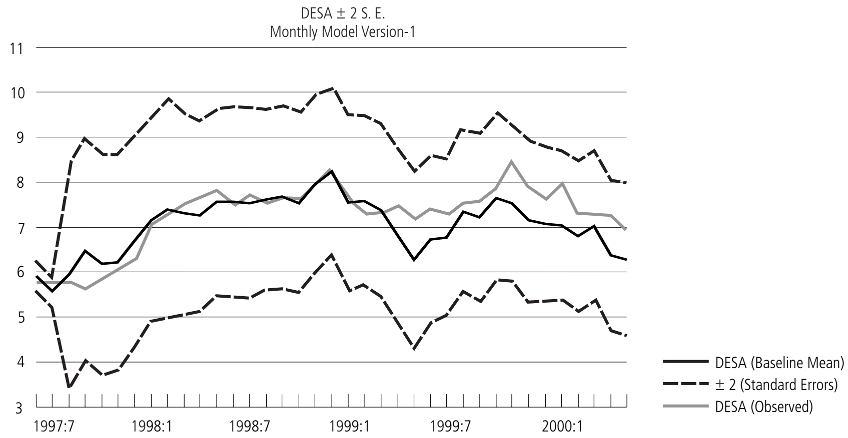
FIGURE 7
STOCHASTIC SIMULATIONS RESULTS: QUARTERLY MODEL VERSION-2
[INV INVESTMENT, R$ MILLIONS, 1990 PRICES]



(unemployment rate) and NUCI (utilization rate) to the latter case. This observation suggests that improvements on equations such as INV, X and IM will contribute more to the stability of the model than will do improvements on other equations. Figure 8 shows Investment INV.

The Monthly Model Version 2 runs successfully only from July 1999 to June 2000. Most variables have explosive variances. Large variances of utilization

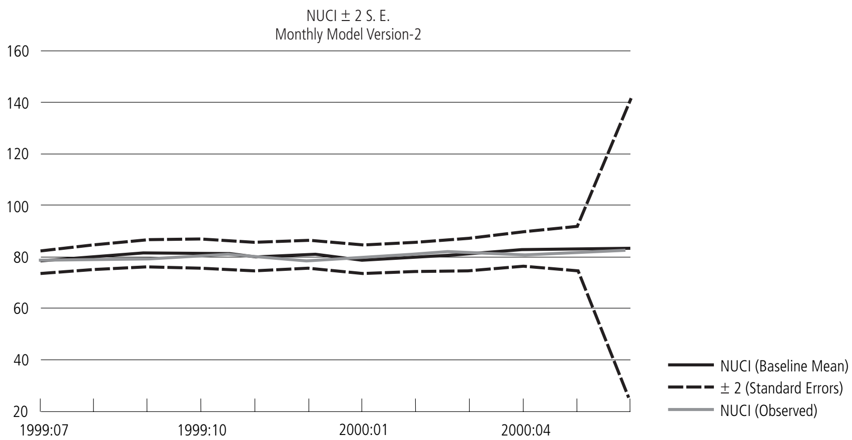
FIGURE 8
STOCHASTIC SIMULATIONS RESULTS: MONTHLY MODEL VERSION-1
[DESA UNEMPLOYMENT RATE, PERCENT]



rate NUCI, of real wage rate AWR, of unemployment DESA, of money supply M1 and of money supply M2 are the sources of the exploding nature of the model. Figure 9 shows the result of NUCI utilization rate.

Across the simulations, the models perform surprisingly well, given the large shocks affecting each equation. In most cases final demand sectors are robust, with the exception of the investment expenditures. The price sectors (except for

FIGURE 9
STOCHASTIC SIMULATIONS RESULTS: MONTHLY MODEL VERSION-2
[NUCI UTILIZATION RATE, INDEX NUMBER]



the annual model) are also robust. However, if one takes into account the fact that the sample periods of the monthly and quarterly models include relatively stable periods, it is understandable. The trade sectors of the models are very much alike.

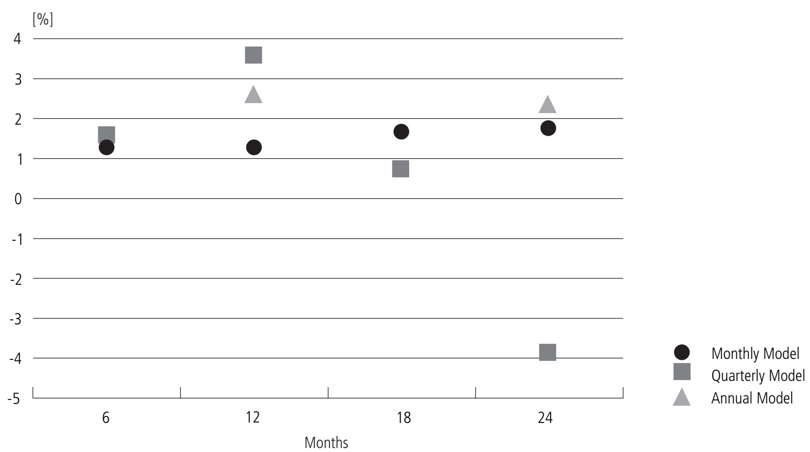
If we include financial variables into the models, as in the cases of Version 2, the models tend to fluctuate more. While this suggests that those variables are sources of fluctuation, it also suggests that the estimated equations sometimes have larger errors. Comparing the results within these variables, interest rates behave well. However, comparing M1 and M2, we find large variances in M2.

Finally, the specifications of the equations affect the results. For instance, those equations estimated in growth rate or logarithm tend to have greater variances because the shocks are added in multiplicatively. Hence, if we introduce various specifications of endogenous variables into the model, we should be careful about the consequences to model characteristics, otherwise we face difficulties in comparing them. At the same time, the nature of the shocks requires more careful attention.

3 MULTIPLIER ANALYSIS

Shocks to the exogenous variables are difficult to handle. One approach is to estimate a time series model for each exogenous variable and add these equations to the model. However, the model becomes different, so the comparisons are troublesome. Here we take the simplest approach of adding sustained shocks to constant terms of consumption expenditure equations. The results are shown in Figure 10.

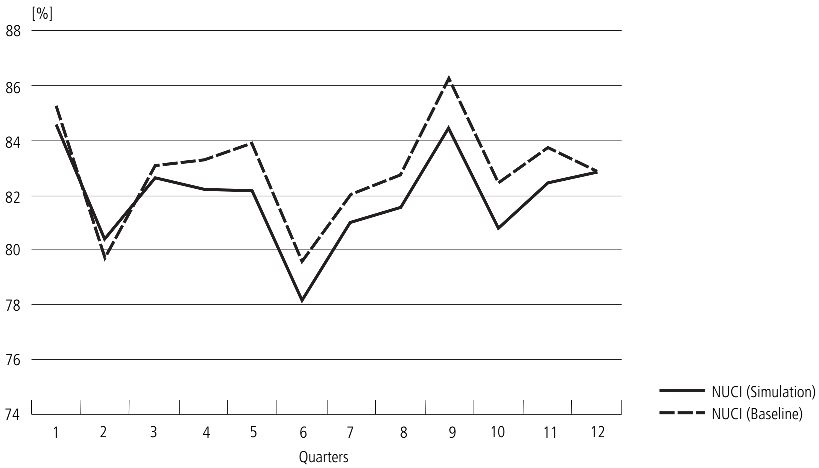
FIGURE 10
COMPARISON OF MULTIPLIERS
TIME AGGREGATED AND SUSTAINED CHANGES



Due to the differences in model structures, data frequencies and sample periods, there is no common ground for comparing multipliers. We postulate that shocks are added to the constant terms of consumption expenditure equations. But even this treatment needs careful interpretation. The Monthly Model includes government consumption in consumption expenditure, the Quarterly Model has private consumption expenditure, and the Annual Model has a private consumption expenditure measure that includes residuals from the use of balance of payments data for national accounting. The shocks are one percent of yearly GDE. Please note that Version 2 is used in the Monthly and in the Annual Models, while Version 1 is used in the Quarterly Model.

First year multipliers are 2.61 for the Annual Model, 3.58 for the Quarterly Model and 1.34 for the Monthly Model. To discuss the appropriateness of these multipliers, we need more simulation exercises. The paths of multipliers are quite different but the Monthly and Annual Models have positive multiplier effects for two years. The Quarterly Model exhibits sharp decreases approximately after one and a half year. It seems that the behavior of the NUCI Utilization Rate is responsible for the different path of the Quarterly Model, as shown in Figure 11. It starts to decrease drastically relative to the baseline from the fourth quarter on.

FIGURE 11
NUCI: UTILIZATION RATE OF QUARTERLY MODEL VERSION-1



4 CONCLUDING REMARKS

This chapter has shown the results of various simulations using three models. It has established the importance and usefulness of stochastic simulations and multiplier analyses to understand the dynamic properties of the models. At the same time, these exercises have provided hints for further developments of the models by identifying possible sources of fluctuation and lack of robustness. In particular, stochastic simulation can be integrated to the model-building exercises as a tool for model selection.

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CHAPTER 7

CONCLUDING REMARKS

Takao Fukuchi
Marco Antônio F. H. Cavalcanti

In order to analyze both the long and medium term trends and the short-term cycles that have characterized the Brazilian economy over the past two decades, we have attempted to construct three econometric models based on different data frequencies (monthly, quarterly, and annual).

Building macroeconometric models for the Brazilian economy is not an easy task, due to the multiple structural breaks caused by various stabilization plans and regime changes. But after lengthy efforts, we have obtained three models with reasonably stable structures and good final test results, as reported in the previous chapters.

The comparison of each model's dynamic properties, based on multiplier analysis and stochastic simulations, revealed that the multipliers for the first two years of simulation were similar for the three models, despite significant differences in the estimation period and model specification. This result reinforces our confidence in each model's predictions and in their applicability for further simulation work.

The stochastic simulation exercise showed signs of instability in a few equations, what means that more attention should be paid to identify structural breaks and to improve the specifications of equations accordingly. It is interesting to note that the labor market equations revealed relatively large instability, particularly in the real wage and the unemployment rate equations. This could imply that structural changes in the economy were especially large in the labor market, due to the abolishment of indexation mechanisms. But this result could also be related to the use of data from different sources or with different coverage. For instance, while GDP covers the whole national territory, other variables such as price indices, wage and unemployment rates refer only to the larger urban areas. The mixed use of such variables may generate sampling errors and therefore contaminate the estimation process. Unfortunately, there is no way to avoid this problem.

The stochastic simulation exercise proved to be a very useful tool, both for assessing the adequacy of the final estimated models for policy simulation and forecasting and for comparing the dynamic properties of models with different data frequencies. Our study could therefore be a useful reference for future empirical modeling work in other countries.

PART II
QUANTITATIVE ANALYSIS OF SOCIAL SECURITY

CHAPTER 8

INCOME REDISTRIBUTION IN PUBLIC PENSION SYSTEMS IN BRAZIL AND JAPAN

Noriyoshi Oguchi
Kaizô Iwakami Beltrão
Francisco E. B. de Oliveira

CHRONOLOGICAL DEVELOPMENT OF THE PAPER

Brazil and Japan are antipodes not only physically but also with respect to many values and everyday procedures. Of course the two countries also have much in common. There are common features in their social security systems, for example, such as the impact of the aging population (more advanced in Japan, of course), the equity question of intracohort and between cohorts (more striking in Brazil), the problem of financing, and so on. However, reform conditions in the two countries are quite different. In Brazil, most of the social security regulation is somehow imbedded in the Constitution, and feasible reforms are rather arduous and have a long way to go. In Japan, on the other hand, the law mandates a regular review of the pension system every five years.

In our first discussions, Oguchi, the late Francisco Oliveira and myself dealt with the characteristics of the system themselves. Of course, it is always a challenge to try to grasp someone else's reality. However, all social security systems do have a common goal: to ease conditions whenever there is a loss of income due to certain untimely situations (death, old age, accidents and health predicaments, among others). At the same time the legal meanders are quite different. But, after a while, we managed to understand each other's systems and started working on the research questions. Were there features that could be somehow translated into figures and compared? That was our starting point. Prior to the social security question, we also had to work on the labor market. This was very close to historic demography: digging up labor trajectories (unemployment rates and average salaries) of several birth cohorts dating back to the 1960 Census and born as far back as the late nineteenth century.

Several hours of work went into the paper. Fortunately, there is e-mail. Although we did have some face-to-face meetings, most of the work was done through the World Wide Web.

The paper tries to quantify the common features of both systems and compares them in a historical perspective. It starts with a historical outline of the development of each system before the latest big reform (in Brazil, the 1988 Constitution and the Twentieth Constitutional Amendment of 1998; in Japan, the 1994[1] social security system reform) and describes their main features.

For certain basic types of individuals, defined by schooling, sex, type of employment (civil servants, workers in private companies, etc.), birth cohort and, in the specific case of Brazil, the type of retirement (length of service, old age, etc.) several statistics related to their relationship to social security were calculated. These statistics included replacement rate, balance between payments to the system, pensions received from the system, and so on. In the end, we can say that both the Brazilian and the Japanese public pension systems have large income redistribution mechanisms built into them and that a very large part of these two systems is difficult to justify economically.

It was a great pleasure to work in this team.

1 INTRODUCTION

Public pension systems are facing many problems in many countries all over the world. One of the most pressing and most acute problems is how to finance these pension systems. Total pension payments have been increasing in most countries, both in total volume and as a share of GDP. Brazil and Japan are no exceptions. In 1997, the pension benefit payments for private sector pensioners were about 11 percent of GDP in Brazil. More importantly, the financial need (shortfall of the revenue from pension contribution to pension payments) of the pension account, including civil servants, was almost 5 percent of GDP. In Japan, the pension benefit payment in 1999 was about 6.6 percent of GDP, although the deficit in the pension account was small.

The situation is expected to worsen as the aging of the population progresses and the number of beneficiaries increases. In 1997, the private sector pension system in Brazil had roughly 30 million contributors and 15 million pension recipients. For the public sector, there were 3.1 million contributors and 2.8 million beneficiaries. In Japan, the contributors in the Private Sector Employee Pension

1. There was also another reform in Japan after 1994, but data was not available at the start of this paper.

System were 33 million, while the beneficiaries were 7 million. It was expected that the number of contributors would decline to 30 million in 2025, while the beneficiaries would increase to 15 million.

Another issue in public pension systems is that of equity. Again both in Brazil and Japan, very large differences in net benefits receipt exist among different population groups. The federal public employee in Brazil receives on average about R$14,000[2] of net benefit per beneficiary, while the private sector employee's average net benefit receipt is about R$ 475. This reflects the average wage premium earned by public sector employees, but at the same time amplifies the income differentials between the public sector and the private sector.

Under the Japanese pension system prior to the reform in 2000, the lifetime pension benefit of an average wage earner born in 1935 was greater than his lifetime pension contributions by US$ 500,000. Under the new pension reform guidelines, however, the same person, earning the same wage, would receive a lifetime benefit that would be *less* than his lifetime contribution by US$ 250,000. This implies a difference of US$ 750,000 in the net pension benefit between the two cohorts.

Such a large difference is difficult to justify economically in today's orientation toward a market economy. There are various reasons for having such unequal treatments built in the system. The pay-as-you-go (PAYG) financing scheme provided room to set rather generous benefits in the early stages of development of pension systems. As a result, quite often, benefits were set for political purposes rather than by economic rationality.

Under the PAYG scheme, the benefit for retirees at any point in time is financed by the contribution payment from the contemporary workers. Hence, when the system is young and the number of retirees is small in relation to the number of workers, there is room to increase the benefit without raising contribution rates. On the other hand, in a period when old age dependency ratio is rising, due to the ageing of the population (i.e., when the ratio of the older population to that of the working generation increases), the *per capita* contribution burden has to be raised accordingly. Thus the contribution burden would vary depending on the relative size of cohorts. Moreover, since there is no strict relationship between contributions one pays and the benefit one receives, the benefit may be arbitrarily set for political reasons, resulting in an inequitable benefit structure among different groups.

2. In the year 2000, the exchange rate was roughly R$1.85 to US$1.

Faced with these problems, both Brazil and Japan reformed their pension systems in recent years. But some problems still remain. The problems mentioned above are only partly addressed by the recent reforms and financial crunch, and inequality problems are looming. Although some of the problems are common to both the Brazilian and the Japanese public pension systems, the underlying philosophy, as well as the social, economic and historical background, seems to be different. Accordingly, the significance and severity of the problems are different and the reform policies vary between these two countries.

In this paper we focus on the inequality built into the public pension systems in the two countries. We estimate the differences of contribution and benefit among various groups, before and after reforms, to have a broad picture of how different urban population groups, and cohorts in the Brazilian formal market, fare in terms of their social insurance schemes. We then compare it with the situation in Japan.

The organization of the paper is as follows. In an evaluation of public pension systems and reform policies, it is useful to examine the basic reasons why we need public pension. Hence, in Section 2, we discuss why we need public pension systems. In Section 3, we outline the public pension systems in Brazil and Japan. Then, the lifetime contribution and benefit for various groups and cohorts are estimated in Section 4. Section 4 also discusses income redistribution in Public Pension Systems and the recent reforms in both countries. In Section 5, we estimate the effects of those reforms and discuss problems to be addressed in the future. Our conclusion is presented in Section 6.

2 WHY DO WE NEED PUBLIC PENSION?

In our free-market oriented economy, most private decisions are left to the individual because, in principle, that should both be better for the individual and, under certain conditions, achieve an optimal point for the economy. The decision on how much to consume and how much to save is a private matter. It is a decision on the intertemporal distribution of consumption, that is, how much to spend in younger years and how much to spend in older years out of one's lifetime income. Pension benefits have a direct effect on spending in older years. Why should the government be involved in this utility maximization decision of an individual through the public pension system?

There are three major reasons for the existence of a public pension system. The first two reasons are to prevent both intentional and unintentional undersavings. If people fall into a situation where they do not have any income or savings, they will have to depend on the social welfare benefit as a last resort. When people know there is a social welfare system to fall back on, those people whose income is near the minimum level may realize that they are better off spending all of their income in younger years instead of saving for their old age and then get social welfare benefit when they retire. In order to avoid an unnecessarily big welfare payment due to this kind of behavior, which is known as "moral hazard," the government can force people to save a minimum necessary amount for old age through a public pension system.

On the other hand, there may be cases in which people find out that the their savings for old age are not enough due to an unforeseen turn of events or a simple miscalculation. Consumers make decisions on everyday spending trying to maximize their utility. However, it is a trial and error process, and even after many trials and errors, they succeed only somewhat. Thus, there is inefficiency in the decision making of individuals. Yet, we still consider this to be better than a situation in which everything is decided on by an authority. In the case of making savings decisions for old age, there is no second chance. Even when a person realizes, after retirement, that he/she did not save enough, it is impossible *for this person* to change savings decision. In a case such as this, it is helpful if the government helps the individual not to fall into a regrettable situation by forcing him/her to save a minimum necessary amount for his/her old age. This government intervention may seem to contradict the principle of a free market economy, but it can be justified in cases in which errors cannot be corrected.

Thirdly, public pension is necessary to complement market failures. An old age pension system is an insurance system against the uncertainty of our life span. The private insurance market is not likely to function efficiently due to adverse selection. Generally, individuals have better information on their physical conditions and on their probable life expectancy than do the insurance companies. Left to the individual's free choice, only those who expect to live long would buy lifetime pension insurance. In fact, there exist only a small number of lifetime pensions offered by private insurance companies in Japan, and the expected rate of return on those pension insurances is very low. Hence, fewer people who believe they will live long enough would buy such insurance, and the premium would rise further. Public pension can circumvent this adverse selection by forcing everyone to participate in the pension insurance and by pooling the risk over a large population and making the insurance system stable.

It is often argued that another role of the public pension is the redistribution of income [see Banks and Emmerson (2000)]. Public pension, however, is an inefficient tool to make income distribution more equitable. There are other more suitable tools for income redistribution, such as progressive tax programs, inheritance taxes, various welfare programs, etc. Since pension contribution disregards property income and is either a flat rate, as in the National Pension in Japan, or wage-based, as in Brazil's pension system and in the Private Sector Employee Pension in Japan, it can work to increase inequality in income distribution when a redistribution mechanism is built in.

In addition, redistribution through public pension causes inefficiency in the economy. The part of the pension contribution that goes to redistribution is perceived as tax on wages and this distorts the labor supply, especially among the young and female workforce.

In the Brazilian pension schemes, especially the ones for public employees, the pension benefits are more like a delayed compensation payment for their employment or a part of a lifetime wage income. In this case, again, it causes inefficiency in the labor market by restricting labor mobility, as they are tied to the length of employment. It also disguises the true cost of employment.

From the above discussion, we see that redistribution in pension programs is more of a problem than a merit, and it is better to have a pension system without a large redistribution mechanism. One major problem with the Brazilian and Japanese pension systems is that they generate a very large redistribution of income across and within generations. In Brazil's case, it increases the inequality of income distribution that is already very large. We discuss the redistribution generated by the pension system in Section 4.

3 A BRIEF OUTLINE OF THE SYSTEMS BEFORE 1998

Although there is some evidence that most of the inequality in Brazilian pension systems is due to the existence of two different pension schemes, one for private sector workers (RGPS[3]) and one for public sector employees (RJU[4]), there is considerable scope for the study of inequality within each of the systems. RGPS itself covers quite a broad spectrum of workers, with a widely different set of risks and rules for benefit eligibility.

The Japanese system also has a built-in mechanism of unequal treatment of different population groups. The rate of return on the pension contribution differs

3. Regime Geral de Previdência Social (General Social Security System).

4. Regime Jurídico Único (Unified Juridical Regime)–Actually RJU regulates various aspects of the civil servants' career. However, in this paper RJU will be used in reference to the civil servants' pension system.

between the National Pension (NP) and the Private Sector Employee Pension (PEP). There is a wide dispersion of the benefit/contribution ratio from cohort to cohort.

3.1 BRAZIL

Broadly, the Brazilian system has two basic components: The General System (RGPS), which covers all workers in the formal private sector; and Special Systems, under specific regulation (RJU), covering civil and military public servants of the Executive, Legislative and Judiciary branches at the Federal, State and Local government levels. As a matter of fact, these special systems encompass a whole diversity of retirement and contribution rules that, for the time being, are not even completely mapped out by the Social Security Ministry.[5]

3.1.1 Private Sector (RGPS)

a) Population Coverage

First of all, it is important to note that in Brazil a large portion of labor is employed 'informally,' that is to say that employment is not registered under labor laws and, as a result, they neither pay any social security contribution nor any other taxes. The informality rate in the labor market fluctuates in time, but RGPS covered only 43 percent of the urban economically active population in 1990. This coverage declined to 35 percent in 1995. Thus a very large segment of employees are not covered by public pensions at all. As shown below, since a move from informal employment to formal employment will increase the labor cost for the employers, there is a strong incentive for employers not to register employment officially.

Although participation in the public pension systems is mandatory, it is hard to say 'mandatory' when there is such a large portion of workers not covered. With the current structure of the contribution and benefit, in order to generate net transfer to participants with deficits in the pension account, inclusion into the system of more workers from the informal sector would aggravate the financial difficulty of the pension system. However, it should be taken into consideration that the majority of workers in the informal sector is comprised of low wage earners who might end up on welfare in their old age, thus increasing social welfare costs.

5. Besides the 27 States, there are more than 5,000 municipalities, each with its own set of rules.

The present system of old age pension also increases nonparticipation in the public pension system. Since the required number of years of work to qualify for old age retirement is five years, there is an incentive to register only during the last five years in the formal sector and to work the rest of the working period in the informal sector. This reduces the coverage rate. At the same time, it also causes another problem. If an individual dies or becomes disabled while working in the informal sector, he/she is not eligible for disability or survivor's benefit. Thus, it is likely that he/she, or their family, becomes income-less.

RGPS covers the officially registered workers in the private sector. There were about 30 million contributors in 1997. It covers workers in the rural sector as well as those in the urban sector. However, the contribution structures are different for those two sectors.

b) Finance

The system is financed by a PAYG scheme. Under this scheme, the contribution revenue should be adjusted to match the benefit payment. Most adjustments were made by changing the contribution rate borne by the employers while the employees' contribution rate was kept fairly constant over time.[6] The contribution revenue is also used to finance other social welfare expenditures besides pension benefits. At the same time, any deficit in the pension account is covered by the general account. Thus, the pension account is not completely separated from the general account.

Under the PAYG scheme, the contribution revenue and the benefit payment should be roughly balanced at any point in time. However, in 1997, the contribution revenue fell short of the benefit payment by an amount as large as slightly over 1 percent of GDP. This deficit was expected to grow over time, as the number of beneficiaries was expected to grow rapidly. It was estimated that, had there been no reform, the deficit would have reached about 4 percent of GDP in 2020 and over 6 percent of GDP in 2030.[7] Such a heavy burden on the general account diverts resources from other public spending. It also transfers wealth from the younger generation to the older generation, regardless of individual needs and ability, thus causing social inefficiency and inequitable redistribution.

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6. In 1923 it was shared as 3 percent + 3 percent for the employees and the employers. Norwadays the employer´s share is close to 22 percent, and the employee´s share is 10 percent in average.

7. The estimates are by Oliveira and Beltrão (1995).

It is inevitable to have fluctuations in the contribution rate and intergenerational transfer under a PAYG scheme as the demographic structure changes. In the case of Brazil's RGPS, however, large transfers and projected deficits are due to the basic contribution and benefit scheme, as we discuss below.

c) Contribution

The rural workers (agriculture) are to pay 1 percent of their sales value, but only a very small number of people are actually paying.

In the urban sector, employers and employees share the contribution imposed on payroll. The employees' contribution rate is progressive, starting from 7.82 percent and going up to 11 percent. There is a ceiling on taxable wage income for employees. The employers' contribution rate has fluctuated with the benefit payment, but it has been around 22 percent for a while now. These add up to 32 percent of payroll, placing Brazil among the countries with the highest contribution rate. This high rate generates large distortions in the economy. It also creates incentive for employers to employ workers informally in order to evade contribution. Self-employed workers pay about 20 percent of their earnings.

d) Benefits

There are several ways to qualify for benefits.

Length of Service

One starts receiving pension benefits after working a fixed number of years irrespective of one's age at the time of retirement. The required number of years of work was 30 years for men and 25 years for women. The benefit was 70 percent of the reference wage, and it increased 6 percentage points for each additional year of work up to 100 percent. That is to say that, after 35 years for men and 30 years for women, the benefit is 100 percent of the reference wage and does not increase further. So, there is no incentive not to collect the pension right away, since the Brazilian legislation neither prohibits individuals from collecting pensions and going on to another job nor penalizes those who do so with a reduction of the benefit. The reference wage is the average wage of the last three years of work. The benefit is price indexed.

Employees in certain categories received preferential treatment. Teachers, for example, could qualify for a pension equivalent to the full length of service five years sooner than the standard service period; that means, 30 years for men and 25 years for women. With the current long life expectancy, it means a very long pension benefit period. If a girl starts to work at age 15, she could start collecting pension benefits at age 45. As mentioned before, even if she starts a second career, the pension benefit does not stop. Since an additional pension contribution on her second career would not change the pension benefit she already has, there is no incentive to pay a pension contribution on the second job. Thus, it is beneficial for both employer and employee to make employment informal. This is another reason for the existence of a large informal sector.

The benefit formula amplifies income differences between low wage earners and high wage earners. Since the benefit is based on the average wage of the last three years of work, those with steep wage profiles end up with a higher benefit. Those who have less education, are less skilled and earn lower wages have rather flat wage profiles and, accordingly, receive lower benefits. As a result, the pension system works to increase lifetime inequality.

Old Age

Workers are eligible for pension benefits after the retirement age of 65 for men and 60 for women. Workers in the rural sector may retire five years younger than the ages mentioned above. Up to 1998, the qualification requirement was the completion of five years of work. The benefit is 75 percent of the reference wage for those with the minimum period of work of five years. It increases by one percentage point for each additional year of work up to the maximum of 100 percent. The reference wage is the average wage of the last three years. Rural workers receive one minimum wage. The benefit is price indexed.

As in the case of length of service benefit, the benefit formula based on the average wage of the last three years of work intensifies income inequality.

Disability and Survivor Benefit

The sum of disability and survivor benefit payments accounts for about one third of the pension payment and, among the beneficiaries, the disability and survivor pension recipients account for about 40 percent. These ratios are rather high compared to other countries. For example, in Japan, disability and survivor benefit payments account for about 10 percent of pension payments. The ratio of the disability and survivor pension recipients is especially high. The survivor pension benefit is 100 percent of the deceased retiree’s benefit. Again, this is very generous when compared with other countries.

3.1.2 Public Sector (RJU)

RJU covers public employees at various levels of government. The federal, the state, and the municipal government each manage their own system independently in different schemes. Hence, we discuss the federal and state systems.

a) Population Coverage

The federal RJU covers about 1 million employees with almost the same number of beneficiaries. State RJUs cover about 2 million employees and pay benefits to 1.8 million beneficiaries. Thus, the beneficiary/contributor ratios are very high. In the public employee pension system, the individual has more to gain by joining the system. Since the employer is the government itself, there is no way for a public servant to get out of the system and, consequently, there is no evasion problem.

b) Finance

In the early stage of the pension system, and for certain parts of the system even now, a pension was considered a part of a deferred wage payment or an earned right rather than mandatory savings for old age. RJU still strongly retains that nature.[8] Until recently, there was no contribution by employees for federal RJU. They were managed by the PAYG scheme in the sense that there was no pension fund, and the benefit payments were made out of revenues of that period. In 1997, the revenue from contribution was R$ 6.3 billion, while the benefit payment was R$ 38.3 billion for all of RJUs. Even after adding the imputed contribution by the government as well as that by the employer, the shortfall of the contribution revenue to cover the benefit payment is about 50 percent of the total benefit payment. In other words, as much as 50 percent of benefit payment is subsidized from the general account.

The high beneficiary/contributor ratio, combined with the low contribution rate and the generous benefits, will continue to generate large deficits. Without a clear notion of the employer's contribution, it is hard to establish independent pension accounts. The pension benefit and the remuneration for work should be clearly separated. Pension benefit as the deferred wage payment distorts labor market. The present system has a lock-in effect on the employment and deters efficiency.

c) Contribution

Until 1992, federal employees did not contribute toward a pension system. Only after 1992 did they start contributing. Their contribution now amounts to 11 percent of wages. Among state and municipal RJUs, the contribution rate varies

8. RJU retirees are kept in the same payroll as active civil servants and are simply recategorized as "inactive civil servants".

from 6 to 17 percent. There is no statutory contribution by the federal government as an employer. At the state level, the contribution rate by the state government again varies from state to state from 0 to 17 percent.

d) Benefit

As in the case of RGPS for the private sector, there are several ways to qualify for benefits.

Length of Service

One qualifies for pension after working a fixed number of years irrespective of one's age at the time of retirement. The required number of years of work was 30 years for men and 25 years for women. The replacement ratio for men after 30 years was 30/35, and it would rise by 1/35 for every additional year of work up to 100 percent. For women, it started from 25/30 after 25 years and would go up by 1/30 for each additional year of work up to 100 percent. The reference wage is that of the last month of employment, and there was no ceiling. The benefit was indexed to wage increase among the active civil servants. These two points are different from RGPS for the private sector and potentially make the benefit more generous for the public sector employees.[9]

Government employees in certain categories received preferential treatment. Teachers working for the government qualified for a pension equivalent to the full length of service five years sooner than the standard service period of 30 years for men and 25 years for women. Military personnel also received special treatment.

Disability and Survivor Benefit

Rules are similar to the private sector, and the survivor benefit is equal to the benefit of the deceased.

3.2 JAPAN

There are three public pension systems in Japan: the National Pension (NP), the Private Sector Employee Pension (PEP), and the Government and Education Sector Employee Pension (GEP).[10] NP covers all adults from 20 to 60 years of age. PEP covers employees in the private sector, and the GEP covers employees in the public

9. Since the government controls civil servants wages, there is the possibility of wages not being inflation adjusted for active civil servants and, consequently, pensions are likewise not inflation adjusted.

10. NP, PEP, and GEP are Kokumin Nenkin, Kosei Nenkin, and Kyosai Nenkin, respectively. Kyosai Nenkin is literally translated as Mutual Aid Pension.

sector and in private schools. Hence, those covered by PEP and GEP are also covered by NP simultaneously.

The NP benefit is common to all three systems. The PEP and GEP benefits are proportional to the lifetime earnings of the insured. Those insured by PEP or GEP receive the corresponding benefits in addition to the NP benefit. This is called a "two-tier scheme."

GEP covers the national and local government employees as well as employees of private educational institutions. Each group has separate organizations and manages its pension independently. Since most of them are similar to PEP, we do not discuss GEP separately in this paper.

3.2.1 National Pension (NP)

a) Population Coverage

NP has over 70 million participants. Those insured under the NP system are categorized into three groups. Group 2 consists of those who are also insured by the PEP or the GEP. They are automatically covered by NP without paying additional contributions. Group 3 consists of the dependent spouses of those insured by PEP or GEP, i.e., the spouses of members of Group 2. Group 1 consists of all other adults. Thus, full-time students, farmers, the self-employed, and their dependent spouses belong to this group.

In this paper, we will call the insured of Group 1 the "self-employed," those of Group 2 the "employees," and those of Group 3 the "full-time housewives." Thus, a full-time housewife is a person whose husband is an employee and whose own income is less than 1.3 million yen a year.[11]

The term 'NP' is used with two meanings. NP, in a broad sense, signifies the system that covers everyone from 20 to 60 years of age, including those who belong to PEP and GEP as described above. NP, in a narrow sense, means only the part of the wide NP system that covers Group 1, that is, the self-employed. Hereafter, when we mention NP, we mean NP in the narrow sense.

Participation in NP is mandatory. However, more than 30 percent of those in Group 1 did not contribute in 1997. About half of this 30 percent was legally exempted from contribution but the rest were deserters of the system. The collection of contribution is delegated to local governments, and local governments are reluctant to collect contribution forcefully.

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11. Own income of 1.3 million yen a year is the limit to be classified as dependent.

The penalty for not paying contributions is a reduction of the pension benefit or a loss of eligibility for the benefit. This does not discourage desertion, because the wealthy do not need the pension benefit and the poor, in their old age, can rely on social welfare payments. Existence of large-scale desertion harms the social system on two fronts. It hurts the financial position of the pension account. It also increases social welfare payment from the general account.

b) Finance

NP is financed by the PAYG scheme. It also receives a subsidy in the value of one third of the annual benefit payment from the general account. NP, in a narrow sense, paid out about 2.8 trillion yen in benefits and received 2 trillion yen in contributions in 1998. With the subsidy from the general account, its revenue and payment are roughly balanced.

c) Contribution

The self-employed only joins the NP. Each insured person makes the same contribution in this scheme, until he/she turns 60 years old. At age 60, the self-employed become vested for the basic pension benefit but become entitled only at age 65. The dependent spouses of the self-employed are treated the same way as the self-employed themselves. Thus, for the self-employed, the system is based on individuals rather than on households, unlike PEP and GEP.

d) Benefit

The NP benefit, which is called the Old Age Basic Pension Benefit, is independent of the earnings of the insured. It is dependent only on the length of the participation period. Since the monthly contribution is the same for everyone, there is no redistribution of income through the NP within the same generation of self-employed people.

Those individuals who contributed more than 25 years start to receive the NP benefit from age 65. The benefit was indexed to wage increase.

Although all like cohorts are treated equally, there were large differences in the net pension benefit (the difference between lifetime contribution payment and lifetime benefit receipt) among generations. Since the system is financed by the PAYG scheme, the contribution had been consistently increased over time to meet the increased benefit payment, as the ratio of retirees to contributors rose. The system generated large transfers of income from younger to older generations.

3.2.2 PEP and GEP

a) Population Coverage

PEP had about 33 million contributors with 8 million retirees in 1998. GEP had 5.3 million contributors and 2.1 million retirees. There is a gray zone between employees and the self-employed. Those who are employed only part-time may be classified either as employees or self-employed. There is a guideline for the classification, but it is not very precise. As the contribution rate of PEP became higher, more employers pushed out part-time employees from PEP to avoid higher labor costs. Those who were not in PEP had to join NP, but, in many cases, they did not. This is one of the reasons for the high ratio of deserters in NP.

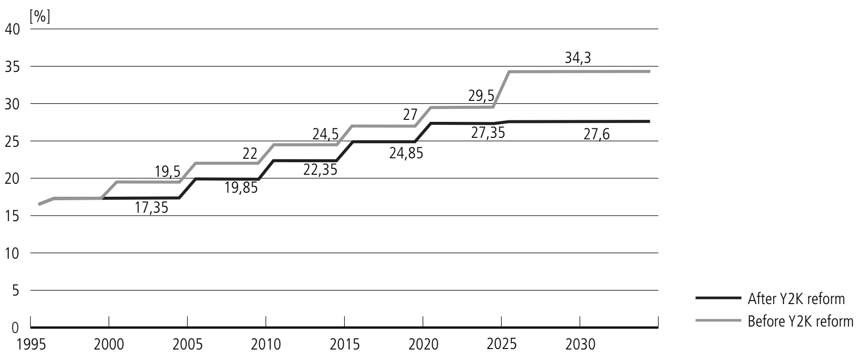
b) Finance

PEP and GEP accounts are managed by the PAYG scheme. PEP paid about 19 trillion yen in benefits. The revenue and payment were almost balanced. However, by the year 2000, it had already accumulated funds of 150 trillion yen.

c) Contribution

Employers and employees share the contribution of PEP equally. The present contribution rate is 17.35 percent. It was expected to rise gradually up to 34 percent as shown in Figure 1. This single contribution covers both the Basic Pension Benefit and the PEP benefit. The contribution is based on the "standard monthly earnings" (hereafter we shall simply call it "monthly earnings"). The contribution rate does not depend on the marital status of the insured. A married man with a dependent wife does not pay any additional contribution above the contribution paid by a single man.

FIGURE 1
SCHEDULE OF CONTRIBUTION RATES OF PEP



d) Benefit

Since those who are insured by either the PEP or GEP are automatically insured by the NP as well, their pension benefits are the sum of the NP benefit and the PEP (or the GEP) benefit. The PEP benefit depends on the lifetime average monthly earnings. The benefits were indexed to the wages of the concurrent working generations as well as to prices.

4 INCOME REDISTRIBUTION IN PUBLIC PENSION SYSTEMS

In this section we examine the redistribution effect before and after the recent reforms.

4.1 BRAZIL

The Brazilian Social Insurance System is plagued by a differentiated and very often unfair treatment of various population groups. Although there is some evidence that most of the inequality is due to the existence of these two different components (RGPS and RJU), there is considerable inequality within each of the systems. RGPS itself covers quite a broad spectrum of workers, with a wide different set of wage profiles, risks and rules for benefit entitlement. In this section, we estimate the values of lifetime contribution and benefit for individuals with different attributes.

In our estimation, all the values are in year 2000 prices. The minimum wage series in 2000 prices and in current price were provided by the IPEA databank. The wage rate data for private sector employees were obtained from Census data of 1970, 1980, and 1990. They provide the wage rates for 14 age groups by sex and for five education levels of rural and urban workers. By combining these three tables, we constructed lifetime wage profile for each combination of educational level/sex/urban-rural-condition and different cohorts. Since the three tables do not provide enough observation to construct a wage profile for the entire lifetime of a cohort, we supplemented them with cross-section data. The way we constructed the profile is given in Table 1.[12] The contribution rate series for RGPS was provided by IPEA.

Using the wage profile and the contribution rate series, we can estimate the lifetime contribution and the lifetime benefit for private sector workers. Based on the life expectancy at age 60, we assumed that male workers live to receive pension benefits till 75 years of age and female workers till 80 years of age. The average life expectancy is changing over time, but, for simplicity sake,

12. Detailed description of the estimation method is given in the Appendix.

TABLE 1
WAGE PROFILE CONSTRUCTION FOR COHORTS

	10/14	15/19	20/24	25/29	30/34	35/39	40/44	45/49	50/54	55/59	60/64	65/69	70/74
1921 to 25	1960	1960	1960	1960	1960	1960	1965	1970	1975	1980	1985	1990	1990
1926 to 30	1960	1960	1960	1960	1960	1965	1970	1975	1980	1985	1990	1990	1990
1931 to 35	1960	1960	1960	1960	1965	1970	1975	1980	1985	1990	1990	1990	1990
1936 to 40	1960	1960	1960	1965	1970	1975	1980	1985	1990	1990	1990	1990	1990
1941 to 45	1960	1960	1965	1970	1975	1980	1985	1990	1990	1990	1990	1990	1990
1946 to 50	1960	1965	1970	1975	1980	1985	1990	1990	1990	1990	1990	1990	1990
1951 to 55	1965	1970	1975	1980	1985	1990	1990	1990	1990	1990	1990	1990	1990
1956 to 60	1970	1975	1980	1985	1990	1990	1990	1990	1990	1990	1990	1990	1990
1961 to 65	1975	1980	1985	1990	1990	1990	1990	1990	1990	1990	1990	1990	1990

we assumed the same lifetime for all cohorts. Since the government sector employees did not pay any contribution before 1992, we cannot compute the benefit/contribution ratio for them. Hence, we calculated the ratio of lifetime pension benefit to lifetime wage to measure the magnitude of income transfer through the pension system.

First we estimated the lifetime contribution and benefit for the private sector workers with different education levels under the prereform system. The cases are labeled with three indicators such as 1.*a*).1). The first number indicates the educational levels. The educational levels are:

1. Less than elementary education
2. At least elementary school but less than junior high school
3. At least junior high school but less than senior high school
4. At least senior high school but without a university degree
5. At least a university degree

The second indicator *a*, *b* or *c* indicates the category of pension.

a) Reduced length of service

b) Full length of service

c) Old age pension

The third indicator gives a combination of the sex of the worker and length of contribution.

1) Female

2) Male

3) Female retired in 1998 after 8.5 years of contribution

4) Female retired in 2008 after 12 years of contribution

5) Female retired in 2011 after 15 years of contribution

6) Male retired in 1998 after 8.5 years of contribution

7) Male retired in 2008 after 12 years of contribution

8) Male retired in 2011 after 15 years of contribution

The cases from 3 to 8 apply only after the 1998 reform. The requirement for old age pension is to be raised gradually to 15 years of contribution from five years required before the reform. We also estimated cases of full length of service retirement of male and female teachers.

We consider the following cases for workers with five different educational levels.

a) Reduced length of service retirement.

a).1). A female worker who started working at age 20 in 1940 and retired at age 45 in 1965 with reduced length of service pension. She started receiving a benefit of 70 percent of the average of the last three years of pay in 1965 and continues to receive till 2000, when she dies at the age 80.

a).2). A male worker who started working at age 20 in 1940 and retired at age 50 in 1970 with reduced length of service pension. He started receiving a benefit of 70 percent of the average of the last three years of pay in 1970 and continues to receive till 1985, when he dies at age of 75.

b) Full length of service retirement.

b).1). A female worker who started working at age 20 in 1940 and retired at age 50 in 1970 with length of service pension. She started receiving a benefit of 100 percent of the average of the last three years of pay in 1970 and continues to receive till 2000, when she dies at age of 80.

b).2). A male worker who started working at age 20 in 1940 and retired at age 50 in 1970 with length of service retirement. He started receiving a benefit of 70 percent of the average of the last three years of pay in 1970 and continues to receive till 1995, when he dies at the age of 75.

b).1) and *b*).2). Teacher. Same as above, except that teachers retired five years earlier and received pension benefits five years longer.

c) Old age retirement.

c).1). A female worker who started contributing at age 55 in 1985 and retired at age 60 in 1990 with age retirement. She started receiving a benefit of 75 percent of the average of the last three years of pay in 1990 and continues to receive till 2010, when she dies at the age 80. (Five years of work.)

c).2). A male worker who started contributing at age 60 in 1990 and retired at age 65 in 1995 with age retirement. He started receiving a benefit of 75 percent of the average of the last three years of pay in 1995 till 2005, when he dies at the age of 75. (Five years of work.)

For after the reform period, we consider the following cases.

b) Full length of service retirement.

b).1). A female worker who started working at age 20 in 1995 and retired at age 50 in 2025 with length of service pension. She started receiving benefits determined by the formula[13] in 2025 and continues to receive till 2055, when she dies at age of 80.

b).2). A male worker who started working at age 20 in 1995 and retired at age 55 in 2030 with length of service retirement. He started receiving benefits determined by the formula in 2030 and continues to receive till 2050, when he dies at age of 75.

b).1) and *b*).2). Teacher. Same as above, except that teachers retired five years earlier and received pension benefits five years longer.

c) Old age retirement.

c).3). A female who retired in 1998 after 8.5 years of contribution with a benefit of 78 percent of the average of the last three years of pay.

c).4). A female who retires in 2008 after 12 years of contribution with a benefit of 82 percent of the average of the last three years of pay.

c).5). A female who retired in 2011 after 15 years of contribution with a benefit of 85 percent of the average of the last three years of pay.

c).6). A male who retired in 1998 after 8.5 years of contribution with a benefit of 78 percent of the average of the last three years of pay.

c).7). A male who retired in 2008 after 12 years of contribution with a benefit of 82 percent of the average of the last three years of pay.

c).8). A male who retired in 2011 after 15 years of contribution with a benefit of 85 percent of the average of the last three years of pay.

13. The formula is given on page 30 of this paper.

Tables 2A and 2B and Figure 2 show that before the reform the reduced length of service pension paid out more benefits at a slightly higher (around 10 percent) benefit/contribution ratio to the higher income groups within each gender. It thus worked to increase an inequity in income distribution that was already very large. This regressive property of the benefit scheme was due to the formula

TABLE 2A
BRAZIL: BEFORE 1998 REFORM, FEMALE—RGPS – REAL (2000 PRICES)

	A) Lifetime Contribution	B) Lifetime Benefit	C) = (B) / (A)	D) Lifetime Net Benefit = (B) – (A)
1. a). 1)	21216	164059	7.733	142843
1. b). 1)	29711	205038	6.901	175327
1. c). 1)	3793	45339	11.952	41546
2. a). 1)	11298	88391	7.824	77094
2. b). 1)	15931	111819	7.019	95888
2. c). 1)	7105	84915	11.952	77810
3. a). 1)	23584	192629	8.168	169045
3. b). 1)	34028	252082	7.408	218054
3. c). 1)	12821	153241	11.952	140420
4. a). 1)	35871	294741	8.217	258871
4. b). 1)	51628	380307	7.366	328679
4. c). 1)	17048	203756	11.952	186709
5. a). 1)	52507	453839	8.643	401333
5. b). 1)	77043	592183	7.686	515140
5. c). 1)	29280	349966	11.952	320685
4. b). 1) Teacher	35871	421059	11.738	385188

TABLE 2B
BRAZIL: BEFORE 1998 REFORM, MALE—RGPS – REAL (2000 PRICES)

	A) Lifetime Contribution	B) Lifetime Benefit	C) = (B) / (A)	D) Lifetime Net Benefit = (B) – (A)
1. a). 2)	61929	262315	4.236	200385
1. b). 2)	76805	240911	3.137	164105
1. c). 2)	5382	26911	5.000	21529
2. a). 2)	29789	124212	4.170	94423
2. b). 2)	44659	240818	5.392	196158
2. c). 2)	11944	59722	5.000	47778
3. a). 2)	67978	299428	4.405	231450
3. b). 2)	96046	454551	4.733	358504
3. c). 2)	23236	116181	5.000	92945
4. a). 2)	110243	497800	4.515	387557
4. b). 2)	153399	698880	4.556	545482
4. c). 2)	34934	0	0.000	-34934
5. a). 2)	151305	688570	4.551	537265
5. b). 2)	216234	1051468	4.863	835234
5. c). 2)	64055	320273	5.000	256219
4. b). 2) Teacher	110243	711143	6.451	600900

that considered the reference wage for the benefit as the average wage of the last three years before retirement. The wage profile for people with a higher education was very steep, while that for workers with no education was almost flat. This difference resulted in a larger difference in the benefits than in the lifetime average wages. The increases in the ratio for higher income groups do not amount to as much as Figure 2 shows, but the absolute net gain through the system is more relevant in this case, since individuals do not have the freedom to decide how much to invest in the system. Figure 3 shows that the net benefits for the higher income groups are much larger than those for lower income groups.

FIGURE 2
WAGE AND BENEFIT/CONTRIBUTION RATIO, REDUCED LENGTH OF SERVIC, BEFORE REFORM

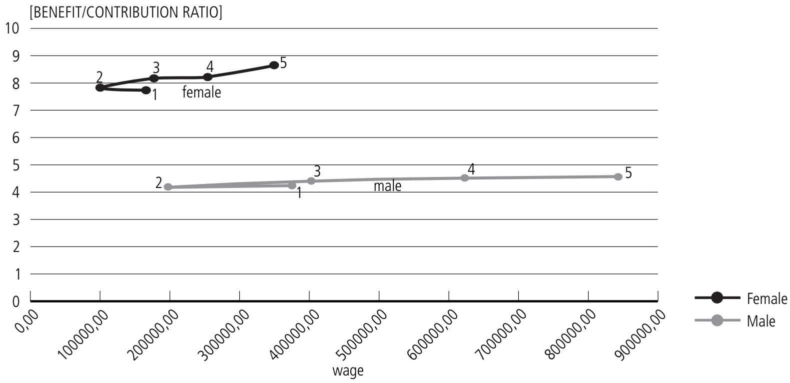
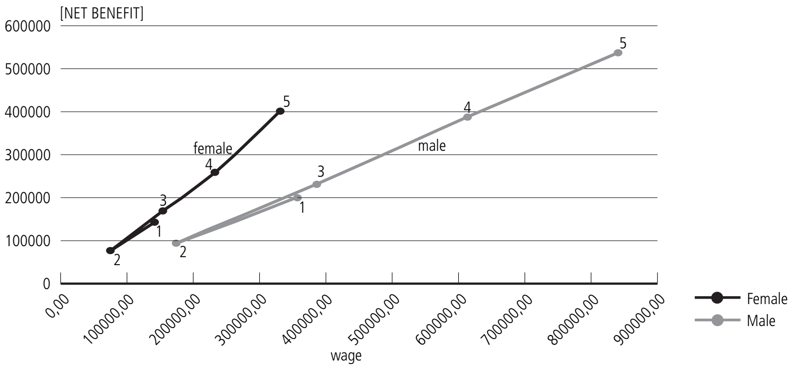


FIGURE 3
WAGE AND NET BENEFIT, REDUCED LENGTH OF SERVICE, BEFORE REFORM



Women as a whole enjoyed a much a higher benefit/contribution ratio than men, as shown in Figures 2 and 3. This was because the required years of service were shorter and the average life expectancy was longer for women. However, the absolute values of net benefits were lower for women than for men with the same education level. For comparable salaries, though, women fare better. Since the average wage was much lower for women, this favorable treatment of women worked to reduce income inequality between genders.

A notable feature of the system is that benefit/contribution ratios are consistently above unity resulting in a deficit in the pension account. Hence, in order to reduce deficits, and at the same time make redistribution progressive, it is necessary to reduce the benefit/contribution ratio for the higher income groups, possibly below unity.

The full length of service had basically the same property, as can be seen in Tables 2A and 2B and Figures 4 and 5. The estimates for teachers are added and they show that teachers enjoyed the most generous benefit/contribution ratio within the same gender. This is because of the privilege teachers had. They needed to work five years less than others to become eligible for a full pension. However, the absolute values of net benefits were not as large as those for people with college education due to the difference in wages at the time of retirement.

Figure 6 shows similar patterns for the age retirement for men and women. Before 1991, the minimum eligibility requirement for old age pension was only five years of contribution. The benefit was 75 percent of the reference wage. As a result, Figure 6 shows that the higher the reference wage is, the higher the net

FIGURE 4
WAGE AND BENEFIT/CONTRIBUTION RATIO, FULL LENGTH OF SERVICE, BEFORE AND AFTER REFORM

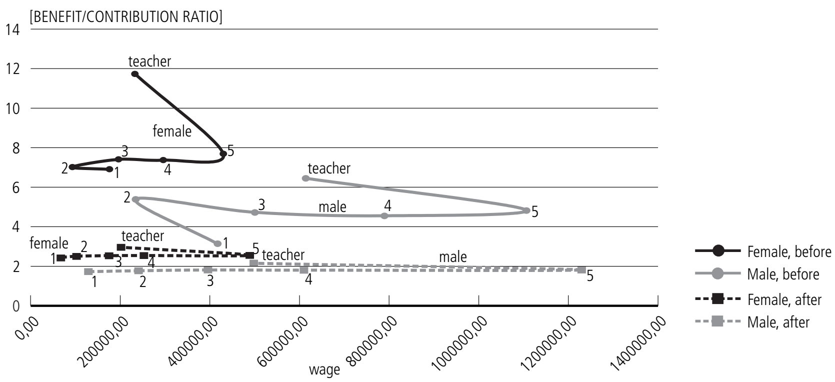


FIGURE 5
WAGE AND NET BENEFIT, FULL LENGTH OF SERVICE, BEFORE AND AFTER REFORM

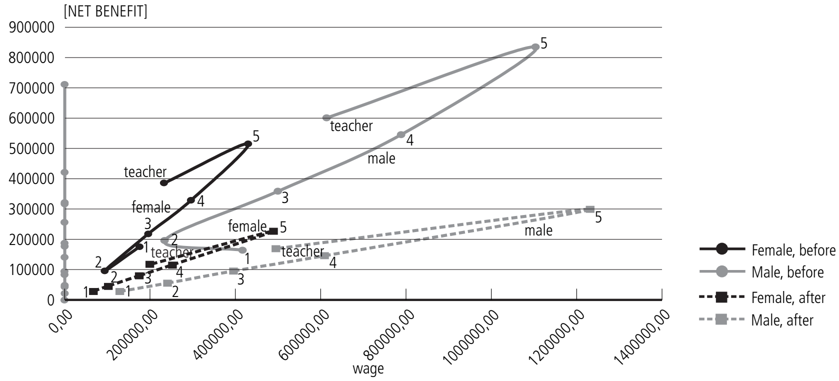
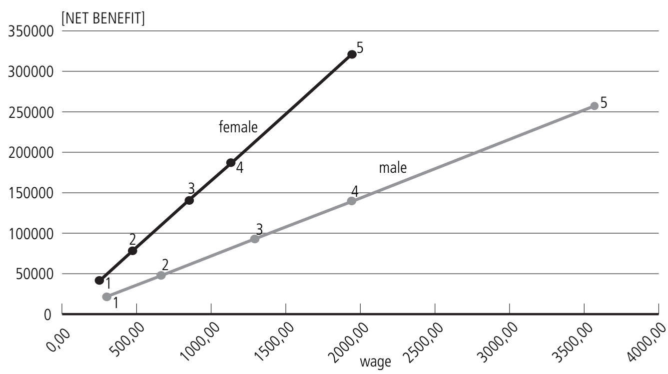


FIGURE 6
WAGE AND NET BENEFIT, AGE RETIREMENT, BEFORE REFORM



benefit will be. Again, that does not constitute a progressive income redistribution. Also, since the benefit is based on the average wage of the last three years, groups that end their career at the highest wage in their career enjoy a higher benefit/contribution ratio.

For public employees, we estimated the lifetime pension benefit for certain groups. The cases are labeled with three indicators, such as 1.a). 1). The first number indicates career/educational levels. The career/educational levels are:

1. Educational personnel
2. Noneducational personnel (intermediate level)
3. Noneducational personnel (university level)

The second indicator *a* or *b* indicates the category of pension.

a) Reduced length of service

b) Full length of service

The third indicator informs the sex of the worker

1) Female

2) Male

So, the following cases of retirement are considered:

1. *b*). 1. A female working as a teacher at age 20 in 1940. She retired at age 45 in 1965 with length of service retirement and started receiving a benefit of 100 percent of her last pay in 1965 till 1990, when she died at the age of 80.

1. *b*). 2). A male who started working as a teacher at age 20 in 1940. He retired at age 50 in 1970 with length of service retirement and started receiving a benefit of 100 percent of his last pay in 1970 till 1985, when he died at the age of 75.

2. *a*). 1). A female who started working as a noneducational (intermediate level) public employee at age 20 in 1940. She retired at age 45 in 1965 with a reduced (proportional) length of service retirement and started receiving a benefit of 25/30 of her last pay in 1965 till 1990, when she died at the age of 80.

2. *a*). 2). A male who started working as a noneducational (intermediate level) public employee at age 20 in 1940. He retired at age 50 in 1970 with reduced (proportional) length of service retirement and started receiving a benefit of 30/35 of his last pay in 1970 till 1985, when he died at the age of 75.

2. *b*). 1). A female who started working as a noneducational (intermediate level) public employee at age 20 in 1940. She retired at age 50 in 1970 with length of service retirement and started receiving a benefit of 100 percent of her last pay in 1970 till 1990, when she died at the age of 80.

2. *b*). 2). A male who started working as a noneducational (intermediate level) public employee at age 20 in 1940. He retired at age 55 in 1975 with length of service retirement and started receiving a benefit of 100 percent of his last pay in 1975 till 1985, when he died at the age of 75.

3. *a*). 1). A female who started working as a noneducational (university level) public employee at age 20 in 1940. She retired at age 45 in 1965 with reduced (proportional) length of service retirement and started receiving a benefit of 25/30 of her last pay in 1965 till 1990 when he died at the age of 80.

3. *a*). 2). A male who started working as a noneducational (university level) public employee at age 20 in 1940. He retired at age 50 in 1970 with reduced (proportional) length of service retirement and started receiving a benefit of 30/35 of his last pay in 1970 till 1985, when he died at the age of 75.

3. *b*).1). A female who started working as a noneducational (university level) public employee at age 20 in 1940. She retired at age 50 in 1970 with length of service retirement and started receiving a benefit of 100 percent of her last pay in 1970 till 1990, when he died at the age of 80.

3. *b*). 2). A male who started working as a noneducational (university level) public employee at age 20 in 1940. He retired at age 55 in 1975 with length of service retirement and started receiving a benefit of 100 percent of his last pay in 1975 till 1985, when he died at the age of 75.

Since there was no formal employee contribution to the public servants system, we will consider benefits instead of net benefits in the graphs, tables, and comments that follow. The estimation results are summarized in the Tables 3A and 3B. Figure 7 shows the relationship between lifetime wage earnings and lifetime benefit. We see the same pattern as in the case of the private sector employee. For

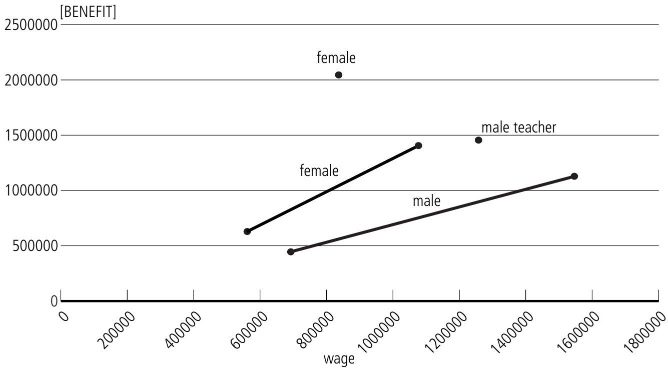
TABLE 3A
BRAZIL: BEFORE 1998 REFORM, PUBLIC SERVANTS—REAL (2000 PRICES)

	A) Lifetime Wage	B) Lifetime Benefit	C) = (B) / (A)
2. a).1)	454588.3	795956.4	1.750939
3. a).1)	843653.4	1556981	1.845523
1. b).1)	836202.5	2043274	2.443516
2. b).1)	564128	625249.4	1.108347
3. b).1)	1076293	1389483	1.29099
2. a).2)	583389.1	479453.7	0.821842
3. a).2)	1274800	1165879	0.914559
1. b).2)	1257780	1455198	1.156958
2. b).2)	691606.4	442831.3	0.640294
3. b).2)	1545953	1128835	0.730187

TABLE 3B
BRAZIL: AFTER 1998 REFORM, PUBLIC SERVANTS—REAL (2000 PRICES)

	A) Lifetime Wage	B) Lifetime Benefit	C) = (B) / (A)
1. b).1)	802067.1	1033453	1.288
2. b).1)	441429.9	402328.9	0.911
3. b).1)	887516.3	973681.8	1.091
1. b).2)	1148343	697991.1	0.608
2. b).2)	542138.6	264090.6	0.487
3. b).2)	1293754	768414.7	0.594

FIGURE 7
LIFETIME WAGE AND LIFETIME BENEFIT, BEFORE REFORM, PUBLIC EMPLOYEE



both men and women, the higher the lifetime wage is, the larger the lifetime benefit will be. As previously mentioned, since there was no contribution made by the public employee before 1992, the total lifetime benefit is the net benefit. Thus, pension benefits increased the differences in lifetime income. If we look at the lifetime benefits of men and women, however, women received larger benefit despite lower wage income. Thus, also in the case of public servants, the pension benefit worked to reduce the difference in lifetime income by gender.

Figure 8 shows the ratios of lifetime benefits to lifetime wages. It is close to 2.5 for a female teacher. That means the lifetime benefit is more than 150 percent larger than the wage she earned during her career of 25 years. If this is a delayed compensation for her work, it should be paid during her working days, so that the real cost of employment is visible. Also, as this large amount of income was tied to the length of service, it locks in employment, thus resulting in an inefficient labor allocation.

Figure 9 compares the net benefit for reduced and full length of service retirement for noneducational civil servants. It shows that for the noneducational sector public servants, the net benefits are almost the same for males. But for female servants, the reduced benefit is somehow larger. Thus, there is a very large incentive to retire early and take up a second career. In this second career, since there is no merit in paying pension contribution, it is more likely that the job becomes part of the informal market.

As we have already mentioned, the benefits of public employee pension have been more generous than those in private sector pensions. Figure 10 shows that the lifetime net benefit/wage ratio within each group is slightly upward sloping,

FIGURE 8
LIFETIME WAGE AND BENEFIT/WAGE RATIO, BEFORE REFORM, PUBLIC EMPLOYEE

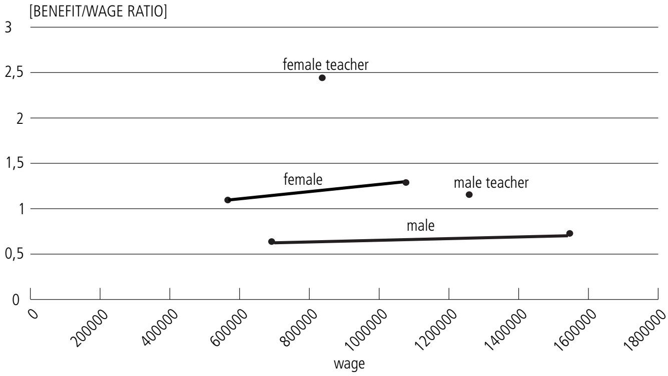


FIGURE 9
NET BENEFIT, FULL AND REDUCED LENGTH OF SERVICE, PUBLIC EMPLOYEE

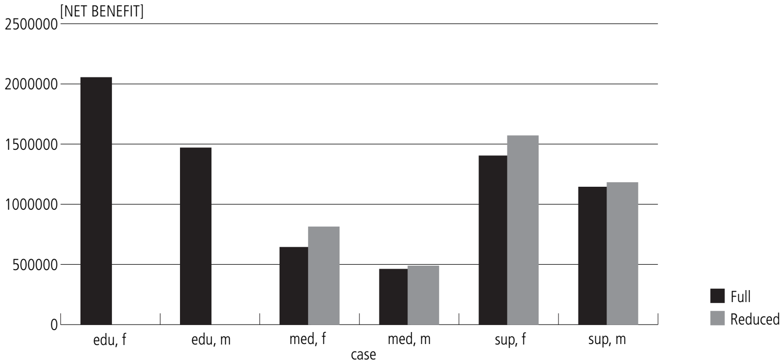
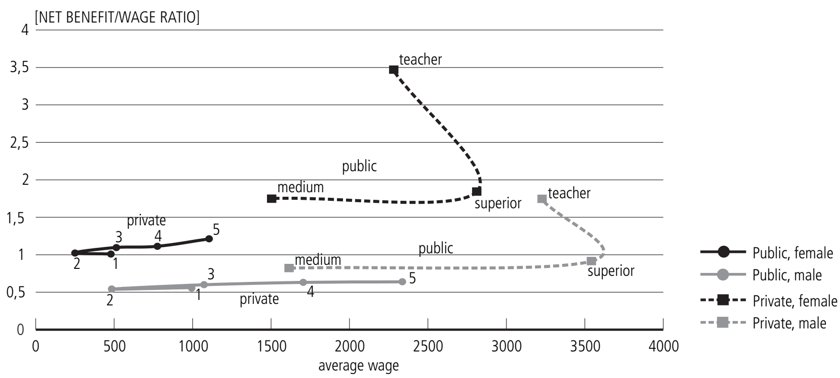
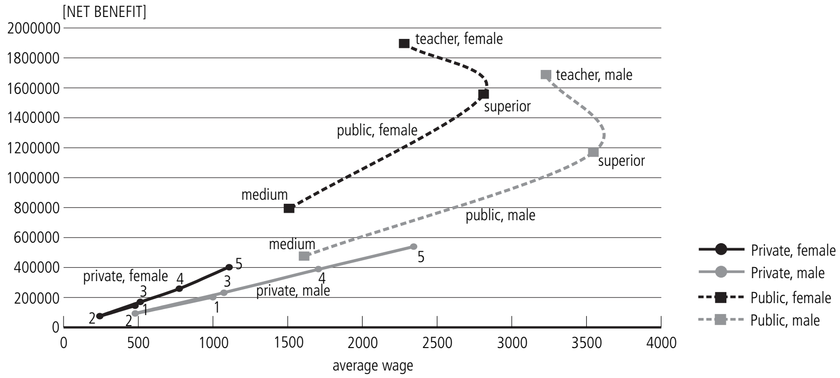


FIGURE 10
LIFETIME AVERAGE MONTHLY WAGE AND LIFETIME NET BENEFIT/WAGE RATIO BEFORE REFORM



but, between groups, the graphs for public employees lie to the northeast of those of private workers. The reason is partially because no contributions for the public employee were taken into account. On average, public employees earn not only higher wages but also even higher pension benefits than do private workers. This is more clearly shown in Figure 11, which presents the net pension benefits in monetary terms. It also shows that, within the groups, the slope is steeper in RJU than in RGPS. Thus RJU increases income inequality within public employees and over private sector workers. Females, in general, get better treatment than their male counterparts. Teachers of both sexes also fare better than other noneducational civil servants.

FIGURE 11
LIFETIME AVERAGE MONTHLY WAGE AND LIFETIME NET BENEFIT, BEFORE REFORM



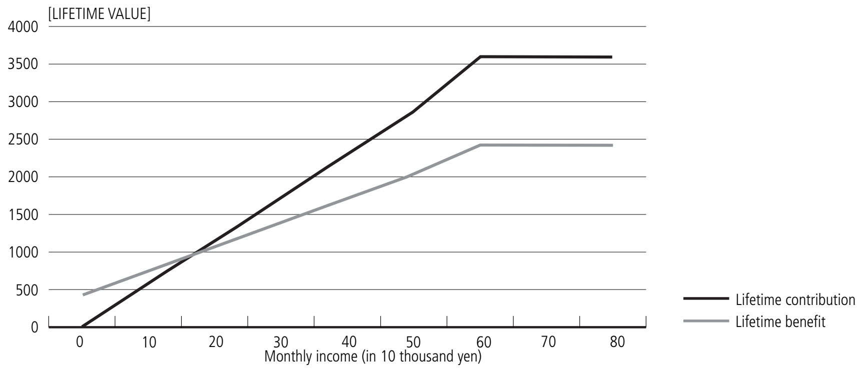
4.2 JAPAN

The Japanese pension systems also have built-in redistribution mechanism. There is a very large intergenerational redistribution due to the PAYG financing scheme, but there is redistribution within the same cohorts as well.

Since both the benefit and contribution are flat amounts for the members of Group 1 (self-employed) of National Pension, there is no redistribution within the same cohorts in this group. Even though the benefit is the same for Group 2 (employees) and Group 3 (housewives) as well, the contribution system is different. As a result there is redistribution among these three groups.

Employees are either insured by PEP or by GEP. At the same time, they are automatically insured by NP without additional premium payments. Thus, their pension benefits are the sum of the NP benefit and the PEP (or GEP) benefit. A single contribution covers both PEP and NP. As mentioned before, the contribution rate does not depend on the marital status of the insured and the dependent spouses of employees (Group 3) do not pay any additional contribution. Thus, there is a transfer of income from single employees to housewives. This redistribution is often regressive. Figure 12[14] shows the relationship between income level and benefit among employees.

FIGURE 12
LIFETIME CONTRIBUTION AND BENEFIT BY MONTHLY INCOME LEVEL (10 THOUSAND YEN)



As Figure 12 shows, there is a progressive income transfer mechanism in PEP. In PEP, a full-time housewife is treated as an employee with no monthly earnings. Thus, full-time housewives get the most favorable treatment in PEP.

In contrast, the wife of a self-employed person is required to pay the contribution for her NP benefits just like other members of Group 1 of NP. In fact, if a self-employed woman, without a job, marries a salaried man and becomes a full-time housewife, she becomes eligible for the NP benefit without continuing to pay the NP contribution, and there are no additional charges to the husband's PEP contribution.

While both husband and wife are alive, a full-time housewife gets only the NP benefit. If she survives her husband, she receives the survivor benefit from her husband's PEP in addition to her own NP benefit. The survivor benefit is three quarters of the husband's PEP benefit. Thus, the two-tier scheme works not only for employees but also for their spouses. This can generate a regressive redistribution.[15]

14. Figure 12 simplifies reality slightly. In the actual scheme, there is a lower limit for low-income earners on both contribution and benefit. Also, there is an upper limit for high-income earners. For simplicity, we disregard these limits in the discussion follows.

15. For example, a single woman who earns a minimum wage has to make PEP contributions and receives a little more than the Old Age Basic Pension Benefit, while a wife of a salaried man, with a large inherited property, receives the same Old Age Basic Pension Benefit without making any contributions.

Figure 13 shows intergenerational differences in contribution and benefits in PEP. The thick, solid, upward-sloping line in Figure 13 depicts the lifetime contribution rates (i.e., the ratio of the lifetime pension contribution to the lifetime wage income) of an average employee in the PEP system before the recent reform.[16] The thick, solid, downward-sloping line shows the corresponding lifetime benefit rates (i.e., the ratio of the lifetime benefit to the lifetime wage income).[17]

The figure shows that the cohort born in 1935, who is now 66 years old, receives a net benefit equal to 26.2 percent of his lifetime wage income. On the other hand, those born after 2005 will receive a net benefit equal to minus 13.9 percent of their lifetime wage, making a net excess payment to the system. These lines show that the lifetime contribution and the lifetime benefit are equal for the cohort born in 1962. The older cohorts receive positive net benefits, while the younger cohorts receive negative net benefits.

Figure 14 shows the net lifetime contribution and benefit of each generation in monetary terms. It shows how much an average person, born in 1935, would have contributed and received, if he had been faced with the lifetime contribution and benefit rate schedule that each younger cohort faces. According to this figure, an average person born in 1935 receives a net pension benefit of approximately 50 million yen (US$500,000). However, the person would have paid 25 million yen (US$250,000) more than the benefits received if faced with the contribution and benefit schedule of the cohort born in 2005. The net receipt of 50 million yen by one cohort and the net payment of 25 million yen by another make up the lifetime net receipt difference between the two cohorts 75 million yen.

This extreme intergenerational inequity produced by the pension system reflects, in part, the rapid aging of the Japanese population. However, it is also due to the generous increases of the benefit without a corresponding increase in contribution in the past, mainly for political reasons. A generation that has lost its assets in war, or has been affected by an unanticipated lengthening of life spans, may deserve help from younger people when it goes into retirement. Public support for such a generation may be justifiable. However, often, the benefits were increased to win votes in elections. Such political increases were possible under PAYG scheme,

16. The total sum of the present value of the contribution paid throughout one's life is called a lifetime pension contribution. The sum of the present value of wage income throughout one's life span is called the lifetime wage. The lifetime contribution rate is the lifetime ratio of lifetime contribution to lifetime wage. The upward-sloping solid line shows the lifetime contribution ratio of a male of average wage income, who participated for the full forty years. The benefit includes the pension benefit of the wife, the basic pension benefit, and the wife's widow's benefit. We used a discount rate of 3.5 percent *per annum* for all the calculations.

17. The lifetime benefit is the sum of the present value of the benefits one receives throughout one's life.

FIGURE 13
LIFETIME CONTRIBUTION RATE AND LIFETIME BENEFIT
[BEFORE AND AFTER Y2K REFORM]

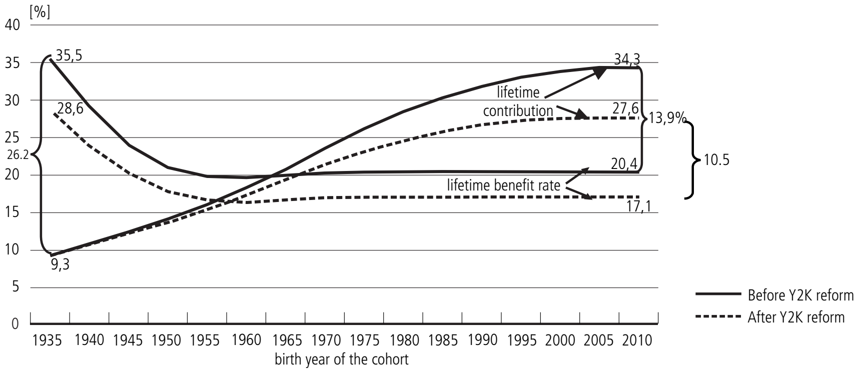
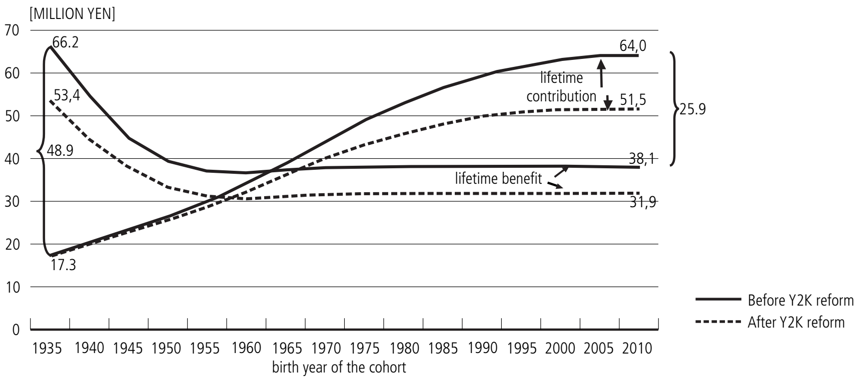


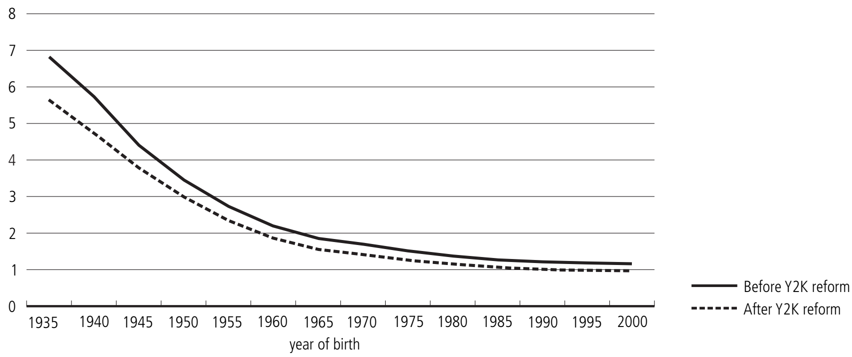
FIGURE 14
LIFETIME CONTRIBUTION AND LIFETIME BENEFIT



when the pension system was not yet mature and there were many more contributors than retirees.

There is intergenerational redistribution in the NP as well, since the financing is basically on the PAYG scheme. The solid line in Figure 15 shows the lifetime benefit/contribution rate by cohort. As in the case of the PEP, the cohort born in 1935 receives seven times as much benefit as the contribution he made in his lifetime. The overpayment of benefit declines steadily and the benefit/contribution rate is about unity for the cohorts born after the year 2000. Thus, for the NP, the redistribution is not as bad as in the case of PEP, and there is not much room to improve the situation since most of the benefit overpayment has already been made.

FIGURE 15
LIFETIME BENEFIT/CONTRIBUTION RATIO OF NATIONAL PENSION



5 RECENT REFORMS AND REMAINING PROBLEMS

5.1 BRAZIL

5.1.1 Recent Reform

For the private sector RGPS, the major reforms are as follows:

1. The reduced (proportional) pension of the length of service retirement is eliminated.

2. For the full length of service pension, the benefit was changed from 100 percent of the average wage of the last three years to the one given by the following formula:

$$\text{Benefit} = M \times F$$

where M is the average of the 80 percent highest contribution wage of the insured worker during his contribution time after 1994 and F is defined as follows:

$$F = \{(Tc \times A)/Es\} \times \{ 1 + (Id + Tc \times A)/100\}$$

where Tc is contribution time;[18] A is the contribution rate, including the employer's contribution, assumed to be equal to .32; Es is the remaining life expectancy at the time of retirement, which is provided by the life table published annually by IBGE for this specific purpose; Id is the age at retirement.

18. For females, 5 is added automatically to the actual number of years of contribution.

As a result of the change in the benefit, after transition is completed, the average benefit is reduced by about 75 percent. This reduction in benefit reduces the benefit/contribution ratio to about 30 percent.

3. Reference period was changed from period of work to period of contribution.

4. Eligibility requirement for Old Age pension was gradually increased to 15 years of contribution.

Item 1 eliminates the early start of pension benefit. Combined with the reduced benefit due to Item 2, the pension finance is expected to improve greatly. Item 3 is to bring out more employment to the formal sector. Item 4 is also to improve employment registration, as well as to bring down the benefit/contribution ratio.

After the 1998 reform, the reduced pension was abolished. Hence, there are no cases under *a*) after 1998. The full length of service pension remains. The benefit is determined by the formula given above. We estimate the case for those whose entire work life is covered by the system after reform. Hence, we estimate the following two cases (combined with the five educational levels; the first index is omitted):

b). 3). Female worker who started working at age 20 in 1994. She retires at age 50 in 2024 with length of service retirement and starts receiving a benefit determined by the formula from age 50 in 2024 till 2054, when she dies at the age of 80.

b). 4). Male worker who started working at age 20 in 1994. He retires at age 55 in 2029 with length of service retirement and starts receiving a benefit determined by the formula from age 55 in 2029 till 2049, when he dies at the age of 75.

For the old age retirement pension, the required contribution period was to be gradually increased. Hence we estimate for the following three cases, each for female and male workers.

c). 3). Female worker who started contributing at age 51 in 1989. She retires at age 60 in 1998 with age retirement and starts receiving a benefit of 78 percent of the last pay in 1999 till 2008, when she dies at the age of 70. (Contribution of 8.5 years.)

c). 4). Female worker who started contributing at age 48 in 1996. She retires at age 60 in 2008 with age retirement and starts receiving a benefit of 82 percent of the last pay in 2009 till 2020, when she dies at the age of 70. (Contribution of 12 years.)

c). 5). Female worker who started contributing at age 44 in 1996. She retires at age 60 in 2011 with age retirement and starts receiving a benefit of 85 percent of the last pay in 2011 till 2020, when she dies at the age of 70. (Contribution of 15 years.)

c). 6). Male worker who started contributing at age 56 in 1989. He retires at age 65 in 1998 with age retirement and starts receiving a benefit of 78 percent of the last pay in 1999 till 2008, when he dies at the age of 75. (Contribution of 8.5 years.)

c). 7). Male worker who started contributing at age 53 in 1996. He retires at age 65 in 2008 with age retirement and starts receiving a benefit of 82 percent of last pay in 2009 till 2018, when he dies at the age of 75. (Contribution of 12 years.)

c). 8). Male worker who started working at age 49 in 1996. He retires at age 65 in 2011 with age retirement and starts receiving a benefit of 85 percent of the last pay in 2012 till 2021, when he dies at the age of 75. (Contribution of 15 years.)

The results are given in Table 4 and Table 5.

For the public employees, RJU was changed as follows:

1. Contribution rate of 11 percent.

2. Minimum retirement age of 53 years old for men and 48 years old for women was imposed. These are to be raised to 60 and 55 years old, respectively.

3. Requirement of 5-year stay in a post before receiving a pension benefit equivalent to the salary of that post.

4. Requirement of 10 years as a civil servant to be entitled to receive a pension in the RJU system.

5. Ceiling on the benefits equivalent to the retiree's last salary.

Compared to the reforms made on RGPS, these reforms are relatively minor despite the fact that benefits for public employees are much more generous. The most significant point is that 100 percent replacement rate was not changed. Items 3 and 4 are merely to close loopholes to obtain benefits of more than 100 percent of the last salary. Thus the difference of benefits between public employees and private sector workers was increased. With the imposition of a minimum required age for retirement, civil servants will stay working longer than the previously prescribed 30/35 years for full benefit. Additional working years will not increase the benefit.

TABLE 4
BRAZIL: AFTER 1998 REFORM, FEMALE—RGPS – REAL (2000 PRICES)

	A) Lifetime Contribution	B) Lifetime Benefit	C) = (B) / (A)	D) Lifetime Net Benefit = (B) – (A)
1. b). 1)	20022	48878	2.441	28856
1. c). 3)	3862	33468	8.665	29605
1. c). 4)	6677	36641	5.487	29964
1. c). 5)	8252	39093	4.737	30841
2. b). 1)	30437	76286	2.506	45850
2. c). 3)	6729	59883	8.899	53153
2. c). 4)	11320	63442	5.605	52122
2. c). 5)	13413	65515	4.884	52101
3. b). 1)	51966	131887	2.538	79920
3. c). 3)	11953	106452	8.906	94499
3. c). 4)	20049	112712	5.622	92664
3. c). 5)	23545	115922	4.923	92377
4. b). 1)	75113	191013	2.543	115900
4. c). 3)	18382	167973	9.138	149591
4. c). 4)	30139	172073	5.709	141934
4. c). 5)	34483	172416	5.000	137933
5. b). 1)	145247	372175	2.562	226928
5. c). 3)	34743	311015	8.952	276272
5. c). 4)	57930	327252	5.649	269322
5. c). 5)	67302	334106	4.964	266804
4. b). Teacher	60060	177691	2.959	117631

TABLE 5
BRAZIL: AFTER 1998 REFORM, MALE—RGPS – REAL (2000 PRICES)

	A) Lifetime Contribution	B) Lifetime Benefit	C) = (B) / (A)	D) Lifetime Net Benefit = (B) – (A)
1. b). 2)	38223	66075	1.729	27852
1. c). 6)	6150	25800	4.195	19650
1. c). 7)	9306	29423	3.162	20117
1. c). 8)	12115	32270	2.664	20156
2. b). 2)	71577	127001	1.774	55424
2. c). 6)	13817	60897	4.407	47081
2. c). 7)	19893	65296	3.282	45403
2. c). 8)	24492	68086	2.780	43594
3. b). 2)	117501	212782	1.811	95280
3. c). 6)	27254	126339	4.636	99085
3. c). 7)	37187	127025	3.416	89838
3. c). 8)	43048	125288	2.910	82240
4. b). 2)	181015	326747	1.805	145732
4. c). 6)	40900	188390	4.606	147489
4. c). 7)	56208	190972	3.398	134764
4. c). 8)	62844	179446	2.855	116603
5. b). 2)	365260	664454	1.819	299195
5. c). 6)	73813	321597	4.357	247784
5. c). 7)	107045	350165	3.271	243120
5. c). 8)	131556	367454	2.793	235898
4. b). Teacher	147877	317766	2.149	169889

For public employees after the reform, we estimated six cases of full length of service retirement as we did for before the reform. We only changed the years and the contribution periods for teachers. Hence we estimate following two cases in three career paths.

A female employee started working at age 20 in 1998. She retires at age 50 in 2028 with length of service retirement and starts receiving a benefit of 100 percent last pay in 2028 till 2058, when she dies at the age of 80.

Male employee started working at age 20 in 1998. He retires at age 55 in 2033 with length of service retirement and starts receiving a benefit in 2033 till 2053, when he dies at the age of 75.

The estimation results are presented in Table 3B.

5.1.2 Effects of the Reform

Figure 4 and Figure 5 show the effect of changes in the length of service pension in RGPS. It is clear from these figures that the net benefits are substantially reduced. The new formula for benefits determination was introduced to bring the system close to actuarial balance. This actually does happen, since figures for the ratio after the reform are much closer to one. Female ratios dropped from around 7.5 to 2.5, a reduction to a third of the original value. The ratio for males went through a similar, but not so strong reduction, going from values around 5 to values below 2. Hence it is natural that the net benefits are greatly reduced. However, there still remain large net benefits for high wage groups. The regressive nature of paying more net benefits for higher wage groups was somehow attenuated but did not change in nature. The relationships between the education level and net benefits are given in Figure 16. The upward sloping curves became less steep but are still upward sloping.

The net benefit for the lowest education level is reduced to 10 percent of what it was before the reform, while for the group with the highest education level, it was reduced by three quarters, as shown in Figure 17 and Figure 18. The larger reduction is not due to the nature of the reform but rather to the historical path of relative wage rate between groups with different education qualification. These two figures show the magnitude of the eventual reduction in the net benefits. The younger generation cannot expect as great a net benefit from the system as the older generation enjoyed.

The effect of a longer contribution period requirement for eligibility for Old Age Pension is clearly shown in Figure 19 and Figure 20. Figure 20 shows that the benefit/contribution ratio was reduced, as a longer contribution period

FIGURE 16
NET BENEFIT, LENGTH OF SERVICE, BEFORE AND AFTER REFORM

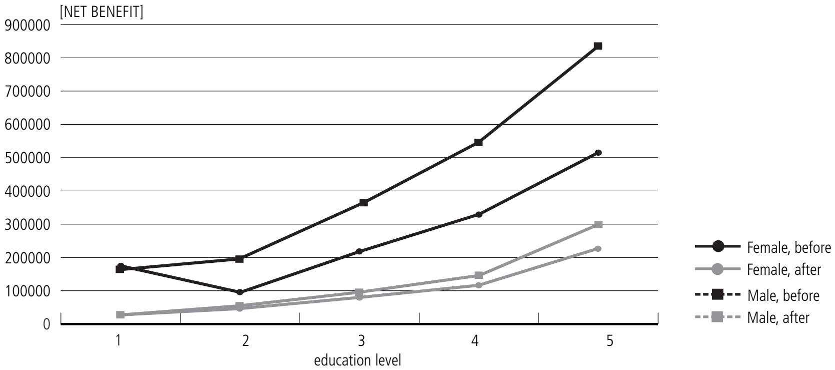


FIGURE 17
NET BENEFIT, BEFORE AND AFTER REFORM, RGPS, LENGTH OF SERVICE, FEMALE

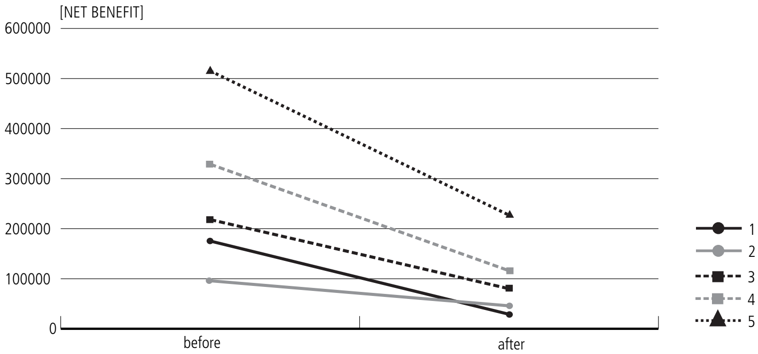


FIGURE 18
NET BENEFIT, BEFORE AND AFTER REFORM, RGPS, LENGTH OF SERVICE, MALE

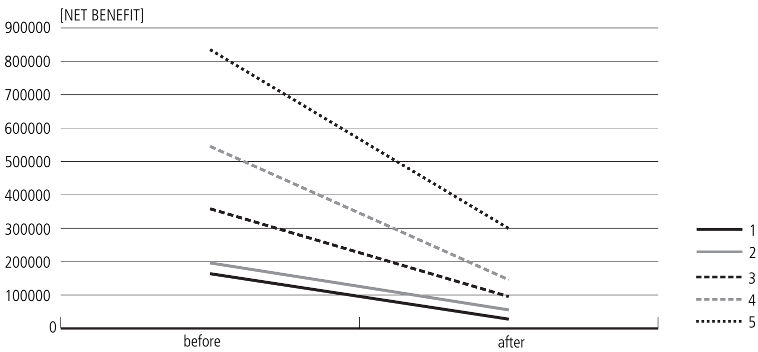


FIGURE 19
WAGE AND NET BENEFIT, RGPS, OLD AGE RETIREMENT, AFTER REFORM

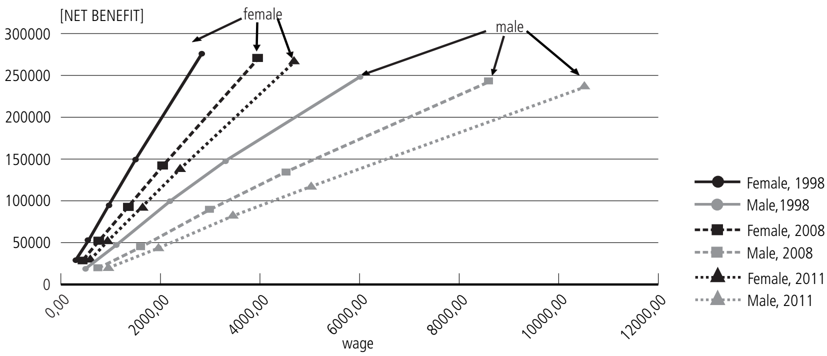
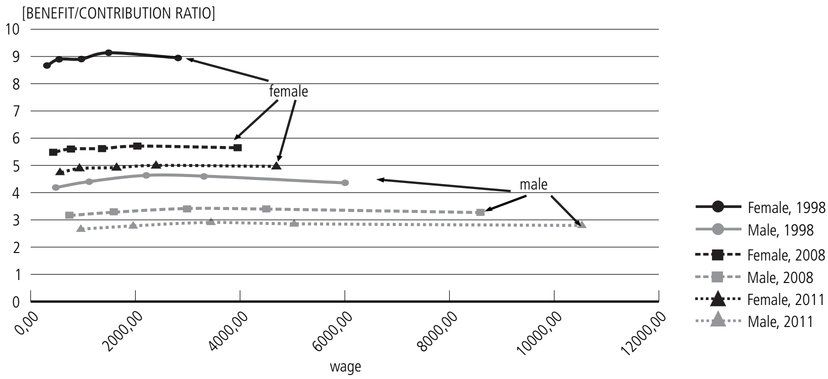


FIGURE 20
WAGE AND BENEFIT/CONTRIBUTION RATIO, RGPS, OLD AGE RETIREMENT, AFTER REFORM



was required. The reduction was more impressive for females than for males. However, the ratio is still above two, indicating actuarial imbalance. Also, the near constancy of the ratio over wage level was not changed as in the case of length of service pension. As a result, the system still redistributes larger absolute net benefits for higher wage groups. Figure 19 shows that the slope became less steep, but the difference in the net benefit for the lowest wage group and the highest wage group is still large.

The reform in RGPS moved the system a little closer to actuarial balance. There still remains a large excess of benefits over contributions. Also, the regressive nature of distribution of excess benefits is still present.

As mentioned before, value-wise, the reform in RJU was not as substantial as that in RGPS, but the imposition of a minimum required age for retirement greatly affects the lifetime benefit. The reduction is more impressive for female teachers, but affects all groups with at least a 20 percent reduction in the benefit to wage ratio. Public servants still receive very large net benefits. Also, as in the case of RGPS, the regressive nature of net benefit is still present. Not only do the absolute amounts of net benefits increase with wage level, as shown in Figure 7 and Figure 21, the benefit/wage ratio is also larger, the higher the wage, as shown in Figure 8 and Figure 22. Even after the reform, public employees receive benefits of as much as 50 to 130 percent of their total wage earnings before retirement.

While the recent reform of RJU did not change its basic benefit structure, the benefits in RGPS were reduced considerably. To be able to compare these two systems, Figures 10 and 11 show net benefit and the ratio of net benefit to wage as a function of average monthly wage. Figure 10 and Figure 11 show the increased differences in

FIGURE 21
LIFETIME WAGE AND LIFETIME BENEFIT, AFTER REFORM, PUBLIC EMPLOYEE

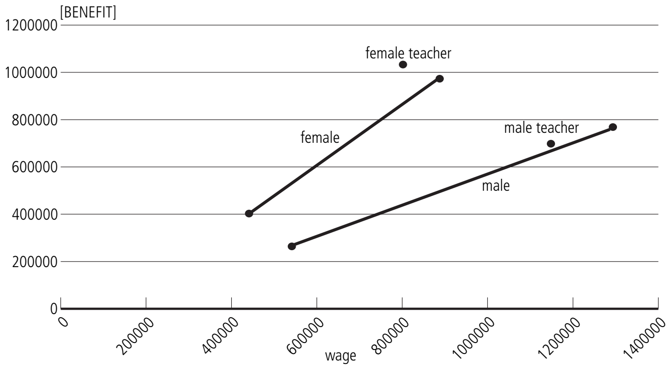
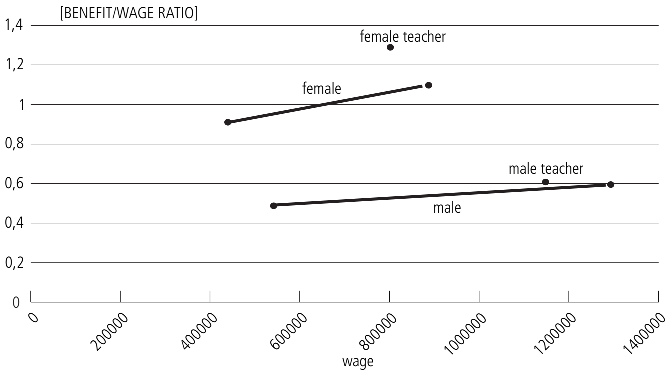


FIGURE 22
LIFETIME WAGE AND BENEFIT/WAGE RATIO, AFTER REFORM, PUBLIC EMPLOYEE



the net benefits between RJU and RGPS. The contribution rate of RJU of 11 percent is too low for the generous benefits, and benefits still remain as a deferred wage in nature. The average wage for public employees is much higher than that for private workers, as Figure 11 shows. With these generous pension benefits, the difference in lifetime income between the private and public sectors becomes much larger.

5.2 JAPAN

5.2.1 Recent Reform

In order to lower the maximum scheduled contribution rate from 34.3 percent and to improve the financial position at the same time, the government undertook a significant reform in early 2000. (Hereafter we call this reform the Y2K reform.)

We list the major changes made by the Y2K reform.

1. The future contribution rate hike schedule is changed as shown in Figure 1, reducing the maximum rate to 27.6 percent from 34.3 percent for PEP.

2. The starting benefit of the income proportional part of PEP is cut by 5 percent.

3. The benefits of both the basic pension and the income proportional part of PEP are not to be indexed to the wage rate after the start of reception of the benefit payment.

4. The starting age of the benefit of the income proportional part of PEP is to be raised gradually to 65 during the period from 2013 to 2025.

5. The subsidy from the general account is to be increased from 1/3 to 1/2 of the benefit payments of the basic pension.

6. The flat contribution of NP is to be raised from its present level of 13,300 yen per month, by 800 yen every year, instead of the 500 yen previously scheduled, until it reaches the value of 24,000 yen per month.

It has been widely discussed, and there was a general consensus, that the maximum contribution rate of 34.3 percent, as scheduled before the reform, was simply too high and would not be an acceptable figure to the population. Thus, the first point was to lower this rate to a level that would be accepted by the general public. The schedule of the contribution rate hike in the Y2K Reform is presented by the thin, solid line in Figure 1. The rest of the changes were to make the system financially sustainable with this reduction in the contribution rate. With the lower contribution rate, the expenditure must also be cut. Items 2 to 4 are the major reductions in the benefit.

Item 2 is a straightforward cut. Item 3 will have a larger impact on the benefit. Even after the starting age of benefit is raised to 65, with present life expectancy, an average man will receive benefits over 15 years, and an average woman over 20 years. If the wage rate grows at 2 percent annually on average, the starting benefit of a 65-year-old man is about 35 percent more than the benefit of 80-year-old. This applies to the basic pension benefit that is considered to provide the basic necessities of life.

Item 5 is a change to increase the revenue of the pension account. With this change, the financial position of the pension account improves a lot but at the cost of the general account. This change makes the burden of the pension look small by shifting the burden to the general account with the total burden of the people unchanged. This, in a sense, simply hides the cost of pension from the pension account. The reform bill does not specify how this subsidy from the general account is to be financed. With the large accumulated debt and the deficit in the general account in the past few years, it is clear that the government cannot accumulate more debt. Thus, it is widely suspected that the government is considering a tax hike. The intergenerational income redistribution depends on the type of tax to be raised.[19]

5.2.2 Effects of the Y2K Reform

The large inequity in lifetime contribution and benefit among generations in PEP was rectified slightly by the Y2K Reform. The two dotted lines in Figure 13 show the lifetime contribution and benefit rates. The excess payment of those born after 2005 is reduced to 10.5 percent from 13.9 percent of lifetime wage. This was brought about by the large reduction of the lifetime contribution rate. The cuts of the future benefits made this reduction in the contribution rate only partially possible. A large part of the reduction was due to the increase of the subsidy from the general account. Since this is simply a shift of the burden from the pension account to the general account, the burden of the younger generation did not really become small as the graph suggests. The intersection point of the lifetime contribution line and lifetime benefit line is shifted from the cohort born in 1962 to the one born in 1957. This shift is not big enough. The key to reducing the burden to the future generation is to eliminate the excess benefit to the baby boom generation. Y2K Reform failed to do so. It cuts the benefit the baby boom generation receives, but, at the same time, it reduces the contribution they make

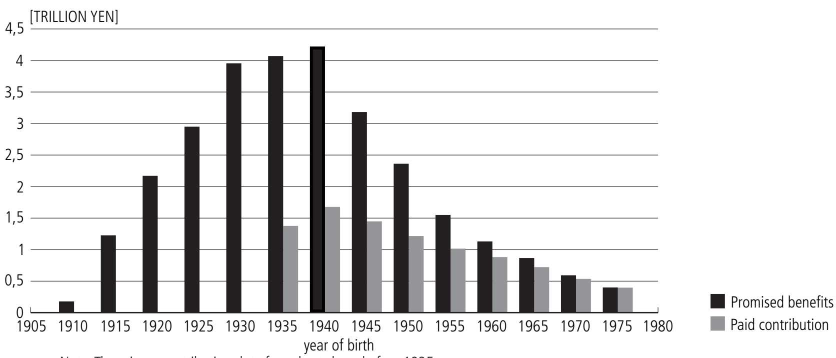
19. Oguchi (1998) analyzed the difference in the redistributional effect of income tax and consumption tax as the source of pension subsidy.

by delaying the schedule of the contribution rate hike. As result, the net reduction in the excess benefit was rather small for the baby boom generation.

The lifetime contribution and benefit in monetary terms after Y2K Reform are presented by dotted lines in Figure 14. After the Y2K Reform, the difference in the net pension benefit between the cohort born in 1935 and the one born in 2005 is reduced to 55 million yen from 75 million yen. The cohort born in 2005 still has to contribute about 20 million yen more than they receive. Thus, there still remains a large inequity among generations, with overpayment by the younger generation. This is a source of discontent among the younger generation causing some of them to drop out of the system.

The dotted line in Figure 15 shows the lifetime benefit/contribution rate of NP by cohorts after Y2K Reform. The reform slightly reduces the exceedingly generous benefits for older generations. For younger generations there is not much change as the ratio was already close to unity. This graph is for an individual who makes contributions for 40 years and lives till 80 years of age. The aggregate values for the cohorts are shown in Figure 23. For the aggregate, the average benefit is smaller than for the individual mentioned above, since there are many people who do not qualify to receive benefits despite their contributions.[20]

FIGURE 23
PENSION DEBTS AND PAID CONTRIBUTION OF NATIONAL PENSION BY COHORTS



Note: There is no contribution data for cohorts born before 1935.

20. There is a 25-year minimum contribution requirement for NP and 20 years for PEP and GEP.

The Y2K Reform in the Japanese pension system did not greatly change the intergenerational redistribution of income in PEP. It is inevitable that the younger generations will have to bear the burden of overpayment in the past; still the burden can be spread more widely over a longer period of time, thus reducing the burden born by each generation.

6 CONCLUSION

Both the Brazilian and Japanese public pension systems have large income redistribution mechanisms built into them. A very large part of these mechanisms is difficult to justify economically. The Brazilian RGPS system has not been actuarially balanced and presents much larger benefit payments than contribution revenues. Furthermore, the excess benefit payment over contribution was larger for higher wage earners. Thus, RGPS was regressive and aggravated the inequity of income distribution. The recent reform somehow reduced the excess of benefit over contribution. However, it did not go far enough and regressive redistribution still remains. The situation in RJU is more serious. The total excess benefit over lifetime is about 50 percent to 130 percent of total wage before retirement. The magnitude is appalling, and it is even more regressive than RGPS. The higher the wage is, the higher the benefit/wage ratio. The system needs to be reformed based on economic rationality.

There are large redistribution mechanisms that are economically difficult to justify in the Japanese system as well. The excess of lifetime benefit over lifetime contribution varies from positive 26 percent of lifetime wage earning to negative 14 percent over generation. Within the same cohorts, dependent spouses of employees (mostly housewives) are favorably treated over wives of self-employed workers or single women.

In many countries public pension systems are facing financial difficulties and governments are trying various reform measures. In designing pension reform policy, it is important to remember why we need public pension systems in a free economy. Population coverage is always a concern, since there are some groups that cannot or will not save enough for old age and will depend on the government later in life. Both in Brazil and in Japan, the amount of people not covered by the system is increasing instead of decreasing. The reasons are manifold, some are related to new labor market rules and some to the lack of enforcement of prevailing laws.

However, in a free economy, the prevailing principle should be to minimize government intervention in private matters. In return, this means that people should not depend on governments unnecessarily. There is no "free lunch" in the pension system as a whole. Basically, pension is a form of forced saving. Hence, it serves this purpose better by making the system free of redistribution as much as possible. If there is a redistribution mechanism in the system, it should help improve economic equity in the society.

APPENDIX

DATA

Brazilian Census,[21] conducted roughly every 10 years, besides the census questionnaire itself, has a sample questionnaire for some specific population characteristics (fertility, mortality, income, working status, etc.). The 1970 and 1980 Census used a 25 percent sample rate for all municipalities and the 1991 Census used a variable sampling rate depending on municipality size. For large cities, the sampling rate was 10 percent; for small cities it was 25 percent; and for intermediate size cities, the sampling rate was 20 percent. For each census, sample data is available in CD-ROM (ASCII format). For each Census selected, microdata were tabulated according to some characteristics:

Formal schooling (5 categories)

1. Less than elementary school
2. Elementary school but less than junior high school
3. Junior high school but less than senior high school
4. Senior high school but less than university
5. University degree

Urban/rural condition (2 categories)

1. Urban
2. Rural

For civil servants, the database used was the payroll file. The average salaries in each of three careers (educational personnel, noneducational positions of university level and noneducational positions of intermediate level) were calculated per individual age and sex. Only cross-section data was available. The computation was also carried out using the minimum wage as unit. The overall trend is an

21. Brazilian Census is the responsibility of IBGE–Instituto Brasileiro de Geografia e Estatística–Brazilian Institute of Geography and Statistics.

increasing one, but less steeper for intermediate level civil servants. Professors and other civil servants with a university degree follow a very similar path as a function of age (Figure A.4).

Sex (2 categories)

1. Male
2. Female

5-year age group (15 categories)

from 10/15 year age group to the open-ended group of 75 years of age and over, and an unknown age category.

We considered 5x2x2 different population groups (further disaggregated by age). In the rural labor market there are no workers above junior high school level, and some of the classes considered are very sparse. At the end only 14 groups were used: ten for the urban population and four for the rural population (formal schooling levels 1 and 2).

For each population group considered, the average salary was computed and a second or third degree polynomial was adjusted as a function of the mean age of the 5-year age group. For most trends, the third degree coefficient was not statistically significant and the second-degree polynomial was considered the best fit. For each cohort, we used the adjusted rate for the census years available and interpolated it for the intercensal period. Because of the periods of high inflation Brazil went through, salary information was converted to 1991 currency using INPC—Índice Nacional de Preços ao Consumidor (National Consumer Price Index) from IBGE. For information before 1970 and after 1991,[22] we assumed that the cross-sectional information could take the place of the time series. For example, for the cohort born between 1940 and 1945, the first available information is the 1970 census and refers to the 30 to 35 year age group. The trend followed by this cohort up to this age group is assumed to be equal to the cross sectional information for the 1970 census. In 1980 the cohort information corresponds to the 40 to 45 year age group and in 1991 to the 50 to 55 year age group. The corresponding trend for older age groups is assumed to coincide with the 1991 cross sectional information. For years ending in 5, the available information was interpolated, assuming a linear trend. For example, information

22. To be consistent with the other censuses, the reference period was considered to be equal to 1990.

for this cohort at the 35 to 40 year age group was obtained as the average between the 1970 census information at 30 to 35 year age group and the 1980 census information at 40 to 45 year age group.

As an example, Figures A.1 to A.3 show the raw data and the adjusted polynomial for Brazilian urban males for the 1970 and 1980 and 1991 censuses. Minimum wages were used as measurement unit. As such, they are not strictly comparable, since the minimum wage did not keep a constant value in real terms. It is worth mentioning that the downward slope found at older ages is related to two main factors: shorter working hours and exit of the better off from the work force.

FIGURE A.1
AVERAGE SALARY (IN MINIMUM WAGES): 1970—BRAZILIAN URBAN MALES—BY SCHOOLING LEVEL—RAW DATA AND ADJUSTED INFORMATION

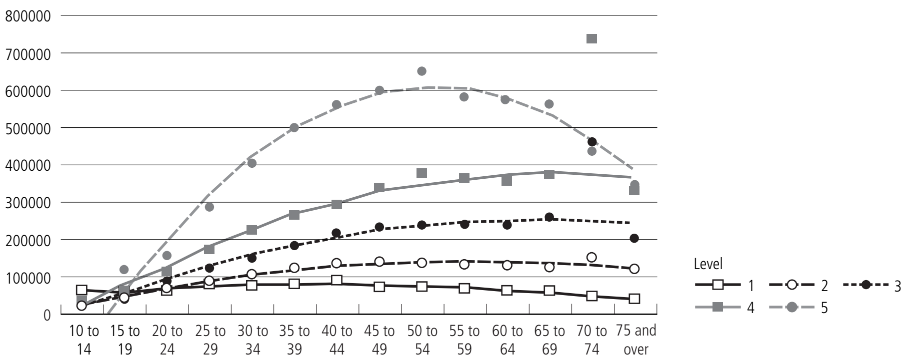


FIGURE A.2
AVERAGE SALARY (IN MINIMUM WAGES): 1980—BRAZILIAN URBAN MALES—BY SCHOOLING LEVEL—RAW DATA AND ADJUSTED INFORMATION

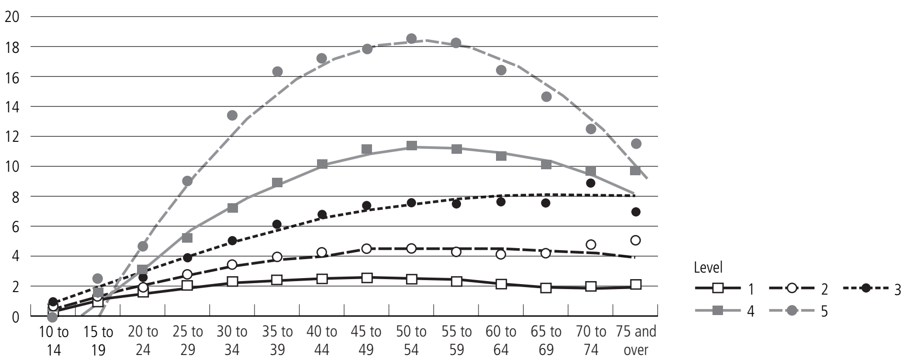


FIGURE A.3

AVERAGE SALARY (IN MINIMUM WAGES): 1991—BRAZILIAN URBAN MALES—BY SCHOOLING LEVEL—RAW DATA AND ADJUSTED INFORMATION

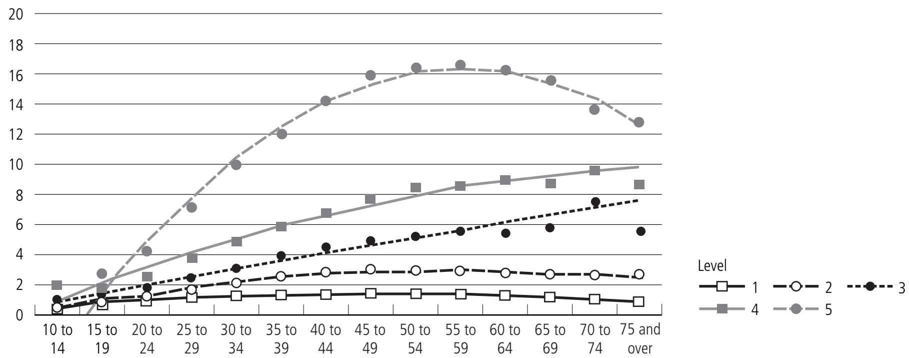
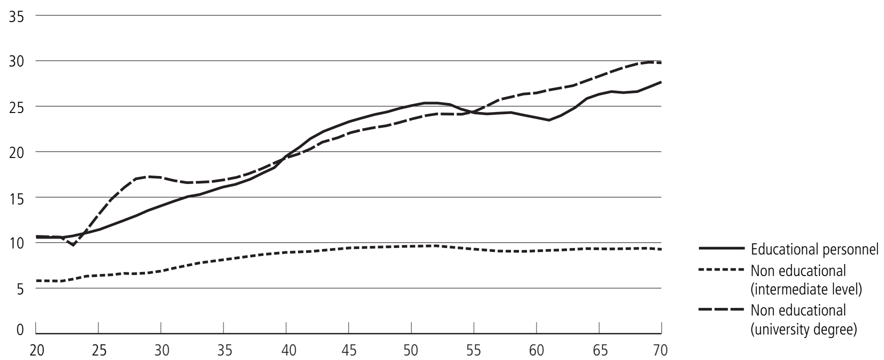


FIGURE A.4

AVERAGE SALARY (IN MINIMUM WAGES): 1998—BRAZILIAN MALES CIVIL SERVANTS BY CAREER—SMOOTHED INFORMATION



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CHAPTER 9

IMPLICATIONS OF THE BRAZILIAN SOCIAL SECURITY SYSTEM ON SOCIAL WELFARE

Roberto Ellery Jr.
Mirta N. S. Bugarin

1 INTRODUCTION

In any contemporaneous economic analysis, issues on social security and its financing mechanism arise naturally. From an applied economics point of view, particularly when focusing on public policies, the institution of social security becomes a matter of extreme relevance. The distribution mechanism of social security benefits has an undeniable impact on social welfare. The related issues range from intergeneration solidarity to income distribution considerations. On the other hand, the social cost of financing the social security scheme turns out to be a major public finance issue for the majority of the countries, as recent demographic changes increasingly threaten the financing capacity of the system all around the world.

Some studies indicate that starting in the year 2030 the U.S. Social Security system will present a fiscal deficit [see Feldstein and Samwick (1997)], as will also be the case with many European countries and Japan. In Brazil, the inability to finance the expenses related to the social security system is already apparent. In 1998 the social security deficit was the main source of the Federal government's primary deficit,[1] and, in 1999, despite strong fiscal efforts, the Brazilian General Social Security System [*Regime Geral de Previdência Social* (RGPS)] showed a deficit of approximately R$ 30 billion or 3.1 percent of the country's GDP.

Chile was one of the first countries that tried to solve the fiscal imbalance by changing the social security system itself. The Chilean proposal consisted of transforming the former pay-as-you-go system into a funded system, or a system of individual accounts, in which each (future) benefit would be related to the associated contribution in order to face the changes in the Chilean demographic structure, which threaten the financial balance of the system. This reform proposal was based on the main existing theoretical literature, which argued that the change

1. Data from the National Treasure Office [Secretaria do Tesouro Nacional (STN)].

to a funded system would lead to increases in the saving rate of the population and, hence, to an increasing supply of capital. This increase, in turn, would allow for a faster capital accumulation, thus leading to a faster output and consumption growth or, equivalently, to higher levels of social welfare. The cost of the transition from the former pay-as-you-go to the funded system was considered worth bearing, in view of the future social welfare benefits. With this result so confidently expected, the discussion turned to the issue of how to find ways to finance the cost of this transition, regarded as the sole obstacle to achieving the social benefits of the funded system. Chile's experience was often taken as a benchmark case for analyzing alternative proposals [see Barreto (1997)].

As time went by, some new issues were raised. In particular, it was noted that the funded system could transfer risks—especially specific individual risks—to the insured. This would occur, for example, if an individual were dismissed and were unable to contribute toward his/her personal account. This problem is more serious in countries where agents cannot count on a financial system that allows them to (optimally) smooth out consumption during the economic cycle. This point is one of extreme relevance for Brazil, since most of the families in the country do not, in fact, have access to the credit market [see Reis et al. (1998)].

Another aspect is related to the question of dynamic inefficiency. Studies based on dynamic models suggest that if the economy presents dynamic inefficiency, an increase of capital accumulation does not imply an increase in welfare. Along this line of argument, for this type of economy, when capital supply increases due to the introduction of the funded social security system, social welfare can be, in fact, reduced in spite of a higher capital accumulation.

Some authors, using overlapping generation (OLG) models, recently studied problems of the Brazilian RGPS [see Barreto and Oliveira (1995), Barreto (1997) and Lannes Jr. (1999)]. The present study aims to contribute to this line of research. We extend the standard OLG model by including some special features, so as to incorporate into the analysis some of the questions raised above. In particular, credit restrictions will be introduced into the agent's per period budget constraint to capture this feature of the Brazilian economy, and idiosyncratic shocks will be incorporated, namely unemployment and uncertainty about the agent's life span.

The article is organized as follows: Section 2 presents the extended OLG model and defines the equilibrium that it should be numerically solved for; Section 3 explains the calibration of the model based on Brazilian data; Section 4 shows the results of the simulations; and, finally, Section 5 concludes by introducing some suggestions for future research.

2 THE MODEL ECONOMY

This section presents the OLG model developed by Imrohoroglu, Imrohoroglu and Jones (1995),[2] which will be used to quantitatively assess the implications of the social security system on social welfare. The basic structure of the model is a combination of two types of models. The first type, studied by Kotlikoff (1996), is given by a structure of overlapping generations such that, in any period, many different generations can coexist. The second type, named Bewley Models[3] by Sargent and Ljungqvist (2000), and used by Imrohoroglu (1989) and Hugget (1993), is characterized by an economy in which agents are subjected to idiosyncratic shocks but do not possess any means to perfectly insure themselves against such shocks.

According to these models, the life span of an individual is given by a probability distribution, for the individual knows the maximum time he/she can live but does not know in which period he/she is going to die. This assumption will allow us to study a more realistic demographic dynamics than the ones present in traditional overlapping generation models [see Kotlikoff (1996)]. To formalize this demographic process, it is assumed that agents who are alive in the period j–1 will also be alive in period j with a probability $\psi_j \in (0,1)$. It is also possible that some agents reach the maximum age J and, in this case, the probability of living until J+1 is assumed to be zero. In each period the number of births grows at a ratio given by n. To analyze the steady state, it is necessary to get a limit distribution for the demographic structure, in which the fraction of each generation, $\{\mu_j\}_{j=1}^{J}$, is computed according to the rules $\mu_j = \dfrac{\psi_j \mu_{j-1}}{1+n}$ and $\sum_{j=1}^{J} \mu_j = 1$. These values will be required, in turn, when aggregate amounts are calculated.

Furthermore, it is also assumed that agents in this model economy can face a stochastic income stream during their lifetimes, for they could be dismissed in any active period. Denoting the states on the job condition by $s \in S = \{e,u\}$, where e stands for employed and u for unemployed, the two-state Markov process, along with the associated transition probability matrix, can fully describe the transition between the states, $\prod(s',s) = [\pi_{ij}], i, j = e, u,$ where $\pi_{ij} = \Pr\{s_{t+1} = j \mid s_t = i\}$. In case an individual is dismissed, it is assumed that he/she receives an income from the

2. Imrohoroglu, Imrohoroglu and Jones (1998*b*) present an expanded version of the model where land is included as a production factor.

3. Named after Truman Bewley for his pioneering articles (1977, 1980, 1983, 1986).

unemployment insurance program equivalent to $\phi\omega\varepsilon_j$. Once retired, the individual receives a benefit b from the social security system and consumes his/her stock of accumulated assets. The computation of the social security program benefit, $b_j, j = 1,2,\ldots,J$, is done according to the following equation:

$$b = \begin{cases} 0 & j = 1,2,\ldots, j_R - 1 \\ \theta \dfrac{\sum_{i=1}^{j_R-1} \omega_i^e}{j_R - 1} & j = j_R, j_R + 1,\ldots, J \end{cases} \tag{1}$$

where R represents the mandatory retirement age. Accordingly, the per period individual income is given by

$$q_j = \begin{cases} (1-\tau_s-\tau_u)\omega\hat{h}\varepsilon_j & j \in [1, j_R),\ s = e \\ \phi\omega\hat{h} & j \in [1, j_R),\ s = u \\ b & j \in [j_R, J] \end{cases} \tag{2}$$

Another feature of the model consists of introducing an assumption according to which no individual in the model economy may become indebted, in other words, he/she faces constrained liquidity. This hypothesis is clearly relevant, for, without access to the credit market, the individual reduces the possibility of insuring himself/herself against the possible loss of his/her income, particularly after a certain age. In this case, the social security system works as insurance, noting that from equation (1) above, the social security benefit does not depend on the agent's job history. Moreover, this assumption is even more relevant for the Brazilian economy, as can be inferred from empirical studies, such as Reis et al. (1998), among others, which show that about 80 percent of Brazilian consumers are constrained to consuming their entire per period income within every period.

Also, since the date of death is uncertain, there exists the possibility that an individual can hold a positive net supply of assets in the period of death. Should this be the case, it is assumed that the involuntary bequest will be equally distributed among all remaining agents. Denoting the supply of assets in period t by $a_t \geq 0$, and ξ being the bequest received, the consumer's budget constraint will be given by the following expression:

$$a_j = (1+r)a_{j-1} + q_j - c_j + \xi, \quad j = 1,2,\ldots,J \tag{3}$$

The lifetime utility of each individual is assumed to possess the following functional form:

$$E_0 \sum_{j=1}^{J} \beta^{j-1} \left[\prod_{k=1}^{j} \Psi_k \right] \frac{c_j^{1-\gamma}}{1-\gamma} \tag{4}$$

which he/she maximizes subject to the per period budget constraint (3).

Once the description of the consumers is presented, the next step will be devoted to characterizing the firms of the model economy. The numerous identical and competitive firms are introduced according to the traditional hypothesis that allows for the use of the aggregate production function $Q = BK^{1-\alpha}N^{\alpha}$, where Q is output, K is capital, and N is labor. Thus, as usual, the first order conditions of the firms' profit maximization problem determine the respective prices of capital r, and labor ω, as given by the expressions below:

$$\begin{aligned} r &= (1-\alpha)B\left(\frac{K}{N}\right)^{-\alpha} - \delta \\ \omega &= \alpha B\left(\frac{K}{N}\right)^{(1-\alpha)} \end{aligned} \tag{5}$$

In order to describe the stationary equilibrium of this economy, it will be necessary to write the consumers' problem as a dynamic programming problem (DPP) and then to define, for each age, the limiting measure that describes the distribution of the asset supply among the agents of the economy. The value function that describes the DPP of an individual of age j can be written as follows:

$$V_j(a,s) = \max_{c,a'}\{u(c) + \beta\Psi_{j+1}E_{s'}V_{j+1}(a',s')\} \quad j = 1,2,\ldots,J \tag{6}$$

with the optimization subjected to (3) and $a' \geq 0$.

Given the decision rules $A_j, j = 1,2,\ldots,J$ and the wealth distribution λ_1, the limiting measure can be obtained according to the following rule:

$$\lambda_j(a',s') = \sum_{s} \sum_{a:a' \in A_j(a,s)} \prod(s',s)\lambda_{j-1}(a,s) \tag{7}$$

Then, with the above definitions in hand, it is possible to define the stationary equilibrium of the model, which will next be numerically solved.

Definition: A stationary equilibrium for a given set of policy arrangements $\{\theta,\phi,\tau_s,\tau_u\}$ is a collection of value functions $V_j(a,s)$; individual policy rules A_j and C_j; age-dependent, but time invariant, measures of agent types λ_j; relative prices of labor and capital $\{\omega,r\}$; and involuntary bequest ξ, such that:

1. individual and aggregate behaviors are consistent:

$$K=\sum_j\sum_a\sum_s \mu_j\lambda_j(a,s)a_{j-1} \text{ and } N=\sum_{j=1}^{j_R-1}\sum_a \mu_j\lambda_j(a,s=e)\varepsilon_j \tag{8}$$

2. factor prices $\{\omega,r\}$ are given by (5);

3. given $\{\omega,r\}$, $\{\theta,\phi,\tau_s,\tau_u\}$, and ξ, the individual policy functions $C_j(a,s)$ and $A_j(a,s)$ solve the dynamic problem in (6);

4. commodity markets clear:

$$\sum_j\sum_a\sum_s \mu_j\lambda_j(a,s)\left\{C_j(a,s)+\left[A_j(a,s)-(1-\delta)A_{j-1}(a,s)\right]\right\}=Q \tag{9}$$

5. the collection of time invariant measures $\lambda_j(a,s)$ for j=1,2, ..., J satisfies

$$\lambda_j(a',s')=\sum_s \sum_{a:a'\in A_j(a,s)} \prod(s',s)\lambda_{j-1}(a,s)$$

6. the social security system is self-financing:

$$\tau_s=\frac{\sum_{j=1}^{J}\sum_a \mu_j\lambda_j(a,s)b}{\sum_{j=1}^{j_R-1}\sum_a \mu_j\lambda_j(a,s=e)\omega\varepsilon_j} \tag{10}$$

7. the unemployment benefit insurance program is self-financing:

$$\tau_u=\frac{\sum_{j=1}^{j_R-1}\sum_a \mu_j\lambda_j(a,s=u)\phi\omega\varepsilon_j}{\sum_{j=1}^{j_R-1}\sum_a \mu_j\lambda_j(a,s=e)\omega\varepsilon_j} \tag{11}$$

8. and the involuntary bequests are given by

$$\xi=\sum_j\sum_a\sum_s \mu_j\lambda_j(a,s)(1-\Psi_{j+1})A_j(a,s) \tag{12}$$

Given this definition of equilibrium, we turn to the next section to describe the calibration procedure, which assigns values to the parameters of the model economy so as to render the above artificial economy consistent with the Brazilian economy.

3 CALIBRATION

The main objective of this section is to provide a set of values for the parameters of the model economy such that it can properly represent the Brazilian economy through the process known as calibration. Ellery Jr., Gomes and Sachsida (2002) list some of the basic problems associated with the calibration of dynamic models for Brazil and also suggest several solutions to deal with them. Some of the questions pointed out by the authors apply to the model presented in the previous section, but other questions are specific for the model they were using.[4]

Herein, whenever the calibration problem coincides with one of the listed by the above authors, their suggested solution will be used. Also, the calibration procedure for a specific parameter will be different from the one proposed by Imrohoroglu, Imrohoroglu and Jones (1995, 1998*a* and *b*, and 1999). Such divergences result from a specific problem related to the available Brazilian data. Whenever those cases occur, the two calibration procedures and the related implications will be discussed as well.

Beforehand, it is possible to classify the set of parameters according to their specific roles in the model economy, as it is shown by the different types of parameters listed below.

- Demographic: describes the age structure of the population.
- Preference: characterizes the utility function of the consumers.
- Technological: describes the production process.
- Policy: describes the social security system and the unemployment insurance program.
- Parameters of the random process that characterize the per period condition of being employed or unemployed.

Thus, the calibration process of the model economy parameters is described below following the above classification.

4. Ellery Jr., Gomes and Sachsida (2002) analyze a class of infinite-lived representative agents models, so that questions such as life expectancy and social security are excluded. However some questions such as consumption and capital accumulation may have a similar treatment.

3.1 Demographic

The demographic structure in the model is characterized by two sets of parameters. The first one consists of the survival probabilities or the probability that an individual that reached age j–1 comes to reach age j, denoted by Ψ_j in the model. The second one represents the ratio between the size of each age cohort j, j = 1,2, ..., J, and the total population or, in other words, the age structure of the population.

Once the values of Ψ_j are known, for j = 1,2, ... J (the fraction of agents of each age in the total population), the measure of each set of age j, j = 1,2, ..., J (agents defined as μ_j), can be determined in turn. As the measure of the total population is one, μ_j can be interpreted as the probability of a randomly chosen individual being of age j. To derive the value of μ_j from Ψ_j, the rule $\mu_{j+1} = \frac{\Psi_{j+1}}{1+n}\mu_j$ and the requirement $\sum_{j=1}^{J} \mu_j = 1$ are used, where n denotes the growth rate of the population. According to the available data from IBGE,[5] the average rate of growth of the Brazilian population is approximately 2 percent per year.[6]

Therefore, the problem associated with the characterization of the demographic structure of the model is reduced to find the value of the survival probability for each age j individual, Ψ_j. To this end, the Mortality Table (IBGE) for to the year 1998 will be used to obtain the probabilities that age j individual could die between ages j–1 and j.

However, an important caveat applies when IBGE's table is used for calibration purposes: the model economy includes agents from 21 to 85 years of age,[7] while the IBGE data encompass individuals from zero to 80 years of age. To render the populations comparable, first we excluded agents under 21 years of age from the IBGE data, and assumed the additional hypothesis that $\psi_1 = 1$, which is equivalent to assuming that all agents reach the first age of the model economy. Second, a linear extrapolation of the population to the range from 81 to 85 was undertaken, based on IBGE's mortality tables.

5. Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística*).

6. Data from IBGE covering the period between 1970 and 1998.

7. The authors plan a future extension where agents may enter the workforce at ages below 21, even though Barreto (1997) and Lannes Jr. (1999) have also assumed 21 as the age that the agents enter the labor market.

3.2 Preferences

Two parameters are related to the description of the preferences. The first parameter describes the individual's degree of risk aversion, γ; the second characterizes the subjective discount factor, β. The calibration of both parameters is troublesome for the Brazilian economy in particular, as very few good estimates are available for the first parameter. As for the second parameter, there is a problem related to the estimation of the country's wealth supply.

One of the traditional ways to calibrate the value of the risk aversion parameter is to use the estimates of its reverse, namely the intertemporal elasticity of substitution defined as $\mu = 1/\gamma$. The estimation procedure of this parameter is a sufficiently complex task, as pointed out by Reis et al. (1998). Moreover, the procedure appears to be difficult even for countries with a good tradition in providing accurate databases. For instance, in the United States, Mehra and Prescott (1985) argue that reasons exist to believe that the intertemporal elasticity of substitution would be between zero and one.[8] In turn, Imrohoroglu (1989) suggests that in the majority of studied cases the value of this parameter would be between half and one and a half. On the other hand, to study the costs of real business cycles in the United States, Lucas (1987) uses a value close to 0.16 for the same parameter ν,[9] while Hall (1978), from annual data, suggests that this value can be negative. The great disparity between the estimated values made some authors assume that the intertemporal elasticity was equal to one, as a way of getting the operational advantages associated to the logarithmic specification of the utility function.

For the Brazilian case, the estimates also present a great disparity among them. Estimating the Euler equations, Cavalcanti (1994) concludes that the intertemporal elasticity of substitution would be smaller than one and near zero, the same result obtained by Gleizer (1991). On the other side, Reis et al. (1998) suggest that, since, by construction, the ratio includes the credit-unconstrained population, and since the elasticity of intertemporal substitution is statistically zero, there is a clear indication that the value of the intertemporal elasticity of substitution is greater than one.[10] Also, in studies on the Brazilian cycle, Issler and Rocha (1999) use values between zero and one for the elasticity of intertemporal substitution, ν.

8. These values are associated with values ranging from one to twenty for the risk aversion coefficient.

9. A value of 6 for γ.

10. They estimate that the share of unconstrained agents is 0.2.

These estimates for the Brazilian economy could be regarded as an indication of the relevance of the credit constraint faced by Brazilian consumers. Most of these estimates use the consumption sensitivity to interest rate to estimate this elasticity. If the population is constrained to consume all of its income, consumption must present a negligible sensitivity with respect to variations of the interest rate. So, the low sensitivity of consumption to interest rates would not be reflecting a low elasticity of substitution but rather the existence of binding liquidity constraints faced by the consumers.

Due to the great disparity between the estimates for the intertemporal elasticity of substitution, the value of this parameter was drawn from other simulation studies about the Brazilian social security system. Barreto (1997) and Lannes Jr. (1999) use the estimates given by Cifuentes and Valdés-Pietro (1994)[11] for developing countries. Barreto (1997) uses a value of 0.7 for the intertemporal elasticity of substitution, so this will be the value used in the numerical simulations below.

For the subjective discount factor, β, the traditional way to calibrate it is to restrict the model to replicate the observed wealth/income relation in the economy. However, an important share of the wealth is given by the supply of durable goods, and this series is not available for Brazil. Given the lack of an appropriate series for wealth supply, it is possible to calibrate β alternatively from the interest rate of the economy.[12] To deal with this problem, two alternative procedures will be used to define the value for this parameter.

The first one replicates the wealth/income ratio suggested by the series of wealth published by IPEA,[13] which reaches an average value of 2.7 for the period 1970-2000. According to this method, the value of β would equal 1.005. In the alternative procedure, using the interest rate, the value of β would be approximately 0.96. An important theoretical remark is due at this point. OLG models do not require the subjective discount factor to be smaller than one, due to the fact that the policy function and the value function are well defined for agents who reach the maximum age J.[14] Therefore, the solution of the DPP problem does not depend on fixed-point arguments, and, consequently, the Bellman Equation does not

11. The same reference is used in Barreto and Oliveira (1995).

12. This procedure is used in Barreto and Oliveira (1995), Barreto (1997) and Lannes Jr. (1999).

13. This series may be found at IPEADATA (http://www.ipeadata.gov.br).

14. The policy rule amounts to consuming all the assets previously accumulated, plus the current income. To find the value function, one should plug this policy function into the Bellman Equation.

need to be a contraction. Another important point is that the probability of death creates, in fact, an effective discount rate that differs from β,[15] so that values smaller than one for this parameter do not imply negative interest rates either.

3.3 Technology

The parameters defining the available technology in the model economy are the ones related to the production function, B and α, and to the depreciation rate, δ. The parameter B is a multiplicative constant and will be defined so as to equate the output value to one in the basic model.

For the labor share in aggregate income, data from the National Accounts (IBGE) were taken. This series also presents two main limitations. The first one is related to the calculation of labor and capital incomes in case of autonomous workers; the second one relates to the informal economy. These issues can lead to an over estimated share of capital income in the official accounts. The correction of the official data by the labor and capital income shares in the informal sector could solve this problem. However, this alternative was not used in this study due to the low reliability, or even absence, of these estimates on the Brazilian informal sector.

To simplify things, the income of the autonomous workers was added to the official aggregate labor income in order to calibrate the parameter relative to the labor share in aggregate income. With this procedure, the labor income share was set to 0.53. Although this value is lower than the value usually used for the American economy (about 0.66), it is compatible with values used in studies for the Brazilian economy by other authors, such as Barreto and Oliveira (1995), Barreto (1997), Lannes Jr. (1999) and Ellery Jr., Gomes and Sachsida (2002).

The calibration of the depreciation rate on the Brazilian capital stock also presents several shortcomings. First, the Brazilian National Account System does not publish the value of aggregate variables, such as output and investment, neither gross nor net. Second, there is no official capital stock series available; therefore no official estimate of the depreciation rate is feasible.

This lack of an official estimate for δ is circumvented by using different estimates for this parameter value. Barreto and Oliveira (1995), for instance, use a depreciation rate of 3.5 percent for the Brazilian capital stock also when analyzing

15. The effective discount factor is $\left\{\beta^{j-1}\prod_{k=1}^{j}\psi_k\right\}_{j=1}^{J}$ [see Imrohoroglu, Imrohoroglu and Jones (1998*a*)].

the Brazilian social security system, justifying this value as being "a usual value in this type of study". Kanczuck and Faria (2000), on the other hand, argue that there are no reasons for the Brazilian rate of depreciation to be different from the one used in the United States (a value from 4.5 percent to 10 percent).

Cooley and Prescott (1995) propose a standard way to calibrate the depreciation rate. Their method consists of defining it in such a way that the stability of the capital/output ratio in the balanced growth path can be guaranteed. This calibration procedure can be described by the equation below, directly derived from the linear capital accumulation dynamics:

$$\delta = \frac{I}{K} + 1 - (1+x)(1+n) \qquad (13)$$

where x represents the growth rate of *per capita* GNP, n the population growth rate, and I/K the investment-capital ratio.

Since this method depends on the availability of a capital series data, and, given the lack of official data on the Brazilian capital stock, we decided to follow the suggestion given by Kanczuk and Faria (2000). The authors argue that durable and capital goods consumption in Brazil and in the United States are not significantly different, hence, a similar depreciation rate could be applied to both economies. Following this line of argument, the depreciation rate was set to 10 percent as suggested by Imrohoroglu, Imrohoroglu and Jones (1999) for the latter country.

3.4 Policy Parameters

A given policy in this model economy will be characterized by the values of the replacement rate to the pay-as-you-go social security system, θ, and of the benefit rate associated to the unemployment insurance program, ϕ. Given the values of these policy parameters, the value of the contribution rate to each one of the programs, τ_s and τ_u, respectively, will in turn be defined such that self-financing conditions (10) and (11) are satisfied.

The calibration of the above policy parameters is based on data from the Ministry of Labor (MTb). According to the available official data, the value of the unemployment insurance benefit corresponds, in average, to 40 percent of the employed individual's wage. Hence, this parameter is set to $\phi = 0.4$.

In the case of the replacement rate of the pay-as-you-go social security system, the average remuneration of the private sector employees from the Industry and

Commerce Annual Labor Report [*Relatório Anual de Informações Sociais* (RAIS)] and the legal RGPS regulatory information were taken into consideration.

The present study focuses on the analysis of the RGPS. This choice leaves the Brazilian federal public employees pension system [*Regime Jurídico Único* (RJU)] and other pension schemes from subnational governments and public agencies out of the present study because of the specific legal rules that apply to the former and, in addition, the lack of trustworthy data for the latter systems. Other pension funds, as well as any private retirement programs, must also be excluded from the analysis due to the particular specification of the model economy. Namely, as introduced in the previous section, the model economy does not allow for more than one type of private asset, therefore, any contribution to a private retirement account is imputed in the individual's total saving in the artificial economy.

Finally, the mandatory retirement age, *R*, represents another parameter, which is indirectly associated to the retirement policy. Following previous studies on the Brazilian social security system, namely Barreto and Oliveira (1995), Barreto (1997) and Lannes Jr. (1999), the retirement age will be set as 65 years old.

3.5 Labor Market

The labor market considered in the model presents a rather simple structure. In each period an individual either does or does not receive a job offer, and, every time an offer is made, the individual always accepts it. In other words, it is assumed that the labor supply is inelastic.

Therefore, the calibration of the labor market boils down to the description of the stochastic process governing the job opportunities faced by each individual at every period. A discrete time 2-state-Markov process characterizes this process, hence, totally described by the following transition probability matrix:

$$\Pi = \begin{bmatrix} \pi_{ee} & \pi_{eu} \\ \pi_{ue} & \pi_{uu} \end{bmatrix} \tag{14}$$

where each element represents the probability that an individual is at state *j* in time (*t*+1), given that in time *t* he was at the state *i*, that is $\pi_{ij} = \Pr\{s_{t+1} = j \mid s_t = i\}$ with $i, j = \{e, u\}$, where *e* and *u* represent the states where the individual is employed and unemployed, respectively.

There are two alternative ways to calibrate the parameters of the above transition probability matrix Π. The first one consists of observing the duration time of each state and find the values of the π_{ij}'s consistent with the observed values, observing that a given state, ν, will have its duration expressed by $D_\nu = (1 - \pi_{\nu\nu})^{-1}$. For this procedure, following Imrohoroglu (1989), given the observed duration of each state and using the fact that each line of the matrix Π, by definition, has to add up to one, the corresponding values of the elements of the transition matrix can be obtained. Even though this method is more suitable for calibrating the above matrix, it will not be implemented in this study due to the lack of trustworthy data on the persistence of employment/unemployment states for the Brazilian economy.

The implemented procedure to calibrate the transition matrix follows Imrohoroglu, Imrohoroglu and Jones (1999). This alternative method is based on the determination of the value of the elements of the matrix Π so as to replicate the observed unemployment rate in the economy. Brazilian data from IBGE's Monthly Employment Survey [*Pesquisa Mensal de Emprego* (PME)] indicate an unemployment rate of approximately 5.5 percent. This average unemployment rate could be partially induced by the following probability transition matrix:

$$\Pi = \begin{bmatrix} 0.945 & 0.055 \\ 0.945 & 0.055 \end{bmatrix} \tag{15}$$

Using the values of this array, the average duration of the unemployment in the artificial economy becomes $(1 - 0.055)^{-1} = 1.0582$ model periods, equivalent to approximately 55 weeks, which does not exactly reflect the duration of the unemployment in Brazil.[16] However, since the analysis will be focused on the steady state, the limiting invariant measure associated to the probability transition matrix is what really matters. Furthermore, since this measure will be the same, independently of the form taken in the calibration process, the above calibrated matrix will be used for describing the stochastic process that governs the per period employment opportunities of the individual in the model economy.

The limitation associated to this procedure, however, is given by the fact that it cannot replicate the employment persistence effect. In this case, by construction, each of the probabilities $\Pi_{ij}(t+1)$, for $i, j = \{e, u\}$, does not depend on the employment situation in period t. This restriction would cause some side effects only when applied to a short run business cycle analysis, but again, the present study focuses on the steady state analysis.

16. Imrohoroglu, Imrohoroglu and Jones (1999) have alerted to the fact that this calibration procedure would overestimate the duration of the unemployment.

Another factor indirectly related to the labor market is that the effective wage of each individual could be correlated with his/her age. The hypothesis that the productivity can vary according to the individual's age is well explored in the economic literature [see Jovanovic and Nyarko (1996)], however there is no consensual conclusion about the mechanism and the direction that this relationship could occur.

The present study does not aim to explore this controversy. In fact, what the model does is to assume that there exists such a relationship without assuming any hypothesis about its sign, or, in other words, whether the wages tend to increase or decrease according to the individual's age. To calibrate this efficiency index, the data from Rais relative to 1998 was used.

The calibration procedure of the model economy is eventually complete with the above calibration of the labor market. The next step is to numerically compute the theoretically defined equilibrium and to implement alternative policy simulations, varying the replacement rate of the social security system, in order to evaluate the welfare impacts of those policies.

4 SIMULATIONS RESULTS

The objective of this section is to quantitatively assess the impact of alternative pay-as-you-go social security systems on social welfare. To this end, the implemented numerical simulations set the replacement rate policy parameter, θ, to vary from zero (0 percent) to one (100 percent).

Moreover, two alternative values for the subjective discount factor, β, were considered for simulation purposes. The first value for this parameter was chosen such that the wealth-output ratio of 2.7 could be derived for the Brazilian economy. In this first case, taking the replacement rate of the social security system between 90 percent and 100 percent, the subjective discount factor corresponds to $\beta = 1.005$. The social security system in Brazil refunds in full the wage of all the workers of the system earning up to 10 minimum wages. Taking into consideration that the average wage is approximately 5.1 minimum wages, according to the 1998 RAIS, and given the well-known high-income concentration in the country, the alternative policies were simulated by varying the replacement rate of the model's social security system, θ, between 0.9 (90 percent) and 1 (100 percent).

Alternatively, a value of $\beta = 0.96$ for the subjective discount rate was used. This value is compatible with the one used by Oliveira, Beltrão and Maniero (1997) and also with the wealth/income ratio value suggested by Ellery Jr., Gomes and Sachsida (2002).

The values for the remaining parameters were set according to the procedure described in the previous section. Thus, the labor income share in aggregate income was set to α = 0.53; the depreciation rate to δ =10 percent; the *per capita* GNP growth rate to x = 2.6 percent; the population growth rate to n = 2 percent; the risk aversion parameter to γ = 1.4285, and the mandatory retirement age to R = 57, which corresponds to 37 model periods. The probability transition matrix describing the employment opportunities was calibrated as

$$\Pi = \begin{bmatrix} 0.945 & 0.055 \\ 0.945 & 0.055 \end{bmatrix} \qquad (16)$$

The results of the first set of simulations are shown in Table 1.

The results obtained from the simulation show that, in this case, the OLG model economy with a subjective discount factor of β = 1.005 reaches its maximum welfare when there exists a pay-as-you-go system that (partially) refunds 30 percent, i.e., θ = 0.3, of the individual's working age income.[17]

TABLE 1
IMPACTS OF THE SOCIAL SECURITY SYSTEM ON WELFARE (β = 1.005)

θ	τ_s	ω	r	Aggregate Consumption	Wealth/Output	Welfare
0	0	2.31	0.0463	0.6308	3.21	−121.72
0.1	0.0153	2.28	0.0490	0.6306	3.15	−121.46
0.2	0.0307	2.23	0.0525	0.6298	3.08	−121.32
0.3	0.0461	2.19	0.0554	0.6288	3.02	−121.30
0.4	0.0615	2.16	0.0582	0.6277	2.97	−121.33
0.5	0.0769	2.12	0.0610	0.6261	2.92	−121.48
0.6	0.0923	2.09	0.0637	0.6245	2.87	−121.68
0.7	0.1076	2.06	0.0666	0.6227	2.82	−121.96
0.8	0.1230	2.03	0.0693	0.6207	2.77	−122.26
0.9	0.1384	2.01	0.0716	0.6188	2.73	−122.61
1	0.1537	1.99	0.0735	0.6173	2.70	−122.98

Another interesting result points out that welfare levels associated with all the replacement rates above 60 percent are lower than the welfare levels associated with the replacement rates derived from a pure funded system, i.e., θ = 0. This result strongly suggests that guaranteeing an integral (100 percent) income for the retirement period by means of a pay-as-you-go system does not guarantee the maximum social welfare in the presence of individual risks. In other words, at the

17. This result is similar to that found by Imrohoroglu, Imrohoroglu and Jones (1995, 1998*a* and *b*, and 1999) for the American economy and also similar to the conclusions obtained by Oliveira, Beltrão and Ferreira (1997) for the Brazilian economy.

TABLE 2
IMPACTS OF THE SOCIAL SECURITY SYSTEM ON WELFARE (β = 0.96)

θ	τ_s	ω	r	Aggregate Consumption	Wealth/Output	Welfare
0	0	1.76	0.0983	0.5934	2.38	–54.06
0.1	0.0153	1.74	0.1018	0.5890	2.32	–54.54
0.2	0.0307	1.72	0.1046	0.5860	2.29	–54.97
0.3	0.0461	1.69	0.1076	0.5827	2.26	–55.43
0.4	0.0615	1.68	0.1100	0.5802	2.23	–55.88
0.5	0.0768	1.66	0.1130	0.5766	2.20	–56.37
0.6	0.0922	1.64	0.1160	0.5733	2.17	–56.87
0.7	0.1076	1.62	0.1185	0.5704	2.14	–57.35
0.8	0.1230	1.60	0.1209	0.5677	2.12	–57.83
0.9	0.1384	1.59	0.1234	0.5650	2.10	–58.33
1	0.1537	1.57	0.1257	0.5625	2.08	–58.82

steady state equilibrium, such a system is Pareto-dominated by any other partial refund pay-as-you-go system or even by a funded system.

Table 2 shows in turn the simulation results when setting the subjective discount factor to $\beta = 0.96$.

In this case, a pure funded system, i.e., $\theta = 0$, Pareto-dominates all alternative pay-as-you-go social security systems.

Cross-comparing the results of Table 1 with those of Table 2, it is apparent that the value chosen for the subjective discount factor β is of crucial importance in order to assess the welfare effect of the social security system introduced into the OLG model economy.

One of the possible theoretical explanations to justify this high sensitivity of the results obtained to the value of β is based on the presence of dynamic inefficiency. According to this line of argument, the reduction in accumulation driven by the introduction of a pay-as-you-go system can lead to a welfare improvement. Although empirical evidences do not support the dynamic inefficiency argument for the Brazilian economy, Table 1 results, with $\beta = 1.005$, show that this calibration can better mimic the wealth/output ratio observed in the Brazilian economy (2.7) than the second set of simulations shown in Table 2. These results suggest that higher values of the subjective discount factor β could be producing some dynamic inefficiency in the OLG artificial economy.

Another possible interpretation of the high sensitivity of the results to the alternative values of β is based on the definition of the subjective discount factor itself. The smaller this factor is, the less the individual values future consumption and, therefore, the weaker are the incentives to reduce his/her present consumption to guarantee a better future income. Hence, a pay-as-you-go social security system that implies discounting on current income would not lead, in this case, to any welfare gains.

Another interesting point derived from Tables 1 and 2 is that the rate of the contribution to the social security system able to finance a full retirement benefit would be approximately 15 percent on the payroll. The average contribution to the RGPS system in the Brazilian economy amounts to a remarkably high contribution of 33 percent on the payroll (an average contribution of 22 percent on the payroll from the employers plus 11 percent from the employees), but still the RGPS shows a considerable deficit.

In particular, two possible reasons could justify such a discrepancy between the self-financing contribution rates derived from the model and the discrepancy observed in the Brazilian economy. The first reason has to do with the incorporation of typical social assistance programs into the social security account, such as the rural pension program and, until recently, the Brazilian public health care system. The second reason is the existence of retirement due to disability caused by disease or accident and the existence of early retirement (earned after fulfilling a minimal working life). These are cases that are not considered in the OLG artificial economy.

Also, the self-financing contribution rate of 15 percent of the pay-as-you-go system does not match the findings of Oliveira, Beltrão and Maniero (1997). These authors introduce into the model some additional variables, such as administrative costs, contribution and benefits caps, and age-independent retirements, that are not included in the present OLG model economy and that could lead to differences in the model's contribution rates at the steady state equilibrium.

Moreover, those divergences do not invalidate the main basic conclusion suggested in Table 1, very similar to the obtained by Oliveira, Beltrão and Ferreira (1997). Both their study and the results reported above clearly indicate that the Pareto-superior way to organize the social security in a model economy calibrated for the Brazilian economy is based on a pay-as-you-go system, with only a partial refund. Moreover, if agents in such an economy want to further increase their retirement period income, they would be better off in a pure funded system.

As a shortcoming of the present analysis, the inability to explicitly identify the analytical mechanism behind the welfare gains of the pay-as-you-go system introduced into the OLG model economy remains an open question. As discussed above, the possible dynamic inefficiency generated by the artificial model economy at hand stands as one possible transmission mechanism. This argument is strengthened by the observed alteration in the simulation results when the value of β is reduced to 0.96. An alternative explanation, according to Lannes Jr. (1999), is based on the credit constraint imposed to the agents in the model economy, for, in this case, the social security system might be correcting for this market failure, thus generating social welfare gains. Finally, the explanation can also reside in the presence of idiosyncratic shocks faced by the agents in the model economy. Jobless agents unable to contribute to their respective accounts in a funded system could be better off in a pay-as-you-go scheme, for this system could work as an insurance mechanism for them.

Dealing with the same question, Imrohoroglu, Imrohoroglu and Jones (1998*b*) elaborate a model including a fixed factor land—such that the presence of dynamic inefficiency can be avoided. Whenever agents start to accumulate too much capital, the price of the fixed factor (land) would increase, forcing them to substitute capital for land. Thus, the fixed amount of land would limit the accumulation of capital. Once the dynamic efficiency is precluded in the model economy, the results obtained are similar to those of other OLG based studies. Namely, the maximum welfare is always associated to a pure funded system.

The testing for the impacts of the introduction of this factor into an OLG model calibrated for the Brazilian economy is left as a topic for a future extension.

In summary, the simulation results obtained in this section clearly showed that the welfare maximizing social security system is characterized by a pay-as-you-go scheme with a 30 percent partial restitution in an OLG model in which agents face idiosyncratic shocks calibrated for the Brazilian economy. Moreover, the current Brazilian RGPS system, which refunds between 90 percent and 100 percent of the wage income, could be inducing a lower social welfare level compared to a possible welfare attainable through a pure funded scheme, regardless of the value assigned to the subjective discount factor β.

5 CONCLUSION

The present study discussed the welfare implications of alternative social security schemes by numerically simulating an extended OLG model calibrated for the Brazilian economy. Therefore, the analysis contributes to the line of research previously explored by Barreto and Oliveira (1995), Barreto (1997), and Lannes Jr. (1999). The present analysis extends these previous studies by assuming the presence of idiosyncratic shocks to the agents, thus allowing for a more realistic setting, while keeping the credit constraint hypothesis suggested by the later author.

The main results strongly suggest that both the welfare maximizing pay-as-you-go system, which partially refunds 30 percent of the wage income, and the system that provides full refund for the retirement period are clearly Pareto-dominated by a pure funded system in such a model economy.

For public policy purposes, this conclusion suggests that the Brazilian RGPS social security reform should not be directed towards a complete elimination of the current pay-as-you-go system, as it happened in Chile. The results obtained point out to a reform towards a pay-as-you-go scheme with a partial refund only, in which the agents would be allowed to individually add to their retirement income through/from a complementary funded system. From a welfare point of view, this arrangement seems the best among the reform alternatives.

Some possible further extensions into the model economy, in particular the use of different mortality tables for calibrating the demographic parameters and the introduction of other retirement channels (e.g., a disability retirement plan), will be left as a list of challenges for future research.

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PART III
ECONOMETRIC ANALYSIS OF CONSUMER'S EXPENDITURE SYSTEM

CHAPTER 10

AN ANALYSIS OF THE BRAZILIAN CONSUMER BEHAVIOR: A MICROECONOMETRIC STUDY BASED ON REGIONAL PRICE INDEXES AND METROPOLITAN HOUSEHOLD EXPENDITURES*

Seki Asano
Eduardo P. S. Fiuza

CHRONOLOGICAL DEVELOPMENT OF THE PAPER

The first time Prof. Seki Asano took part in JICA's mission to IPEA, in August of 1999, he delivered a speech at one of the seminars in the IPEA's seminar series and presented a paper of his authorship entitled: *Joint Allocation of Leisure and Consumption Commodities: A Japanese Extended Consumer Demand System 1979-90*. Prof. Seki Asano was in search of interesting research topics with Brazilian data and learned from Mr. Eustáquio Reis, director of DIMAC, of the existence of microdata from POF, a survey on Brazilian household expenditure, which Mr. Eustáquio Reis strongly suggested that Prof. Seki Asano use. The last wave of POF data (1995-1996) had, in fact, recently been made available. However, just as had been the case with the first wave of data (1987-1988), very little research had been done with it till then. Most of the work based on POF that was done previously had used only food expenditure data. All the previous consumer demand system estimations were based on ENDEF, as reported in Section 2 of the paper *An Analysis of the Brazilian Consumer Behavior*, including the only application of the AI Demand System, by Thomas, Strauss and Barbosa (1989).

Fiuza was invited by Mr. Eustáquio Reis to join the project because of his graduate background on panel data models, his research emphasis on microeconomic topics, and his programming skills. The benefits of participation included practical training in SAS, additional training in GAUSS, and application

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of microdata from IBGE's household surveys to nonlabor topics. With the much appreciated and invaluable help in the learning process from Viviane Silva, Paola Dias and Márcia Pimentel and the equally indispensable help from Philippe Leite, who graciously provided a previously written SAS code for the extraction of POF data for the Directorate of Social Studies, Fiuza was able to aggregate the expenditures by group for each household and tabulate demographic variables, although not before a long process of trial and error.

In the meantime, IBGE was contacted and asked to produce a special tabulation of nominal prices, so that the Regional Price Difference Index could be calculated. The ideal setting would be to get nominal prices for each metropolitan region in each of the two periods. The Broadened Price Index (IPCA) was the index selected to deflate the data, for it covered the greatest share of POF's population. The team interviewed by Fiuza at IBGE was receptive, although some difficulties to be dealt with were mentioned. First, a comprehensive set of nominal prices would require long research. These nominal prices are typically not stored in IBGE's files, since the team is concerned only with price variation. For that reason, the team would only be able to generate special tabulations with current nominal prices. This solution was feasible, as we had only to apply the cumulated variation between dates to calculate price indices for both periods. The second problem, however, was that a new IPCA weighting structure was just then replacing the old one (see Table A.1). As a consequence of this change, the IBGE dropped the August 1999 data and picked the September price data instead. Still, there were many new subitems whose prices had not yet been collected. The third problem was the fact that not only were the subitems with positive weights not the same across regions, but also the products included in each subitem were different. The solution was to select a core of comparable products in each subitem and redistribute the weights of the excluded subitems proportionally to those subitems that were included. The exclusion of subitems would take place if they were absent (zero weight) in at least one region, or if there was a lack of comparable products with other regions (after trying at least one indirect imputation across regions using pairs of comparable products).

The initial tabulations were brought to Japan in January 2000, when Fiuza joined the first mission from IPEA's side. Unfortunately, the tabulations still required improvement: the documentation on translating the classification from POF 1995-1996 to IPCA had not yet been released, the set of released prices did not account for a large enough share of the index, and it was unfeasible to include many target subitems because of this low coverage, since only subitems collected in all regions were selected. Furthermore, at that time, the only way to deflate the prices was at group level because the price variation at subitem level, before 1990, had not been entered into the IBGE's new system available on the Web, and the staff had not yet been able to locate the shelved backlog tapes.

A new set of prices was ordered to complement the initial set, and that was done with the February collection. New core price selection and recalculation of RPDI lasted from March to late April 2000. Revision of SAS codes following the provision of new documentation and oral explanations by the IBGE staff on obscure points of POF took place from late March to early June. Prof. Seki Asano then started writing two sets of GAUSS code. One to clean up outliers from the sample and another to run the fully nonlinear (but restricted) version of Almost Ideal Demand System (AIDS) with the POF 1995-1996 cross-section only—and RPDI deflated at group level. In late July Prof. Asano came to Brazil for the second time, when demographic variables and POF 1987-1988 data were added to the model, and RPDI deflated at subitem level was introduced. The latter was possible because IBGE's staff was able to locate the backlog files on subitem price variation.

To our surprise, the new runs were extremely successful, all the more when the RPDI deflated at subitem level was used. Apart from minor corrections in the program, the results remained the same until the final version. This phase of the project was a smooth and stress-free operation beyond anyone's expectation. Fiuza continued to try (for two or three months) to add external data on housemaid wage rates and fuel prices, which were not adequately treated by IBGE. He also tried to give better treatment to the seasonal part of the fruits and vegetables items. But the results did not improve by any significant amount.

The initial results were presented and discussed during Prof. Asano's second visit, at an internal seminar at IPEA in August 2000. At that time, Prof. Seki Asano was also invited to present a joint paper previously written with Prof. Takashi Fukushima: *Some Empirical Evidence on Demand System and Optimal Commodity Taxation*, published as IPEA Seminar Paper nº. 26 (August 16).

The first draft of the text was delivered when Prof. Asano came to Brazil the third time, in March 2001. It was presented at IPEA Seminar Series (Paper nº. 59) in June 2001, at the JICA-IPEA Seminar in August 2001, and at the Latin American Meeting of the Econometric Society (LAMES 2001) in Buenos Aires in July 2001.

Seizing the opportunity of Prof. Asano's visit of March 2001, Fiuza introduced the professor to Mrs. Ana Luiza Barbosa, who had attended the August 16, 2000 seminar and was interested in using the parameters of the Brazilian estimated model to perform a similar calculation of optimal commodity tax rates in Brazil. In contrast to Asano and Fukushima's paper, however, a concern on equity was added. The initial GAUSS code was written during Prof. Asano's stay and allowed only for plain commodity taxes, without transfers. New additions were performed in April and May and the first draft was delivered in time to be submitted at the LACEA V Meeting in Montevideo and the IIPF Annual Meeting in Linz, Austria. That paper is a byproduct of the paper reported herein and is due to appear shortly in a Brazilian journal.

The first draft was printed as IPEA Discussion Paper, 793 in May 2001. Comments made at the seminars were incorporated later. The main addition was the tests for homogeneity and symmetry, accounted for in August 2001, and the elasticities by quantile, included in February 2002. Asano, Barbosa and Fiuza's paper appeared as IPEA Discussion Paper, 835, which is listed among the references.

1 INTRODUCTION

This study estimates the Brazilian consumer demand system based on family expenditure data for all the consumption categories and their corresponding price indexes. The data sources for expenditures are the national expenditure surveys (referred to as *Pesquisa de Orçamentos Familiares*, or simply POF) conducted in 1986-1987 and 1995-1996 by the *Brazilian Institute of Geography and Statistics* (IBGE). The sources for price indexes are the monthly national survey of consumer prices.

Section 2 reviews previous estimations of consumer demand systems in Brazil. Section 3 introduces our model: an extension of the Almost Ideal Demand System (AIDS). Section 4 describes the data utilized. Section 5 displays the results, and Section 6 summarizes the conclusions. An Appendix describes the construction of our regional price indexes, another contribution of this work.

2 PREVIOUS STUDIES

Few studies exist on the estimation of consumer demand in Brazil. None of them used POF, but rather were based on older surveys. Moreover, only one previous work estimated price elasticities for all expenditure groups, because of the difficulty to obtain price data for the non-food groups. The methodology adopted varied widely.

The first study of which we are aware was done by Medeiros (1978), who estimated Engel elasticities for food and education in the city of São Paulo using a local Household Expenditure Survey conducted by the University of São Paulo in 1971-1972 (the survey will henceforth be referred to as POF-USP). Medeiros modeled demand with a Box-Cox transformation for both the dependent variable (expenditure on food or on education) and the explanatory variable (total expenditure), allowing for more flexibility of the functional specification. He restricted the Box-Cox parameter to be equal for both sides (estimated λ's were –0.85 for food and ranged from 0.03 to 0.14 for education, depending on whether or not additional explanatory variables are included).

National Household Expenditure Survey (*Estudo Nacional de Despesas Familiares*—ENDEF), a comprehensive survey undertaken from August 1974 to August 1975 in all metropolitan and urban areas as well as in rural areas in the southern, southeastern and northeastern regions of Brazil, was the data source for a large number of studies. Rossi (1982) modeled demand using a Lorenz curve for concentration, following Kakwani (1977*a* and *b*, and 1978), and applied it to ENDEF data from the city of Rio de Janeiro. He also compared the results with estimates obtained by a Box-Cox transformation and found them very similar, except for the tails of the income distribution, where Kakwani's method, albeit coming out in the end with unreasonable patterns, allows for more flexibility (including nonmonotonic paths). Rossi (1983*b*) retrieved these estimates and compared them with those obtained for São Paulo using POF-USP and with those obtained for all metropolitan areas using ENDEF. Box-Cox estimates are also reported for São Paulo. The sum of residuals is lower for Kakwani's method, but it is worth remarking that this is mostly due to three expenditure groups: clothing, recreation, and health care.

Hoffmann (1983 and 1988) proposed an alternative framework—a piecewise linear regression—and obtained estimates for Rio de Janeiro not far from those obtained by Rossi. Although Hoffmann's fit was better [an elementary result, since he only added more variables, as Rossi (1983*a*) points out], it is worth noting that it came at the expense of finding different break points for each commodity run. Another caveat is the omission of standard errors. Both Rossi's and Hoffmann's sets of elasticities add up to approximately one, but neither author makes use of demographic variables.

One other approach was undertaken by Rossi and Neves (1987). By transforming a logit into a linear specification and using the same explanatory variables, he was able to estimate each equation by OLS. The explanatory variables were income (total expenditure), prices and demographic variables (age of head of household, family size). In contrast to the previous articles, the estimation makes use of all the regions covered by ENDEF. The following elasticities are reported for nine income classes: income and family size. Fit is reasonably well done. Unfortunately, standard errors are also missing. He found income-inelastic demands for food, and elastic demands for transportation, education, and reading were found above one. Elasticities with respect to family size suggest that, as opposed to our results below, economies of scale are only present in food, transportation, and education, indicating that the expenditures on these items increase at the expense of the housing and other expenses category. Price elasticities are not reported.

The same approach to transform logit into OLS had been chosen by Cipriano and Brandt (1983) for agricultural products (food and tobacco). However, the authors added some original variables, such as state population, regional dummies, and an income inequality index. Income elasticity estimates, however, are suspiciously too low (probably due to the omission of other goods), and standard errors were also not reported.

Simões and Brandt (1981) ran an expanded linear expenditures system (ELES) using all expenditure categories. But they reported both price and income elasticities only for food and tobacco. Parameter estimates attained 10 percent significance. Unfortunately, additional explanatory variables were simply not listed. The adding up criterion was met.

Thomas, Strauss and Barbosa (1989) ran a generalized version of AIDS based on ENDEF data as well as on all regions covered. Because of the concern on the part of the authors regarding the use of the estimates for agricultural policymaking, the system is very disaggregate and contains some detailed food commodity items as dependent variables. However, disaggregation is limited, mainly due to the difficulty in handling nonzero expenditures, i.e., commodities which are never purchased or whose purchase was not recalled by the household during the survey. Prices are estimated indirectly by the ratio expenditure/quantity (ENDEF collected quantities of all commodities). However, in order to prevent endogeneity and minimize the effect of outliers (mainly due to measurement errors) the regional median prices are used. The system they eventually ran is the following:

$$w_i = \beta_{0i} + \beta_{1i}\ln(x^*) + \beta_{2i}[\ln(x^*)]^2 + \sum_j \gamma_{ij} . \ln(p_j) + \delta_i . \ln(n) + \\ + \sum_d \delta_{id} . (n_{id}/n) + \phi_i . z + \varepsilon_i \qquad (1)$$

where:

x^* is the total expenditure;

w_i is the share of item i in total expenditure;

p_j is the price of good j;

n is the household size;

n_{id} is the number of household members in each of the eight age groups; and

z is a vector of household characteristics: education of head of household and that of the spouse, head of household's gender dummy and the existence or not of a spouse.

Regression estimates provide not only expenditure[1] elasticities (a proxy for Engel elasticities) but also price elasticities.

Alves, Disch and Evenson (1982) estimated demand for food by running share equations in logarithmic prices (including income and squared income) within a SUR model. Prices also came from Endef itself and were also averaged on a regional basis. Both price and income elasticities were reported, and they appear to make sense. The authors note that results were better for a subset of nine geographical regions. Estimates for nonfood goods and services were harmed by lack of independent price data and a consequent untested assumption of separability from food.

3 THE MODEL

3.1 AIDS

The model used in the estimation is based on AIDS, as proposed by Deaton and Muellbauer (1980), which allows a flexible approximation to general preference structure. AIDS specifies the log expenditure function as

$$\ln e(p,v) = \alpha_0 + \sum_i \alpha_i \ln p_i + \frac{1}{2}\sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j + v\beta_0 \prod_i p_i^{\beta_i} \qquad (2)$$

where p is the price vector, v is utility, p_i is the i-th price, and α_i, β_i, γ_{ij} are the parameters. Note that one can assign arbitrary values to utility v. Deaton and Muellbauer suggested assigning zero to utility at subsistence, and one to utility at the bliss point. Then we can interpret α_0 as the log expenditure at subsistence level when all the prices are normalized at one.

The linear homogeneity of the expenditure function with respect to the price vector requires the following constraints:

1. The authors instrumented total expenditure with nonlabor income.

$$\sum_i \alpha_i = 1,\ \sum_i \beta_i = 0,\ \sum_i \gamma_{ij} = \sum_j \gamma_{ij} = 0 \tag{3}$$

We denote the number of commodity groups by M. So the summation in (3) runs through 1 to M. The share of the i-th expenditure group, w_i, is given by

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln p_j + \beta_i \ln(Y/P),\ \mathrm{i} = 1, \ldots, \mathrm{M} \tag{4}$$

where Y is the total expenditure and P is the cost of living index given by

$$\ln P = \alpha_0 + \sum_i \alpha_i \ln p_i + \frac{1}{2}\sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j \tag{5}$$

which is a nonlinear function of prices (p_j's). From (2) we can see that ln P is the log of the income required to attain subsistence utility.

The Hicks substitution matrix is given by

$$S = [S_{ij}] = [\{\gamma_{ij} + \beta_i \beta_j \ln(Y/P) - w_i \delta_{ij} + w_i w_j\} Y/(p_i p_j)] \tag{6}$$

where δ_{ij} is Kronecker's delta (δ_{ij} = 1, if $i = j$ and δ_{ij} = 0, otherwise). Note that symmetry of the substitution matrix implies symmetry of γ_{ij} ($\gamma_{ij} = \gamma_{ji}$). The negative semi-definiteness of the substitution matrix can be examined by calculating the eigenvalues of (6). Also, the expenditure elasticities are given by

$$\eta_i = 1 + \beta_i / w_i \tag{7}$$

It follows that if β_i is negative, the i-th group is a necessity, and if β_i is positive, it is a luxury.

3.2 Estimation Procedure

The model allows for taste variation due to demographic factors, such as age of the head of household, family size, education, etc. We denote these factors by Z. Then, in the context of our data structure, the model eventually used for estimation is written as

$$w_{imlt} = \alpha_i + \sum_j \gamma_{ij} \ln p_{jlt} + \beta_i \ln(Y_{lmt}/P_{lt}) + \sum_k \omega_{ik} Z_{klmt} + \varepsilon_{ilmt} \tag{8}$$

where additional subscripts l, m, and t stand for region (l = 1, ..., 11), individual or cohort in each region (m) and time period (t). The variable ε_{ilmt} is the disturbance term. Note that prices are common within the same region l and time period t, and total expenditure ($\ln Y$) and control variables Z (may) vary across l, m, and t.

The disturbance term has a variance component structure, namely, we write ε_{ilmt} as

$$\varepsilon_{ilmt} = \lambda_{it} + \upsilon_{ilmt} \tag{9}$$

where λ_{it} is the time specific factor which uniformly affects all the regions in a given year but changes over time, and υ_{ilmt}'s are other white noise random factors.

It is well known that when time effects are correlated with the explanatory variables, usual OLS and GLS estimators will be biased. If that is the case, we should correct for the bias by introducing time specific dummies, which is the so-called fixed-effect specification. We employ this specification, so that the covariance matrix of disturbance terms will have the following structure:

$$\begin{aligned} &\mathrm{Cov}(\varepsilon_{ilmt}, \varepsilon_{i'l'm't'}) = \sigma_{ii'},\ \textit{if}\ l = l',\ m = m',\ t = t' \\ &\mathrm{Cov}(\varepsilon_{ilmt}, \varepsilon_{i'l'm't'}) = 0,\ \text{otherwise} \end{aligned} \tag{10}$$

The resulting system in (8) and (9) is nonlinear in parameters, with fixed time effects. Although it is a common practice to estimate the system by replacing $\ln P$ by the Stone's index, $\ln P^* = \Sigma_i w_i \ln p_i$, and applying OLS, we estimate the system by fully nonlinear maximum likelihood.[2]

4 DATA

The data sources for expenditures are the POF surveys run in 1986-1987 and 1995-1996, which collected expenditure data for households on consumption goods and services from eleven metropolitan areas.[3] These surveys were undertaken after the implementation of two major stabilization plans in Brazil (the Cruzado Plan, in February of 1986, and the Real Plan, in July of 1994). The purpose of the surveys was to update the weighting structure of the National Consumer Price Index System (see Appendix). They were, therefore, supposed to reflect household consumption behaviors in low inflation environments. But that was the case only with the last POF survey, for the Cruzado Plan, as well as four other stabilization plans thereafter, failed, in the sense that inflation rates continued to escalate until

2. See Buse (1994 and 1998), Alston, Foster and Green (1994), and Pashardes (1993) for discussion of bias caused by this approximation. Asano (1997) is one of the few studies that estimated an AI demand system as a nonlinear system by Maximum Likelihood.

3. The metropolitan areas are: 1. Rio de Janeiro; 2. Porto Alegre; 3. Belo Horizonte; 4. Recife; 5. São Paulo; 7. Belém; 8. Fortaleza; 9. Salvador; 10. Curitiba. In addition, 6. Brasília-DF and 11. The municipality of Goiânia are also surveyed. For the sake of simplicity, we will, henceforth, call all of them metropolitan areas.

the successful Real Plan was launched. In fact, the average inflation rate during the collection period of the first POF survey (1987-1988) was 11.70 percent a month, as opposed to 1.68 percent during the second POF survey (1995-1996). The first POF survey had started in early 1987, but it was extended by six months, so as not to cover periods when supply shortages and black market premiums had resulted as a consequence of price freezes. The first six months were discarded from the period that was eventually utilized.

Monthly expenditures at the family level on various detailed commodity groups are available in the original POF survey. We aggregate them into seven broad categories: 1) Food; 2) Housing; 3) Furniture and Appliances; 4) Clothing; 5) Transportation and Communication; 6) Health and Personal Care; and 7) Personal Expenses, Education, and Reading. Corresponding price indexes were constructed for the seven categories, as described on the Appendix. The price indexes allow for comparisons both across time and across region.

4.1 Subsample Used for Estimation

The total numbers of observations in the original survey were 12,568 in 1987 and 14,551 in 1996—after selecting families with incomes between 1 and 40 minimum wages only, so as to be consistent with the population targeted by the price index. Our estimation is based on a subsample of families which satisfy the following conditions:

1. Male head of household.
2. Married head of household.
3. Family size less than or equal to eight.
4. Head of household's age greater than or equal to 18 and less than or equal to 60.
5. Spouse's age greater than or equal to 16 and less than or equal to 60.

Some of the observations are dropped from the lower and higher ends of income, total expenditure, and *per capita* expenditure distributions. Also, observations with implausible values, as well as those with missing values, are excluded. The resulting sample sizes are 6,874 in 1987 and 7,427 in 1996. Table 1 shows the number of samples dropped by screening. Table 2 shows the number of original samples retained for estimation for each region/year. Figures 1 through 4 depict the main family and household indicators for the vintiles in Brazil and in three selected metropolitan areas. We note that the level of schooling of the head of the household, the family size and the dwelling size are closely and positively correlated to income, whereas no clear pattern is detected for the age of the head of the household.

TABLE 1
SELECTION OF SAMPLE HOUSEHOLDS (EXCLUSION CRITERIA)

Criterion	Year	
	1987	1996
Total Expenditure Lowest 1 Percent	125	145
Total Expenditure Highest 1 Percent	126	146
Per capita Expenditure Lowest 2 Percent	248	291
Per capita Expenditure Highest 5 Percent	629	728
Food Share Less than 2 Percent	97	544
Transportation Negative	157	188
Income Lowest 1 Percent	125	143
Income Highest 1 Percent	126	146
Female Head of Household	2,776	3,776
Spouse not Female (Including Single)	3,587	4,831
Education of Head of Household Missing	5	28
Head of Household's Age > 60	1,710	2,479
Head of Household's Age < 18	14	22
Spouse Age > 60	580	791
Spouse Age <16 (Including no Spouse)	3,428	4,564
Family Size > 8	650	344
Single Household	643	1,068
Survivor	6,874	7,427
Original Observations	12,568	14,551

TABLE 2
NUMBER OF OBSERVATIONS, BY REGION

Region	Year	
	1987	1996
1. Rio de Janeiro	631	736
2. Porto Alegre	567	608
3. Belo Horizonte	551	696
4. Recife	664	843
5. São Paulo	816	587
6. Brasília	379	414
7. Belém	487	651
8. Fortaleza	816	931
9. Salvador	576	691
10. Curitiba	742	589
11. Goiânia	645	681

FIGURE 1
DEMOGRAPHIC VARIABLES AND DWELLINGS CHARACTERISTICS—BRAZIL

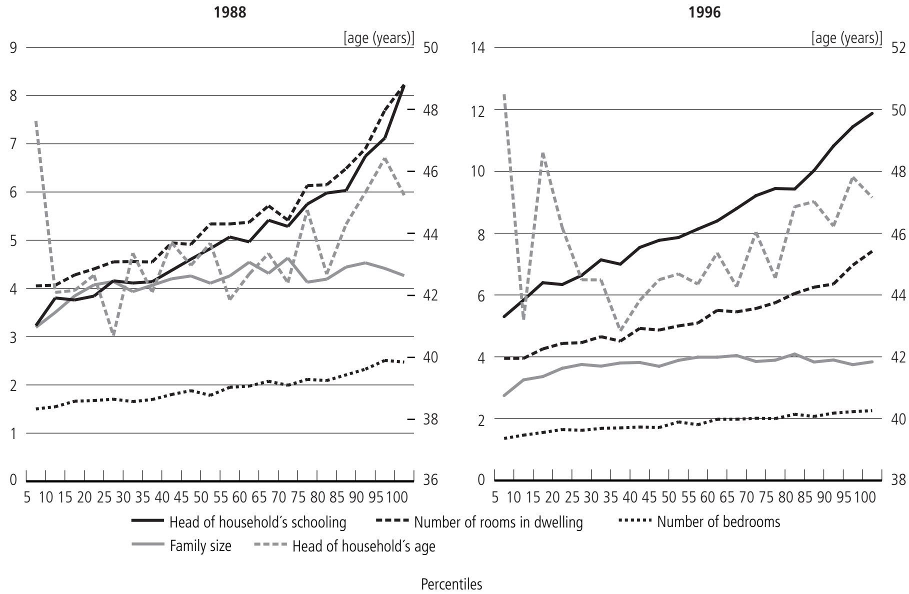


FIGURE 2
DEMOGRAPHIC VARIABLES AND DWELLINGS CHARACTERISTICS—SÃO PAULO

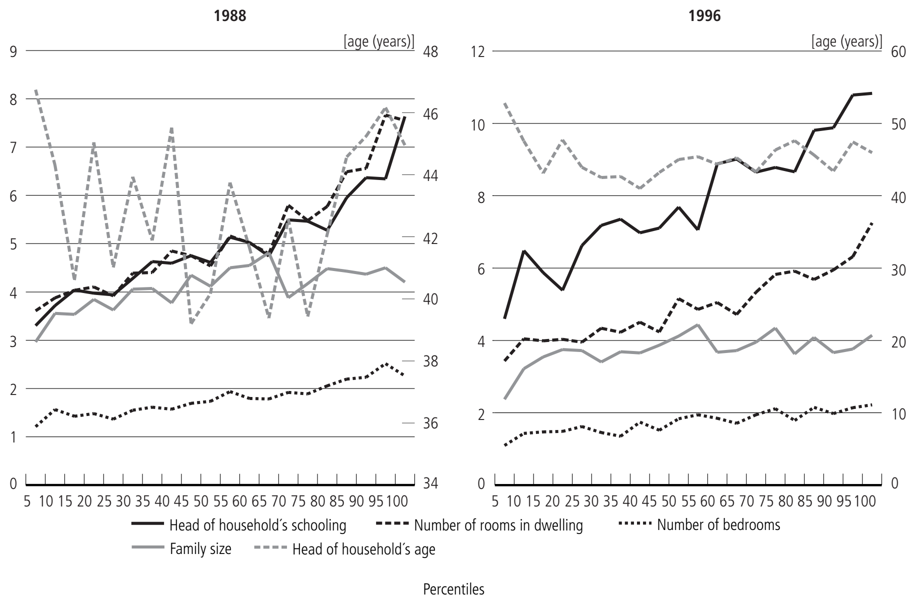


FIGURE 3
DEMOGRAPHIC VARIABLES AND DWELLINGS CHARACTERISTICS—BELO HORIZONTE

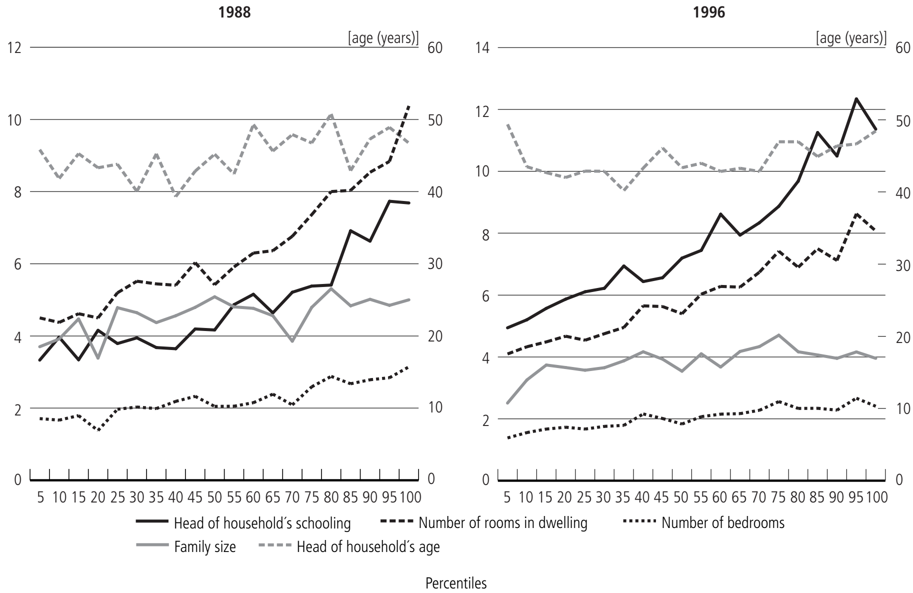
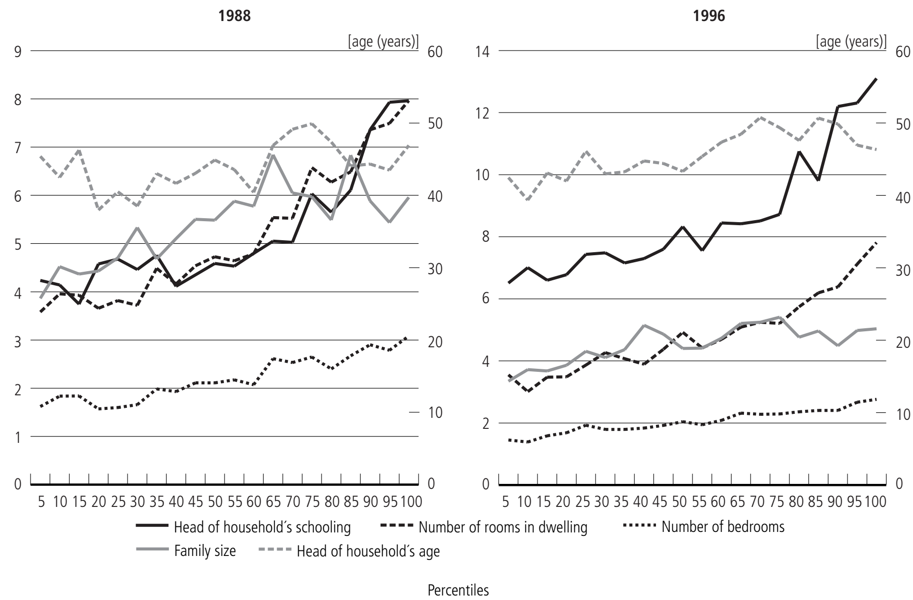


FIGURE 4
DEMOGRAPHIC VARIABLES AND DWELLINGS CHARACTERISTICS—BELÉM



4.2 Aggregation

For expenditure data, after sorting families by their per capita expenditure, we focus on a more aggregate level. Aggregation proceeds as follows: first, the original observation units (households) are sorted by per capita expenditure. Then the sample weights and family size are used to replicate the distribution of the population per capita expenditures in the given region/year. Then, the resulting distribution is divided into 20 equal sized cohorts (income quantiles) classified by magnitude of per capita expenditure. The average shares, total expenditures and demographic variables are calculated for each cohort. This grouping procedure kept estimation in a manageable order. The resulting sample size is 440 (two years, 11 regions, and 20 cohorts per region-year), which provides a sample large enough to estimate the demand system of seven expenditure categories, with high accuracy.

5 RESULTS

We estimated the parameters of the system by maximum likelihood. Although all the parameters of the system can be estimated, we found that the likelihood is very flat with respect to changes in α_0, which is the subsistence income when prices are normalized to one. To bypass this problem, we fixed the value of α_0 at 5.5, which corresponds to an annual expenditure that amounts to R$ 300 per person in 1996 (at September 1996 prices). Hence the statistical inference in this section is conditional on this assumption. The effects of changes in α_0 on price and expenditure elasticities, however, are of negligible order because of compensating changes in $\hat{\alpha}_i$'s.

5.1 Coefficients

Table 3 displays the estimates of the parameters from the restricted model in which homogeneity and symmetry constraints are imposed. In addition to prices and total expenditure, we include four explanatory variables to capture demographic factors that shift intercepts of the share equations. They are as follows: a dummy variable for the northern and northeastern regions (the poorest regions in Brazil); the age of the head of the household (husband); the years of schooling of the head of the household; and the family size.

The dummy variable for metropolitan areas in the northern and northeastern regions[4] was introduced after the first runs, when we noticed that food shares in these areas were systematically underestimated after doing all the other controls.

4. Namely: 7. Belém (north); 4. Recife; 8. Fortaleza; 9. Salvador (northeast).

TABLE 3
ESTIMATED COEFFICIENTS, RESTRICTED MODEL

	Food	Hous	Furn	Clth	Tran	Hlth	Pers Exp
Cnst	0.6768	0.2278	0.1193	0.0989	–0.0922	0.0215	–0.0520
(t-Value)	(11.51)	(5.44)	(3.57)	(2.94)	(–1.38)	(0.74)	(–1.07)
Hous	–0.0123						
(t-Value)	(–0.84)						
Furn	–0.0046	0.0008					
(t-Value)	(–0.37)	(0.12)					
Clth	–0.0153	0.0052	–0.0027				
(t-Value)	(–0.69)	(0.52)	(–0.37)				
Tran	0.0393	–0.0053	–0.0123	0.0162			
(t-Value)	(1.82)	(–0.44)	(–1.23)	(1.30)			
Hlth	–0.0149	0.0163	–0.0006	–0.0060	0.0001		
(t-Value)	(–0.75)	(1.92)	(–0.09)	(–0.23)	(0.01)		
Pers Exp	–0.0040	–0.0135	0.0049	0.0140	–0.0008	0.0120	
(t-Value)	(–0.24)	(–1.59)	(0.75)	(1.25)	(–0.07)	(1.21)	
Lny	–0.0894	–0.0258	0.0205	0.0115	0.0499	0.0077	0.0255
(t-Value)	(–9.38)	(–3.88)	(3.85)	(2.08)	(4.71)	(1.64)	(3.35)
D_NE	**0.0593**	**–0.0362**	0.0046	0.0020	**–0.0199**	–0.0045	–0.0054
(t-Value)	(9.75)	**(–8.42)**	(1.34)	(0.58)	**(–2.91)**	(–1.51)	(–1.08)
Age_H	0.0020	–0.0005	–0.0014	–0.0008	0.0006	0.0002	–0.0001
(t-Value)	(1.50)	(–0.57)	(–1.82)	(–1.03)	(0.39)	(0.37)	(–0.14)
Edu_h	–0.0060	0.0033	**–0.0093**	–0.0030	0.0058	0.0012	**0.0079**
(t-Value)	(–1.70)	(1.32)	**(–4.67)**	(–1.44)	(1.48)	(0.68)	**(2.81)**
F_siz	**–0.0177**	–0.0003	–0.0000	0.0032	0.0018	0.0043	0.0088
(t-Value)	**(–2.40)**	(–0.06)	(–0.01)	(0.75)	(0.22)	(1.17)	(1.46)

Indeed the coefficients of this dummy variable in the demand equations for food, housing, and transportation proved statistically significant. They are negative for housing and transportation, probably capturing omitted variables mentioned in the Appendix. For example, available prices do not make distinctions of apartment sizes nor commuting distance. Therefore, as these areas are smaller, commuting distances are shorter and apartments are bigger, so both the expenses on public transportation, parking, etc., and the price per square meter of housing are much lower than in bigger areas. The positive coefficient for food is more difficult to explain, although several hypotheses come to mind: measurement error in consumption *versus* income (poorer families might spend or report to spend more on food during data collection out of shame for their ordinarily low levels); measurement error on prices; existence of self-consumption in rural enclaves; and other omitted variables (differences in taste, absence of leisure options, etc.).

The age of the head of the household did not prove significant, but the number of years of schooling did have an impact on furnishings and personal expenses: furnishings is negative (perhaps because the less educated spend more on durable goods, such as appliances, at the time of stabilization plans); personal expenses are positive (families whose heads of household are more educated tend to invest more in education and reading, for example).

Last but not least, the coefficient for family size turns out to be significant and meaningful, for the *per capita* expenditures on food are lower when the family size is larger. This is evidence of scale economies in the household meal production function.

5.2 Elasticities

It is rather hard to evaluate results based upon the original parameters. Thus, we examine results based upon the estimates of the price and expenditure elasticities. As shown in Section 2, these elasticities are highly nonlinear in parameters, and they depend on the values of prices and on the total expenditure at which they are evaluated. For both the 1987-1988 and 1995-1996 surveys, elasticities are evaluated at sample mean values of prices and total expenditure. The standard errors for elasticities are obtained by applying Rao's (1973) δ-method.[5] Table 4 presents estimates of elasticities for 1986-1987, and Table 5 shows those for 1995-1996. Fitted shares are plotted along with observed shares on Figures 5 through 15 for all metropolitan areas.

TABLE 4
EXPENDITURE AND PRICE ELASTICITIES, RESTRICTED MODEL—1987

Eigenvalues	–0.239	–0.170	–0.128	–0.099	–0.081	–0.073	0.000
Expenditure	Food	Hous	Furn	Clth	Tran	Hlth	Pers Exp
Shares	0.356	0.102	0.093	0.146	0.118	0.089	0.095
Elasticity	0.749	0.746	1.220	1.079	1.423	1.087	1.267
(Standard Error)	(0.033)	(0.080)	(0.052)	(0.037)	(0.077)	(0.053)	(0.073)
Price Elasticities	Food	Hous	Furn	Clth	Tran	Hlth	Pers Exp
Food	**–0.531**	0.090	0.062	0.093	0.183	0.040	0.061
(t-Value)	**(–4.901)**	–2.344	–1.850	–1.697	–3.142	(0.828)	–1.431
Hous	0.317	**–0.787**	0.082	0.187	0.020	0.241	–0.060
(t-Value)	–2.101	**(–8.066)**	–1.255	–1.604	(0.170)	–2.630	(–0.605)
Furn	0.237	0.090	**–0.735**	0.126	0.025	0.089	0.168
(t-Value)	–1.903	–1.382	**(–8.643)**	–1.546	(0.251)	–1.263	–2.570
Clth	0.227	0.130	0.080	**–0.929**	0.243	0.050	0.198
(t-Value)	–1.721	–2.212	–1.704	**(–5.081)**	–2.947	(0.310)	–3.339
Tran	0.554	0.018	0.020	0.301	**–1.121**	0.101	0.127
(t-Value)	–3.175	(0.172)	(0.250)	–2.662	**(–5.363)**	–1.127	–1.255
Hlth	0.161	0.277	0.093	0.083	0.134	**–0.986**	0.238
(t-Value)	(0.768)	–3.596	–1.244	(0.281)	–1.076	**(–3.132)**	–2.510
Pers Exp	0.229	–0.064	0.164	0.304	0.157	0.221	**–1.012**
(t-Value)	–1.332	(–0.598)	–2.197	–2.066	–1.155	–1.976	**(–7.492)**

5. See Deaton (1997, p.128-129) for a concise description of the δ-method.

TABLE 5
EXPENDITURE AND PRICE ELASTICITIES, RESTRICTED MODEL—1996

Eigenvalues	–0.262	–0.181	–0.128	–0.106	–0.071	–0.050	0.000
Expenditure	Food	Hous	Furn	Clth	Tran	Hlth	Pers Exp
Shares	0.311	0.142	0.065	0.063	0.185	0.080	0.156
Elasticity	0.712	0.818	1.316	1.184	1.270	1.097	1.164
(Standard Error)	(0.030)	(0.043)	(0.104)	(0.122)	(0.069)	(0.068)	(0.055)
Price Elasticities	Food	Hous	Furn	Clth	Tran	Hlth	Pers Exp
Food	**–0.558**	0.129	0.029	0.002	0.259	0.024	0.116
(t-Value)	**(–4.284)**	–2.622	(0.723)	(0.019)	–3.841	(0.322)	–2.131
Hous	0.283	**–0.778**	0.057	0.092	0.114	0.189	0.043
(t-Value)	–3.131	**(–11.539)**	–1.428	–1.682	–1.496	–3.715	(0.877)
Furn	0.137	0.124	**–0.688**	0.034	0.053	0.080	0.260
(t-Value)	(0.726)	–1.270	**(–6.332)**	(0.294)	(0.335)	(0.783)	–2.369
Clth	0.008	0.208	0.036	**–1.112**	0.475	–0.010	0.396
(t-Value)	(0.019)	–1.146	(0.293)	**(–1.932)**	–2.150	(–0.026)	–1.546
Tran	0.435	0.087	0.019	0.162	**–0.967**	0.087	0.176
(t-Value)	–3.819	–1.368	(0.336)	–2.361	**(–6.747)**	–1.380	–2.506
Hlth	0.092	0.337	0.065	–0.008	0.203	**–1.004**	0.315
(t-Value)	(0.343)	–2.423	(0.830)	(–0.026)	–1.556	**(–3.581)**	–2.088
Pers Exp	0.232	0.040	0.109	0.160	0.209	0.161	**–0.910**
(t-Value)	–2.445	(0.872)	–2.841	–2.996	–2.825	–3.047	**(–13.653)**

FIGURE 5
OBSERVED *VERSUS* FITTED EXPENDITURE SHARES PER GROUP—RIO DE JANEIRO

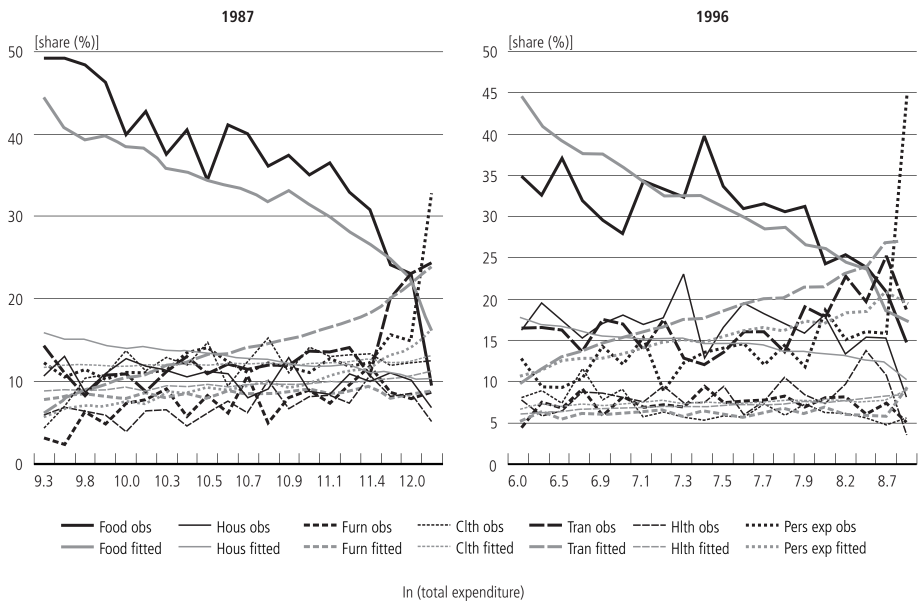


FIGURE 6
OBSERVED *VERSUS* FITTED EXPENDITURE SHARES PER GROUP—PORTO ALEGRE

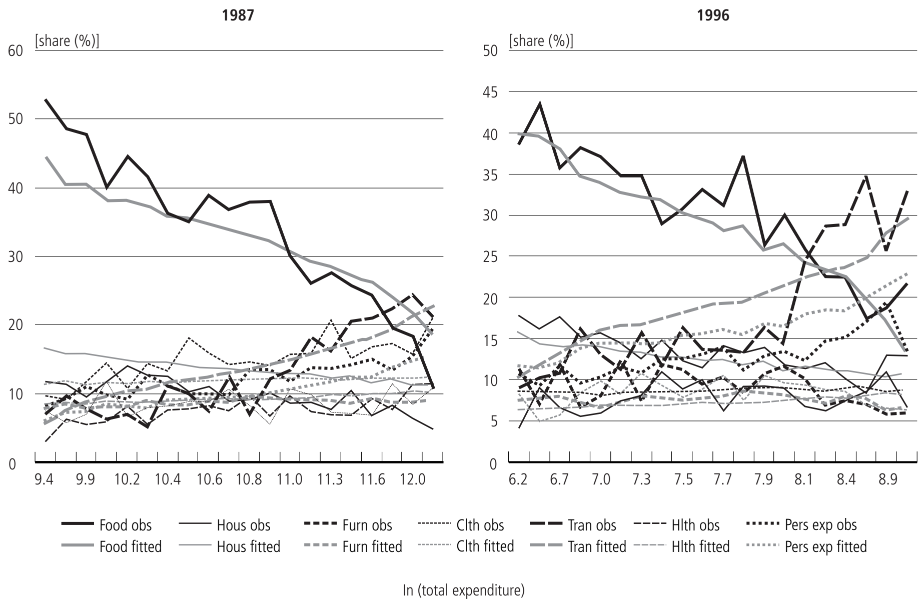


FIGURE 7
OBSERVED *VERSUS* FITTED EXPENDITURE SHARES PER GROUP—BELO HORIZONTE

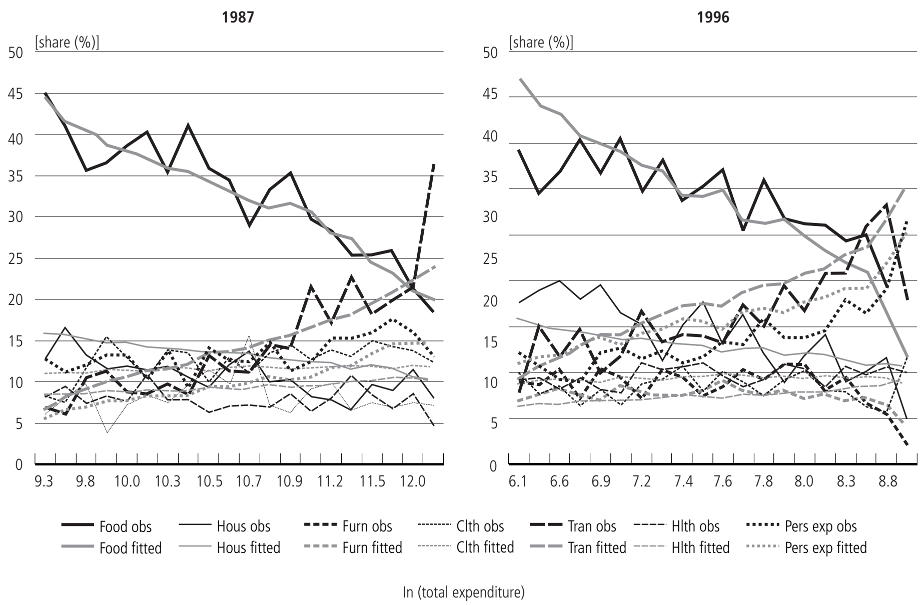


FIGURE 8
OBSERVED *VERSUS* FITTED EXPENDITURE SHARES PER GROUP—RECIFE

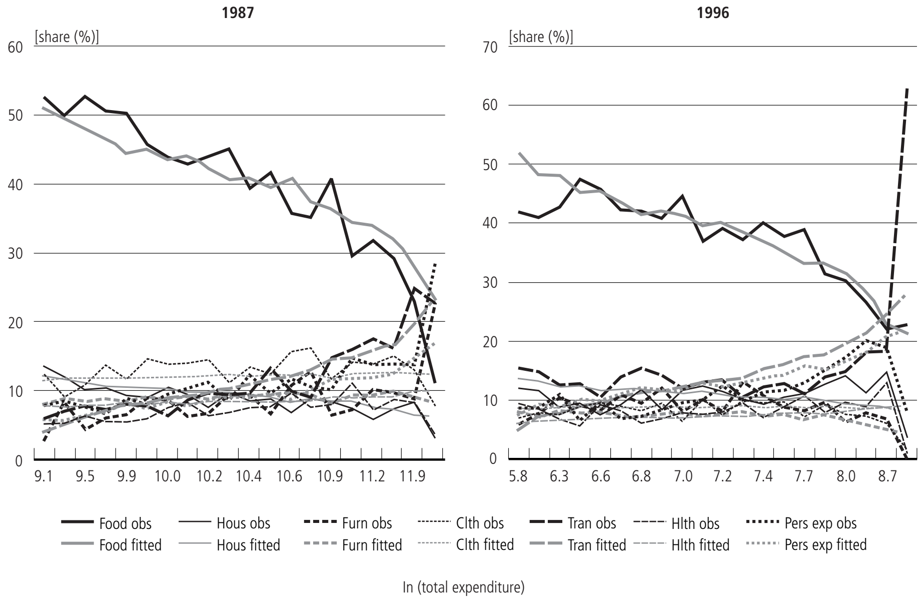


FIGURE 9
OBSERVED *VERSUS* FITTED EXPENDITURE SHARES PER GROUP—SÃO PAULO

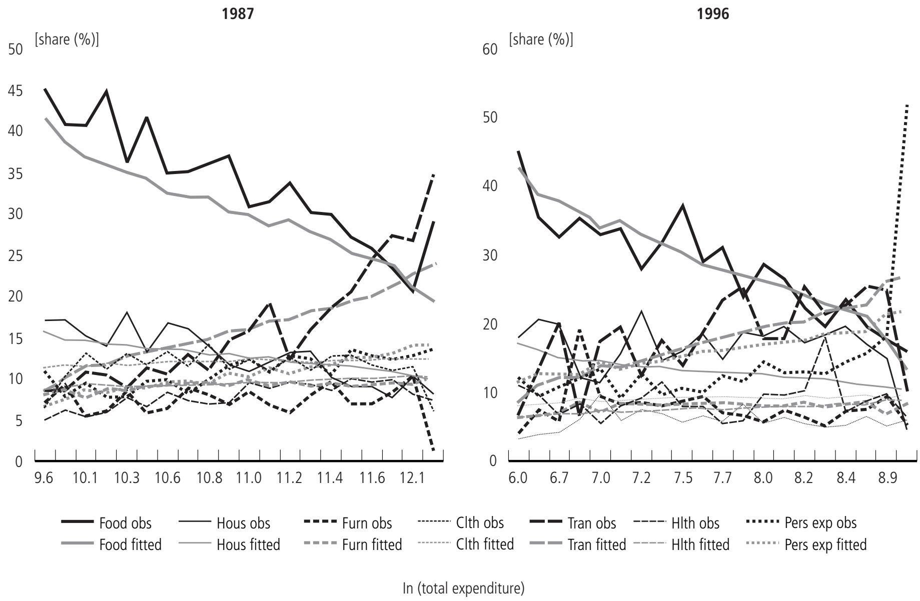


FIGURE 10
OBSERVED *VERSUS* FITTED EXPENDITURE SHARES PER GROUP—BRASÍLIA

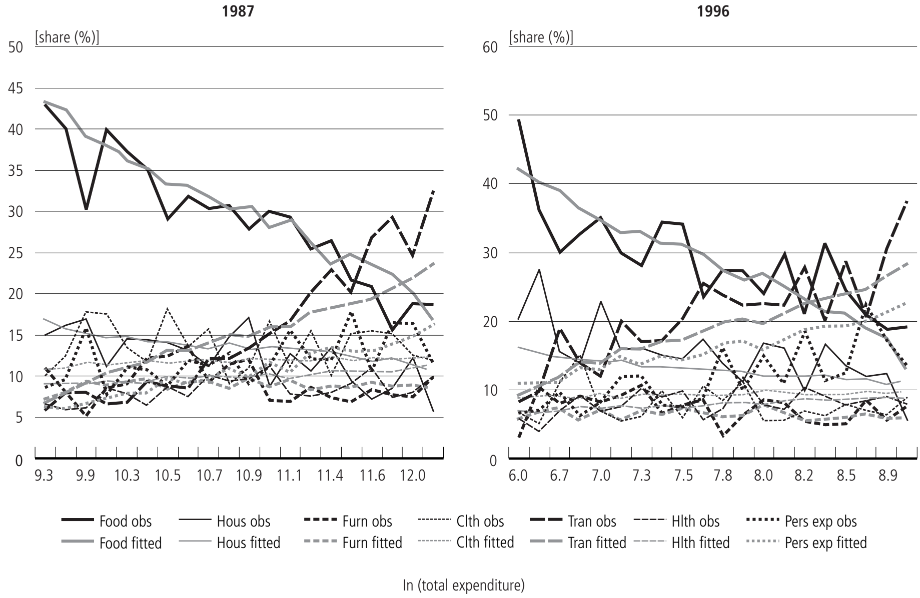


FIGURE 11
OBSERVED *VERSUS* FITTED EXPENDITURE SHARES PER GROUP—BELÉM

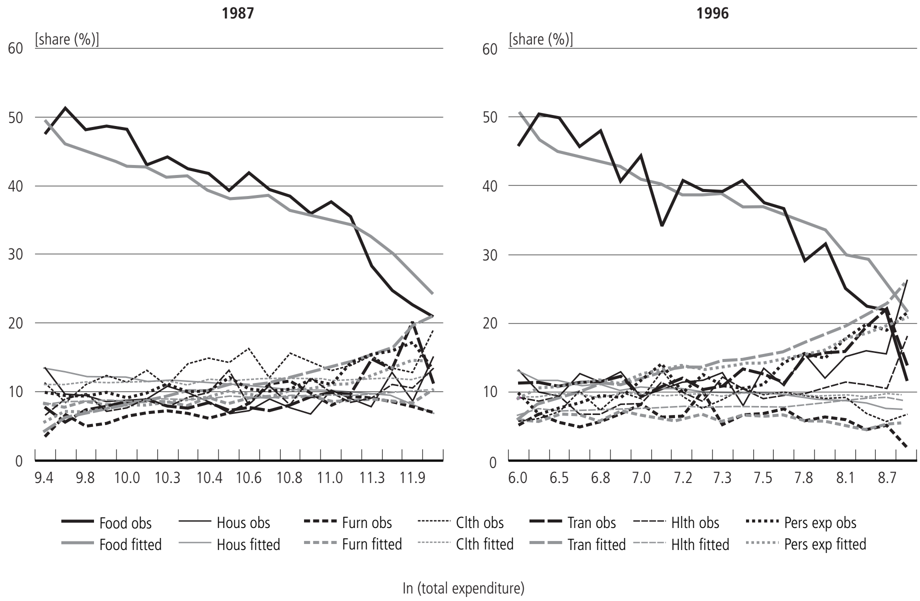


FIGURE 12
OBSERVED *VERSUS* FITTED EXPENDITURE SHARES PER GROUP—FORTALEZA

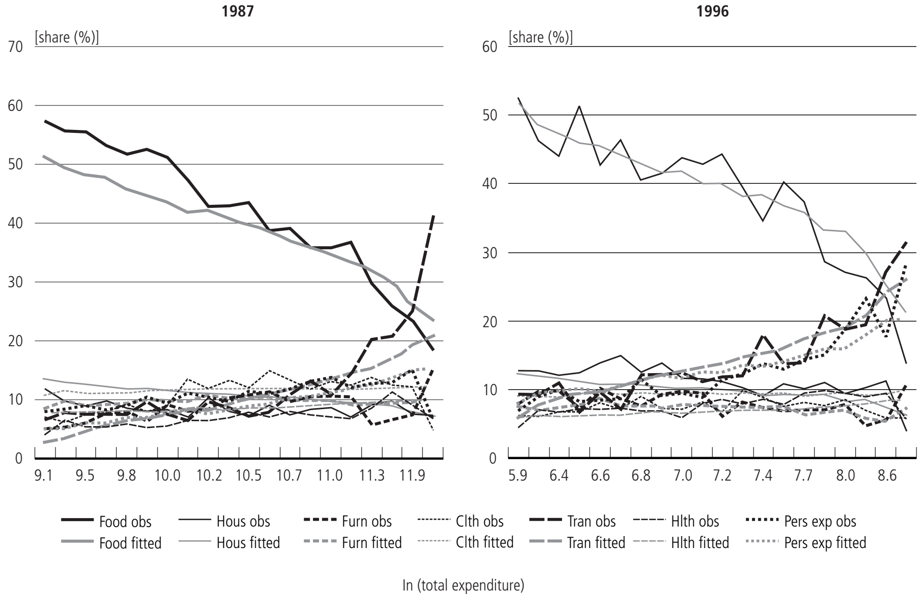


FIGURE 13
OBSERVED *VERSUS* FITTED EXPENDITURE SHARES PER GROUP—SALVADOR

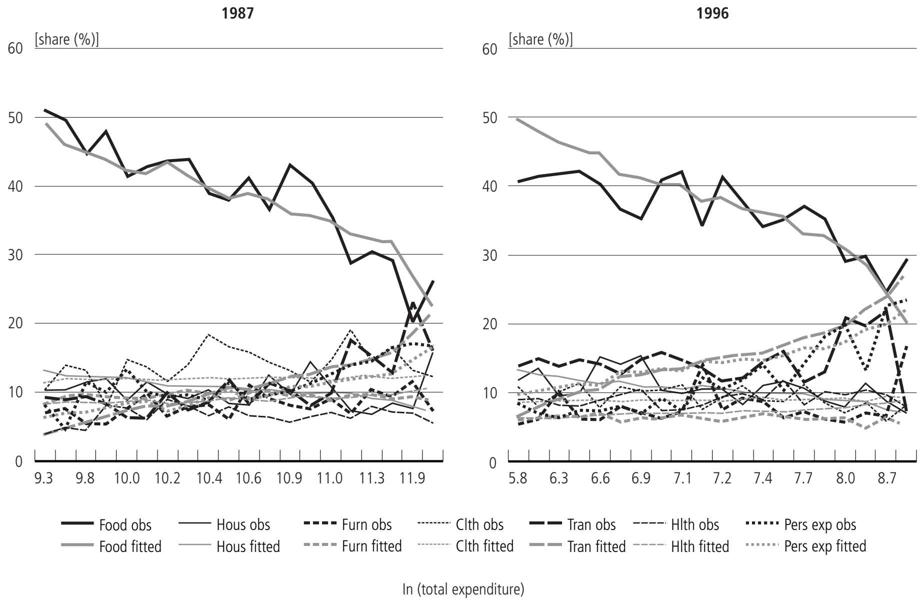


FIGURE 14
OBSERVED *VERSUS* FITTED EXPENDITURE SHARES PER GROUP—CURITIBA

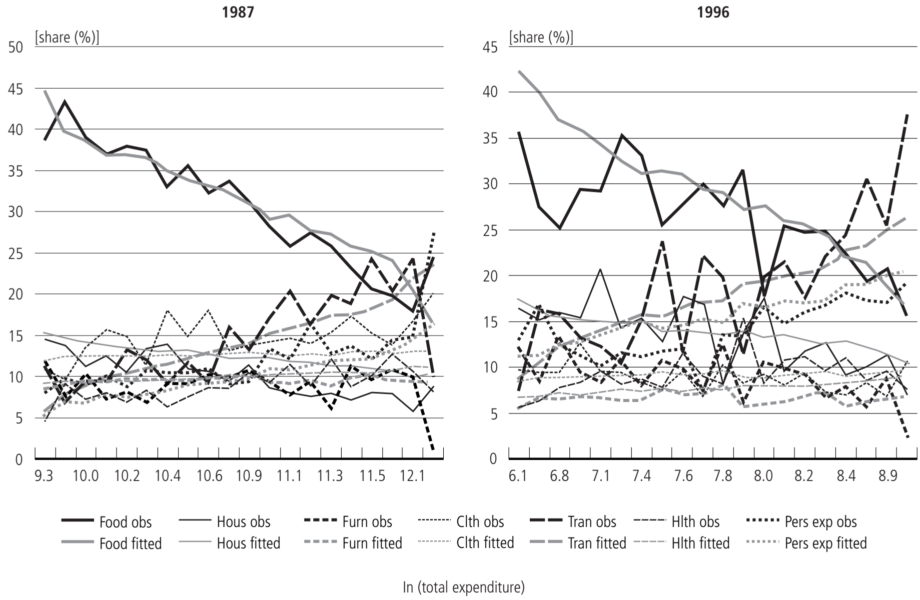
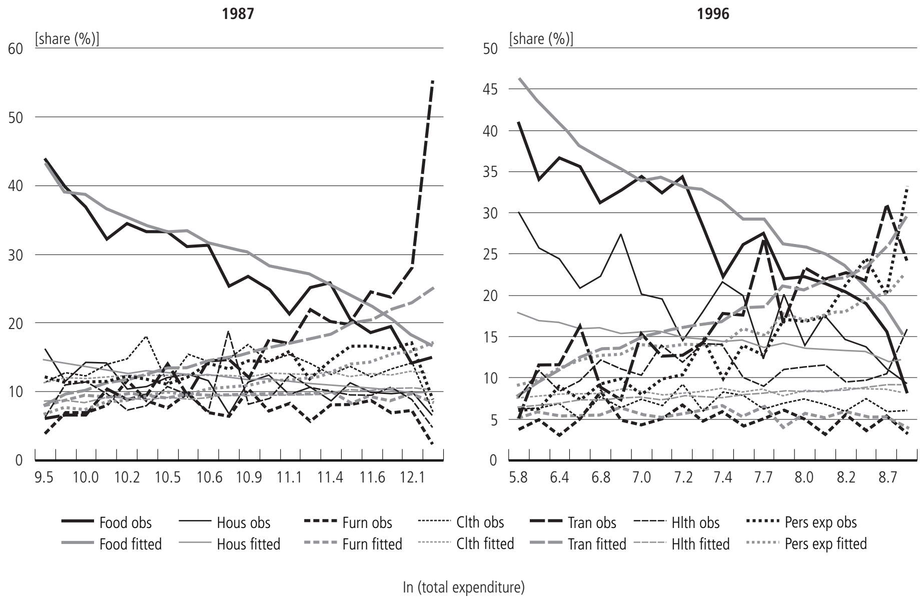


FIGURE 15
OBSERVED *VERSUS* FITTED EXPENDITURE SHARES PER GROUP—GOIÂNIA



The first rows of Tables 4 and 5 show the eigenvalues of the substitution matrix. All the eigenvalues are negative, as expected theoretically. Thus, negativity, i.e., gross substitution, is supported by our data. This is rare in demand studies. In addition, homogeneity and symmetry are supported by comfortable margin (see Tables 6 through 8—we ran the unrestricted model and performed a likelihood

TABLE 6
ESTIMATED COEFFICIENTS, UNRESTRICTED MODEL

	Food	Hous	Furn	Clth	Tran	Hlth
Cnst	0.6682	0.2313	0.1201	0.1029	–0.0919	0.0224
(t-Value)	(11.65)	(5.65)	(3.62)	(3.11)	(–1.37)	(0.78)
Food	–0.1311	0.1234	–0.0215	0.0236	0.0369	0.0076
(t-Value)	(–1.93)	(2.65)	(–0.56)	(0.61)	(0.49)	(0.23)
Hous	–0.0110	–0.0249	0.0047	0.0045	–0.0017	0.0149
(t-Value)	(–0.48)	(–1.50)	(0.35)	(0.34)	(–0.06)	(1.29)
Furn	–0.0098	0.0037	0.0127	–0.0043	–0.0054	–0.0025
(t-Value)	(–0.69)	(0.37)	(1.56)	(–0.53)	(–0.33)	(–0.35)
Clth	–0.1234	0.1424	–0.0303	0.0355	0.0507	0.0304
(t-Value)	(–1.34)	(2.19)	(–0.57)	(0.67)	(0.48)	(0.66)
Tran	–0.0324	0.0170	–0.0095	0.0539	–0.0108	0.0144
(T-Value)	(–0.93)	(0.71)	(–0.47)	(2.72)	(–0.28)	(0.83)
Hlth	0.0417	–0.1351	0.0507	–0.0029	–0.0028	–0.0264
(t-Value)	(0.57)	(–2.58)	(1.20)	(–0.07)	(–0.03)	(–0.72)
Pers Exp	–0.0107	–0.0629	0.0178	0.0252	0.0123	0.0114
(t-Value)	(–0.41)	(–3.33)	(1.17)	(1.66)	(0.40)	(0.87)
lny	–0.0886	–0.0239	0.0194	0.0088	0.0466	0.0073
(t-Value)	(–9.32)	(–3.49)	(3.50)	(1.60)	(4.19)	(1.53)
D_NE	**0.0580**	**–0.0359**	0.0051	0.0018	**–0.0200**	–0.0048
(t-Value)	**(9.48)**	**(–8.37)**	(1.46)	(0.51)	(–2.85)	(–1.60)
Age_h	0.0013	–0.0003	–0.0014	–0.0004	0.0010	0.0004
(t-Value)	(0.97)	(–0.28)	(–1.83)	(–0.45)	(0.64)	(0.62)
Edu_h	–0.0045	0.0017	**–0.0087**	–0.0027	0.0066	0.0010
(t-Value)	(–1.29)	(0.66)	**(–4.20)**	(–1.32)	(1.59)	(0.57)
F_siz	–0.0116	–0.0024	0.0001	0.0002	–0.0007	0.0031
(t-Value)	(–1.55)	(–0.45)	(0.02)	(0.04)	(–0.08)	(0.82)
Homogeneity	–0.2769	0.0637	0.0246	0.1355	0.0791	0.0499
(Standard Error)	(0.1008)	(0.1315)	(0.0758)	(0.1447)	(0.1014)	(0.1108)
Symmetry (Absolute Difference of $\gamma_{ij} - \gamma_{ji}$)						
	Hous	Furn	Clth	Tran	Hlth	Pers Exp
Food	0.1345					
Hous	0.0116	0.0010				
Furn	0.1470	0.1379	0.0260			
Clth	0.0694	0.0187	0.0040	0.0032		
Tran	0.0340	0.1500	0.0532	0.0333	0.0172	
Hlth	0.0283	0.0764	0.0122	0.1304	0.0448	0.0634

TABLE 7
EXPENDITURE AND PRICE ELASTICITIES, UNRESTRICTED MODEL—1987

Eigenvalues	–0.245	–0.16	–0.145	–0.095	–0.082	–0.066	0
Expenditure	Food	Hous	Furn	Clth	Tran	Hlth	Pers Exp
Shares	0.349	0.104	0.082	0.131	0.135	0.079	0.12
Elasticity	0.744	0.751	1.251	1.088	1.369	1.097	1.212
(Standard Error)	–0.034	–0.078	–0.059	–0.042	–0.068	–0.06	–0.058
Price Elasticities	Food	Hous	Furn	Clth	Tran	Hlth	Pers Exp
Food	**–0.536**	0.092	0.050	0.076	0.202	0.030	0.086
(T-Value)	**(–4.841)**	(2.336)	(1.454)	(1.364)	(3.390)	(0.601)	(1.948)
Hous	0.310	**–0.788**	0.071	0.171	0.039	0.229	–0.033
(T-Value)	(2.091)	**(–8.193)**	(1.099)	(1.488)	(0.334)	(2.535)	(–0.334)
Furn	0.213	0.090	**–0.722**	0.108	0.029	0.079	0.203
(T-Value)	(1.491)	(1.207)	**(–7.296)**	(1.168)	(0.254)	(0.997)	(2.727)
Clth	0.204	0.136	0.067	**–0.953**	0.275	0.036	0.235
(T-Value)	(1.379)	(2.050)	(1.266)	**(–4.638)**	(2.944)	(0.197)	(3.573)
Tran	0.522	0.030	0.018	0.266	**–1.073**	0.09	0.148
(T-Value)	(3.434)	(0.342)	(0.252)	(2.707)	**(–5.882)**	(1.148)	(1.672)
Hlth	0.131	0.299	0.082	0.06	0.153	**–1.004**	0.280
(T-Value)	(0.567)	(3.577)	(0.979)	(0.184)	(1.105)	**(–2.857)**	(2.721)
Pers Exp	0.248	–0.028	0.138	0.256	0.166	0.185	**–0.965**
(T-Value)	(1.777)	(–0.333)	(2.311)	(2.16)	(1.523)	(1.980)	**(–8.986)**

TABLE 8
EXPENDITURE AND PRICE ELASTICITIES, UNRESTRICTED MODEL—1996

Eigenvalues	–0.254	–0.164	–0.124	–0.115	–0.083	–0.062	0
Expenditure	Food	Hous	Furn	Clth	Tran	Hlth	Pers Exp
Shares	0.318	0.14	0.077	0.078	0.167	0.089	0.131
Elasticity	0.719	0.815	1.268	1.147	1.298	1.087	1.195
(Standard Error)	–0.029	–0.043	–0.085	–0.091	–0.077	–0.06	–0.067
Price Elasticities	Food	Hous	Furn	Clth	Tran	Hlth	Pers Exp
Food	**–0.554**	0.128	0.041	0.019	0.240	0.034	0.092
(T-Value)	**(–4.345)**	(2.645)	(1.060)	(0.229)	(3.640)	(0.474)	(1.729)
Hous	0.290	**–0.779**	0.068	0.108	0.096	0.200	0.017
(T-Value)	(3.161)	**(–11.375)**	(1.692)	(1.943)	(1.239)	(3.862)	(0.343)
Furn	0.171	0.125	**–0.714**	0.054	0.056	0.089	0.219
(T-Value)	(1.062)	(1.493)	**(–7.604)**	(0.544)	(0.414)	(1.021)	(2.362)
Clth	0.075	0.193	0.053	**–1.062**	0.401	0.017	0.323
(T-Value)	(0.236)	(1.341)	(0.541)	**(–2.328)**	(2.328)	(0.051)	(1.660)
Tran	0.456	0.080	0.026	0.188	**–1.000**	0.098	0.154
(T-Value)	(3.637)	(1.145)	(0.416)	(2.517)	**(–6.328)**	(1.412)	(1.989)
Hlth	0.122	0.315	0.077	0.015	0.184	**–0.986**	0.274
(T-Value)	(0.518)	(2.614)	(1.095)	(0.053)	(1.577)	**(–3.929)**	(2.081)
Pers Exp	0.224	0.018	0.128	0.194	0.197	0.186	**–0.947**
(T-Value)	(1.954)	(0.342)	(2.806)	(2.983)	(2.216)	(2.821)	**(–11.891)**

ratio test[6]). Another way of reading these results is to look at the elasticity matrix: diagonal elements (own-price elasticities) are negative, and off-diagonal elements (cross-price elasticities) are positive. The categories are substitutes of each other. The standard errors reported are also remarkably low, showing that our estimates are quite reliable.

Total expenditure elasticities (a proxy for income elasticities) indicate that food and housing are the only necessities in Brazilian utility functions, whereas furnishings, clothing, transportation, health care and personal expenses are found to be luxuries. All the own-price elasticities are significantly negative. Among them, those for food, housing and furnishings are significantly less than one (own-price inelastic), while clothing, transportation and communication, health care and personal expenses display own-price elasticities around one. Toiletry items and cosmetics are products whose effects may be having an important influence in rendering elastic the demand for Health and Personal Care,[7] and private motor vehicles may be rendering elastic the demand for transportation.

It is also worth noting that the elasticity estimates varied modestly (and the variations were not always statistically significant) between 1987 and 1996, in spite of the multitude of stabilization attempts during this period. High inflation rates, like those recorded in the 1980s and early 1990s, should give rise to a high degree of price dispersion; consumers would lose track of "fair" relative prices and would be expected to be less price-elastic for this reason. Yet, price elasticities are significantly lower in 1996 for furnishings, transportation and communication, and personal expenses, while the only significant rise detected was for clothing (would it be due to income increase?). Movements of income elasticities are more ambiguous and none was significantly different from zero.

Comparing contemporaneous elasticities for different income quantiles (see Figures 16 through 21, selected regions), we also find that they do not vary much across quantiles or along time, except for transportation (own-price elasticity) and food and transportation (expenditure elasticity). They appear, therefore, as the most paradigmatic examples of necessities and luxuries in our demand system.

6. We tested the joint hypothesis of homogeneity and symmetry, for which the number of restrictions is 27. They are the sum of six (for homogeneity) and 21 (number of pairs of off-diagonal elements in g_{ij}'s). The log likelihood ratio test statistic is 68. The 5 percent critical value of the Chi-square distribution (d.f. 27) is 40.11. This implies rejection of the null in the classical test. However, for tests in large samples such as ours, it is preferable to use the critical value given by $q$xln(n), where q is the number of restrictions, and n is the number of observations [Deaton (1997, p.131)]. In our case the critical value is 27xln440 = 164.3.

7. In fact, Andrade and Lisboa's (2001) tabulations of a recent supplement on health expenditures run by IBGE along with PNAD's (an annual household survey) 1998 edition suggest that expenditure shares on health care are *higher* for the *lower-income* deciles.

FIGURE 16
ESTIMATED OWN-PRICE ELASTICITIES BY QUANTILE—RIO DE JANEIRO

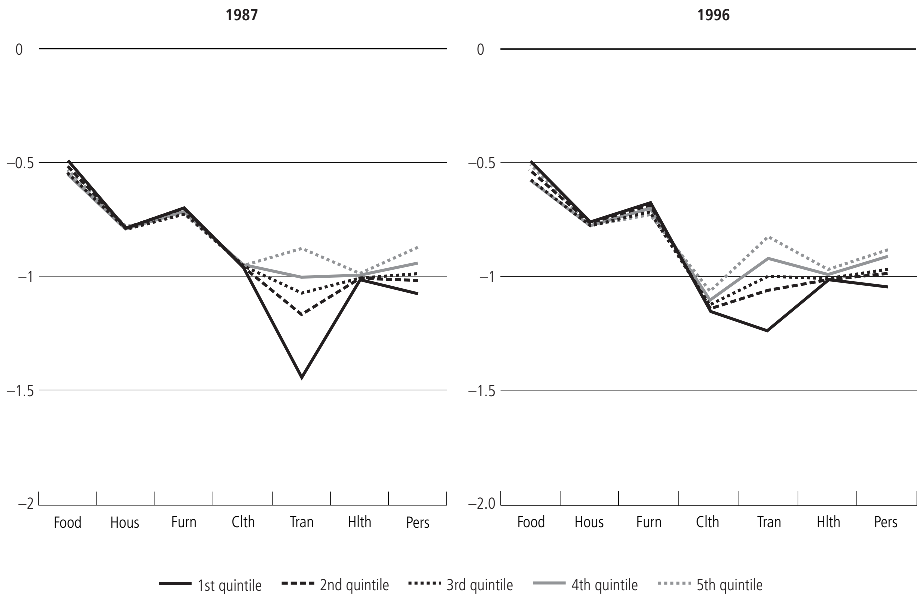


FIGURE 17
ESTIMATED OWN-PRICE ELASTICITIES BY QUANTILE—SÃO PAULO

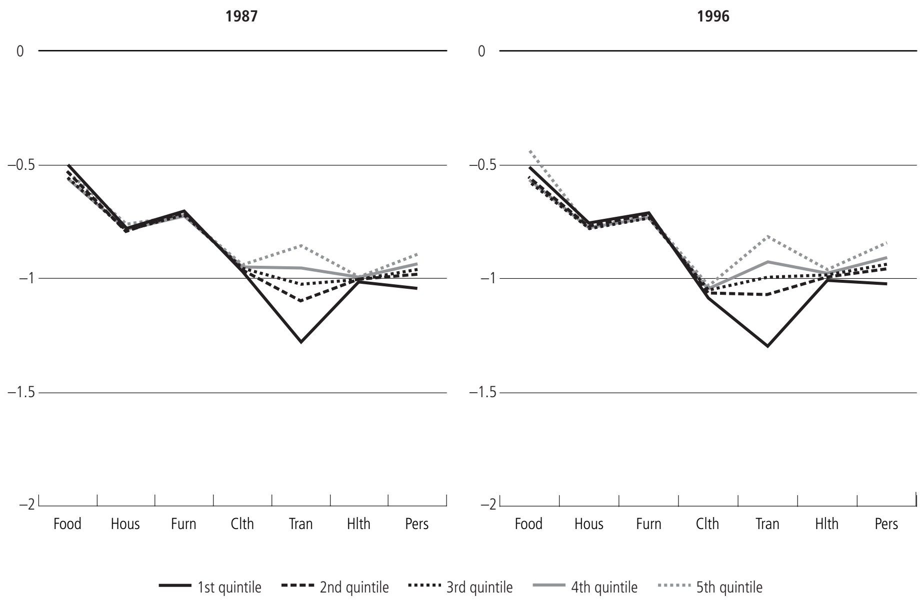


FIGURE 18
ESTIMATED OWN-PRICE ELASTICITIES BY QUANTILE—SALVADOR

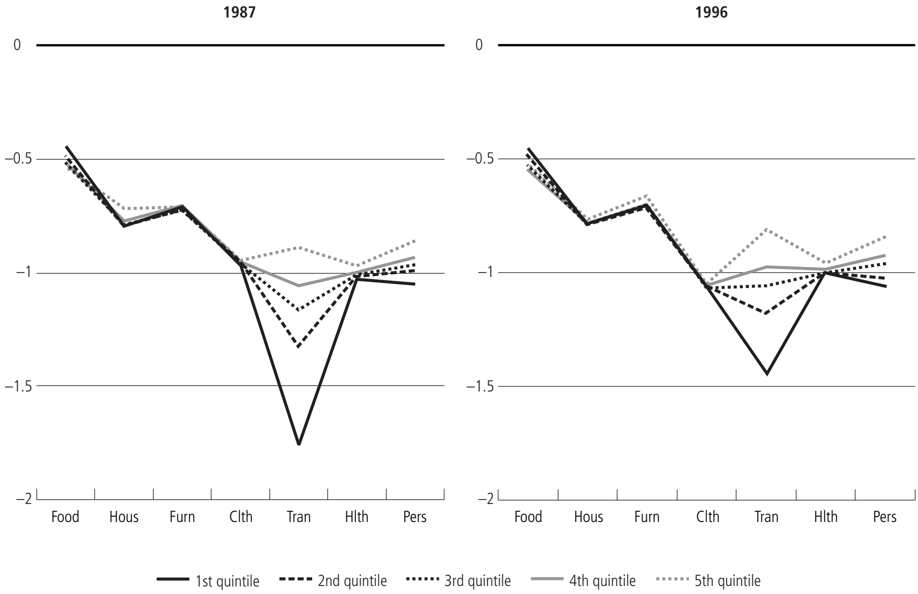


FIGURE 19
ESTIMATED EXPENDITURE ELASTICITIES BY QUANTILE—RIO DE JANEIRO

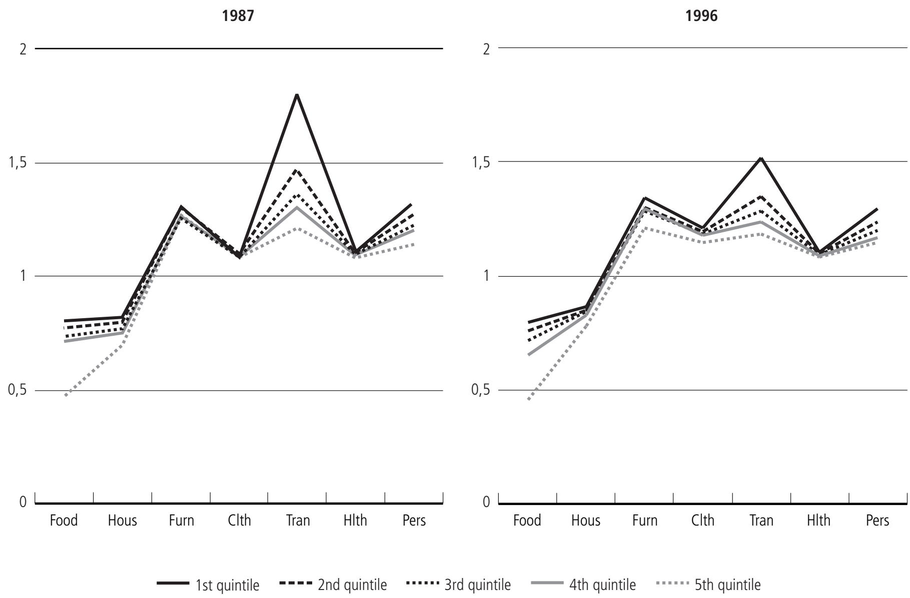


FIGURE 20
ESTIMATED EXPENDITURE ELASTICITIES BY QUANTILE—SÃO PAULO

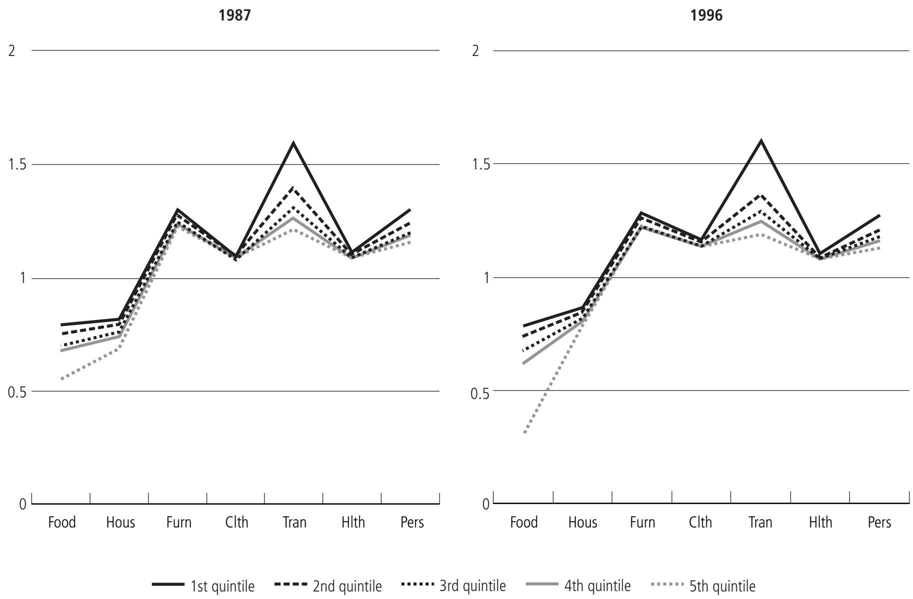
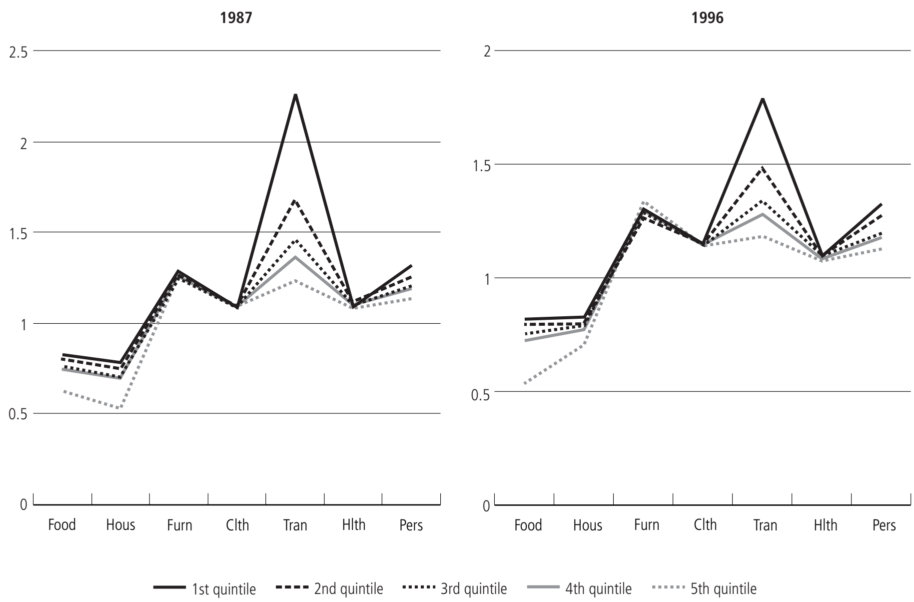


FIGURE 21
ESTIMATED EXPENDITURE ELASTICITIES BY QUANTILE—SALVADOR



Comparing our estimates of expenditure elasticities with those obtained in previous estimates (see Table 9) is a challenging task, for, as we have already mentioned, specifications, samples and expenditure classification are very diverse. We find our estimates to be closer to those obtained by Rossi (1983*b*), Rossi and Neves (1987) and Hoffmann (1983 and 1988) than to those obtained by Thomas, Strauss and Barbosa (1989). This suggests that sample design and categorization may have higher impacts on estimates than the functional form adopted. In particular, we should highlight the proximity of our estimates for health and clothing. transportation and personal expenses are plausible convex combinations of the subgroups constructed by them, while furnishings is a bit lower. As for the categories we found to be necessities, they are much farther from most of the previous estimates. Our estimates for food indicate a much more elastic demand, whereas the opposite occurs for housing, where we find a much less elastic demand than most of the other authors (except Alves, Disch and Evenson, whose figures are not too far from ours).

As noted in Section 2, price elasticities had been reported only by Thomas, Strauss and Barbosa (1989), Alves, Disch and Evenson (1982), and Simões and Brandt (1981). However, only the estimates by Thomas, Strauss and Barbosa, cover all consumption categories, and they are very different from ours[8] (see Table 10). We found that clothing and housing are more price-elastic and that food items cannot be compared due to our aggregation, but transportation figures are very close to each other. Again, differences in sampling or in commodity grouping may be blamed. Otherwise, either the different AIDS specification or a change along time may be what causes such differences. The other estimates were reported for agricultural products only, and in a much more disaggregate level, thus rendering comparisons unfeasible.

Despite the relative stability of our mean elasticities, the mean shares of the categories display some noteworthy changes between the two dates. These changes are due to a combination of income increase[9] and to changes in relative prices and demographic variables (see Table 11).

Personal expenses (from 0.095 to 0.156) and transportation and communication (from 0.118 to 0.185) increased their shares the most, as their expenditure elasticities are quite high and prices increased moderately in the time period, as

8. It is worth noting that the order of size of the cross-price elasticities is, through a visual inspection, not too different from each other.

9. Using the national general index calculated according to our Regional Price Difference Index (RPDI) methodology, annual *per capita* real income (Brazilian average) increased from BRL 1,730 to BRL 2,639 at September 1996 prices (a 51.97 percent accumulated variation, or 4.76 percent per annum rate) in our sample.

TABLE 9
EXPENDITURE ELASTICITY ESTIMATES IN PREVIOUS STUDIES

Author	Medeiros (1978)	Rossi (1982)	Rossi (1983*b*)	Hoffmann (1983 and 1988)	Cipriano and Brandt (1983)
Methodology	Box-Cox	Lorenz Curve	Lorenz Curve	Piecewise Log-Linear	Logit
Data Source	POF-USP 1971-1972	ENDEF 1974-1975	ENDEF 1974-1975	ENDEF 1974-1975	ENDEF 1974-1975
Sample	São Paulo (City)	Rio de Janeiro (City)	Brazil (Metropolitan Areas)	Rio de Janeiro (City)	Brazil
Elasticities Estimated	Expenditure	Expenditure (At Mean Point)	Expenditure (At Mean Point)	Expenditure (Mean)	Expenditure (Mean)
Food	Btw. 0.21 and 0.77	0.20	0.54	0.57	
Grains		0.16	0.19	0.25	0.068 (Cereals)
Tubercles		0.43	0.24	0.45	0.028
Vegetables		0.53	0.63	0.54	0.398 (Potherbs); –0.110 (Legumes)
Fruits		0.91	0.94	0.87	–0.325
Meat and Fish		0.62	0.60	0.63	0.469
Eggs and Dairy		0.70	0.71	0.68	0.528
Beverages		0.50	0.53 (Bev. & Others)	0.52	0.271
Food Away from Home		0.85	0.83	0.79	
Sugar, Oils, etc.		0.18	0.33 (Sugar); 0.31 (Oils)	0.31	0.074 (Sugar); 0.103 (Oils and Fats)
Other Foods			–0.01 (Legumes)		0.840
Clothing		1.21	1.15	1.10	
Housing		1.05	1.07	1.12	
Health		1.16	1.14	1.13	
Education	Btw. 1.54 and 1.64	1.70	1.60	1.38	
Recreation		1.46	1.49	1.22	
Tobacco		0.45	0.51	0.46	0.505
Public Transportation		0.32	0.02	0.57	
Own Vehicle		1.20	1.97	1.49	
Fuel and Transportation			1.68 (Long-Distance Trips)		
Miscelaneous		1.46	1.40	1.44	

continue

continue from Table 9

Author	Rossi and Neves (1987)	Alves, Disch and Evenson (1982)	Simões and Brandt (1981)	Thomas, Strauss and Barbosa (1989)	Our Estimates (For 1987)
Methodology	Logit	Serp	ELES	Generalized AIDS	AIDS
Data Source	ENDEF 1974-1975	ENDEF 1974-1975	ENDEF 1974-1975	ENDEF 1974-1975	POFs 1987-1988 and 1995-1996
Sample	Brazil	Nine Regions	Brazil	Brazil	Brazil (Metropolitan Areas)
Elasticities Estimated	Expenditure (At Mean Point)			Expenditure (Median) and Prices	Expenditure (At Mean Point)
Food	0.55				0.749
Grains		–0.0096 (Rice); 0.2927 (Cereals)	0.1588 (Cereals)	0.58 (Rice); 0.881 (Wheat); –0.49 (Corn); –0.565 (Manioc); 0.282 (Beans)	
Tubercles		0.3251 (Root Crops)	0.100	0.705	
Vegetables		0.434	0.4425 (Potherbs); 0.014 (Legumes)	0.403	
Fruits		0.779	0.630	1.023	
Meat and Fish		0.938 (Beef); –0.023 (Pork); 0.494 (Other Meats); 0.453 (Fish)	0.429	1.025 (Meat); 0.473 (Fish)	
Eggs and Dairy		0.3665 (Eggs); 0.755 (Dairy)	0.513	1.045 (Milk); 1.065 (Eggs & Non-Milk Dairy)	
Beverages		0.2062 (Coffee/Tea)	0.357		
Food Away from Home					
Sugar, Oils, etc.		0.1078 (Oils); 0.908 (Sweets)	0.202 (Sweets); 0.216 (Oils & Fats)	0.266 (Sugar); 0.635 (Oils & Fats)	
Other Foods		–0.0095 (Legumes)		0.570	
Clothing	1.11			1.316	1.079
Housing	1.26	0.898		1.009	0.746
Health	1.18 (Hygiene)				1.087
Education	1.71	1.09 (Education, Recreation, Culture)			1.267 (Personal Expenses, Education and Reading)
Recreation	1.60				
Tobacco			0.43		
Public Transportation	1.60 (Transportation)	1.538 (Transportation)			1.423 (Transportation)
Own Vehicle					
Fuel and Transportation				1.339	
Miscelaneous	1.31	1.054		1.426 (Household Goods); 1.644 (Other Goods)	1.220 (Furnishings)

TABLE 10
PRICE ELASTICITY ESTIMATES IN PREVIOUS STUDIES

Author	Simões and Brandt (1981)	Alves, Disch and Evenson (1982)	Thomas, Strauss and Barbosa (1989)	Our Estimates (Here we Report 1987)
Methodology	ELES	Serp	Generalized AIDS	AIDS
Data Source	ENDEF 1974-1975	ENDEF 1974-1975	ENDEF 1974-1975	POFs 1987-1988 and 1995-1996
Sample	Brazil	Nine Regions*	Brazil	Brazil (Metropolitan Areas)
Food				−0.531
Grains	−0.155 (Cereals)	−0.96 (Rice); 0.66 (Root Crops); +0.64 (Cereals)	−3.59 (Rice); −1.971 (Wheat); −0.114 (Corn); +0.280 (Manioc); −1.679 (Beans)	
Tubercles	−0.087		−1.954	
Vegetables	−0.007 (Legumes); −0.440 (Potherbs)	−0.49	−0.786	
Fruits	−0.624	−0.74	−0.882	
Meat and Fish	−0.435	−0.74 (Pork); −1.34 (Beef); −1.25 (Other Meats); −1.11(Fish)	−0.421 (Meat); −2.561 (Fish)	
Eggs and Dairy	−0.511	−0.77 (Cairy); +0.46 (Eggs)	−3.371 (Milk); −2.470 (Eggs & Non-Milk Dairy)	
Beverages	−0.353	−0.30 (Coffee/Tea)		
Food Away from Home		−0.1538		
Sugar, Oils, etc.	−0.195 (Sweets); −0.211	−0.38 (Sugar); −0.95 (Oils)	−0.004 (Sugar); +2.732 (Oils & Fats)	
Other Foods		−0.52 (Legumes)	−1.440	
Clothing			−0.583	−0.929
Housing			−0.445	−0.787
Health				−0.986
Education				−1.012 (Personal Expenses, Education and Reading)
Recreation				
Tobacco	−0.442			
Public Transportation				−1.121 (Transportation)
Own Vehicle				
Fuel and Transportation			−1.096	
Miscelaneous			0.033 (Household Goods); −0.021 (Other Goods)	-0.735 (Furnishings)

* A missing Appendix should contain a list of the regions selected.

TABLE 11
ACCUMULATED VARIATION OF INCOME AND PRICES BY EXPENDITURE GROUP ACCORDING TO IPCA AND RPDI—OCTOBER 1987-SEPTEMBER 1996
[in %]

Expenditure Group	RPDI	IPCA
0.General	7.2E+09	12.3E+09
1.Food	5.3E+09	9.9E+09
2.Housing	17.8E+09	21.0E+09
3.Furnishings	3.2E+09	5.6E+09
4.Clothing	4.3E+09	4.5E+09
5.Transportation and Communication	8.1E+09	12.9E+09
6.Health Care	14.0E+09	21.2E+09
7.Personal Expenses, Education and Reading	10.1E+09	21.6E+09
Real *per capita* Income	51.97	−11.45

compared to other categories. Housing shares increased moderately, despite the very low expenditure elasticity, and this is certainly due to the fact that the housing category recorded the highest inflation among all the categories, combined with a very low own-price elasticity. Almost the opposite occurred in the furnishings category, where expenditure elasticity is high, but prices increased the least and own-price elasticity is also very low, driving shares down. Clothing shares decreased, despite the high-income elasticity, because their inflation was the second lowest, and the own-price elasticity is high. Health and personal care decreased moderately because the effect of their high inflation combined with a high own-price elasticity dominated the high expenditure elasticity effect. Finally, low inflation, combined with low own-price elasticity and a low expenditure elasticity, drove the food share down.

6 CONCLUSION

This study estimated a complete Brazilian consumer demand system from two family budget surveys (POF/IBGE) conducted in 1986-1987 and 1995-1996. To the best of our knowledge, it is the first study of this kind based on those data. IBGE's stratified sampling scheme used for the survey provides large variations in total expenditures. We look at seven broad categories of consumption goods and services, which cover all consumption expenditures. To enable the estimation of the system, regional price difference indexes are created. By exploiting intertemporal and interregional differences in prices, we estimated the parameters for the price variables. The result showed a striking conformity to microeconomic theory. The estimated price and income (expenditure) elasticities are close to what economic common sense predicts, and their standard errors are fairly small, as opposed to earlier estimates from other studies (based on ENDEF, an earlier and more comprehensive survey). Negativity of the Hicks substitution matrix is supported.

To our knowledge this is a rare result in empirical studies of demand systems which use flexible functional forms. Also, we found that, despite high inflation in the sample period, Brazilian consumers' preferences, captured in terms of elasticities, showed a rather stable pattern.

The estimated system will serve as a solid microeconomic basis for evaluating various policy-related issues, such as the impact of commodity taxation on different goods/services, effects of subsidy to needy families, etc., and for comparing living standards across regions and across income classes. An initial exercise has already been undertaken in Asano, Barbosa and Fiuza (2001), which uses the estimated parameters and the microdata for São Paulo's metropolitan area for calculating optimal commodity tax rates.

APPENDIX

Constructing a Regional Price Difference Index for Brazil

To this date, the only source of estimates for cost-of-living differences across regions in Brazil had been the legal minimum Staple Food Basket (whose composition was enacted by a Federal law in 1938) collected in 16 state capitals by DIEESE, a research bureau supported by labor unions. The need for a more comprehensive and up-to-date household basket of goods and services for the purpose of estimating a system of consumption demand equations led us, therefore, to undertake the construction of a new set of Regional Price Difference Indexes (RPDI). This new set was based on a combination of the existing price variations at subitem level, released monthly by IBGE, with special tabulations of nominal prices provided by the same source. Here, we briefly describe the main features of the available price data from IBGE as well as the construction of the RPDI.

A.1 The National Consumer Price Index System (SNIPC)

The SNIPC was created in 1979,[10] and the first national index was released in 1980, based on nine metropolitan areas and on the Federal capital, Brasília. In 1989, another city, Goiânia, was added to the sample. The SNIPC comprises two main sets of indexes: the National Consumer Price Index (INPC) and the Broadened Consumer Price Index (IPCA). The sources of weighting structure, the target populations, are displayed in Table A.1.

10. Before 1979, price indexes for Brazil had been computed in as many as 13 state capitals by the Ministry of Labor. from 1948 to July 1978.

TABLE A.1
SNIPC STRUCTURE

Period	January 1979 - May 1989	June 1989 - December 1990	January 1991 - December 1993	January 1994 - July 1999	August 1999 - Present
Number of Subitems	486	461	370	369	512
Source of Weights	ENDEF 1974-1975	POF 1987-1988	POF 1987-1988	POF 1987-1988	POF 1995-1996
Target Populations	INPC 1-5 m.w. IPCA 1-30 m.w.	INPC 1-5 m.w. IPCA 1-40 m.w.	INPC 1-5 m.w. IPCA 1-40 m.w.	INPC 1-5 m.w. IPCA 1-40 m.w.	INPC 1-5 m.w. IPCA 1-40 m.w.
Main Modification		POF Introduced	Number of subitems reduced to simplify data collection	Within subitem average changes from arithmetical to geometrical (17 subitems excluded and 16 included), so as to abide to circularity property; weights had to be revised back to initial values	New pof was introduced; two groups and several subitems were subdivided or merged; some codes were renumbered
Our Naming	IPC-1	IPC-2a	IPC-2b	IPC-2c	IPC-3

Notes: m.w. = minimum wage; ENDEF: National Household Expenditure Study covered 53,000 households in all of Brazil's urban area and in the rural area of the northeastern, southeastern and southern regions; POFs covered the nine metropolitan areas and the cities of Brasília and Goiânia only.

The indexes are obtained in the following way: within a defined subitem a set of products[11] is identified for each metropolitan area. Their monthly price variations are then averaged geometrically and non-weighted to obtain the subitem price variation. The subitem *variations* are then averaged to items, subgroups, or groups, according to Laspeyres's formula. The weights are the expenditure weights provided by POF on a regional basis. The regional price indexes thus obtained are then averaged to form the national index. The population of each region represented by the metropolitan area weights this averaging. The only difference between the calculation by IPCA and that by INPC lies on the weights used in Laspeyres's formula, which were obtained from averaging target populations of different sizes (the former contains the latter). These weights are continuously updated by price variations. Note that this regional weighting scheme allows the indexes to compare prices *along time within a given area, but not across areas.* That is why we had to construct the present RPDI.

11. The subitem is the most disaggregate level at which variations are disclosed regularly by IBGE. For example, apple is a subitem of the fruit item, within the food-at-home subgroup, which is a part of food group. However, subitems themselves are made up of products, as defined by IBGE. For example, a 10-door cherry wood wardrobe is a product of the subitem bedroom furniture. Only general and group indexes are calculated.

Throughout the years, a number of revisions were introduced into SNIPC regarding the weighting structure and the subitem calculation. They are also summarized in Table A.1. Note that revisions were introduced even when the source survey (POF) was the same.

Some subitems require specific treatments. For example, clubs, schools, daycare and other services paid for on a monthly basis have their dues collected as prices in the previous month. Vehicle and house property tax variations (nowadays raised on a yearly basis) are spread out in a monthly fashion. Subitems belonging to seasonal food items[12] are assigned an annual calendar, whereby some subitems within a given item disappear, while other items appear each month. Only the whole item's total weight is updated by Laspeyres's formula, and the subitem weights must add up to this total weight. For rent, the accumulated variation is used, both for the numerator (variation accumulated from the base period 0 up to time *t*) and the denominator (variation accumulated from the base period 0 up to time *t*–1). The variations are averaged arithmetically and non-weighted. An important caveat is that own-housing rent is not imputed. An odd proceeding is the one for domestic servant services, for IBGE assumes their price follows the official minimum wage.

As regards public services, two cases exist: *a*) If the subitem is a composite of different products, an arithmetical average is used (e.g., local and intercity buses, postal services, etc.). This arithmetical average is weighted by POF shares, or by revenue shares, provided by public utility companies; *b*) If the price or tariff is nonlinear (i.e., it depends on consumption level—the usual pattern in public utilities), then IBGE calculates, for each area, the mean of the quantity consumed (provided by POF respondents or by the public service suppliers), and it calculates the tariff applying to this consumption level. Note that there is only one average and, consequently, one tariff for each target population (INPC and IPCA)— e.g., water and sewage fees, electricity, residential phone, and taxi rides.

A.2 The RPDI

A.2.1 Definitions and Foreign Experience

An RPDI, as any cost-of-living index, is nothing but the ratio of the minimum expenditures required to attain a particular indifference curve under two price regimes [Pollak (1989, p. 6)]. "Strictly speaking, the cost-of-living index depends only on the comparison prices, the reference prices, and the base indifference curve." (*ibidem*, p. 7).

12. Namely: *a*) tubercles, roots and legumes; *b*) potherbs and vegetables; *and c*) fruits.

The two price regimes refer, naturally, to the price vectors in effect in two different states of the world, for which the index compares the expenditures of a given "individual" (a representative consumer) described by an indifference curve map. Typically these states of the world refer to different periods and/or different regions. So far, SNIPC, as it has been conceived, only compares pairs of price regimes of different periods in a same area. Thus, each area has its own representative consumer (the area's respective IPCA and INPC average target population) and is not to be compared to another area.

Making interregional comparisons of cost of living requires choosing whose preference ordering to use. It follows that we have 11 possible sets of 10 indexes each, each set using the preference ordering (basket) of a different metropolitan area as base. Alternatively, one may use the national average basket of goods and services as base.

Thus far, we are aware of two measures of regional price differences in other countries. One is Japan's Regional Difference Index of Consumer Prices (RDICP) and the other is the U.S. Interregional Cost-of-Living Index. Japan's RDICP is calculated by the Statistics Bureau of the Management and Coordination Agency (MCA). It compares yearly average prices across 10 districts and 47 major cities or across cities where prefectural governments are seated, but it does not take inflation into account. So, a comparison of these indexes along time requires chaining them with CPI. The RDICP has been calculated since 1947. Prices are a subset of the data collected monthly through a Retail Price Survey, also undertaken by MCA, over 34,000 establishments and 24,000 households in 167 municipalities for CPI. Some items, out of a total of 580 in CPI, are excluded from RDICP because their specifications are not uniform throughout the country. On the other hand, the weights in the RDICP are always provided by the current year's Family Income and Expenditure Survey (FIES), conducted by MCA every month, as opposed to CPI's weighting structure, which is updated only once every five years by FIES. The population targeted by FIES comprises all of Japan's urban and rural households, excluding those mainly engaged in agriculture, forestry and fishery and one-person households. About 8,000 households are sampled from this population. MCA calculates two series of the index with Laspeyres's formula, one for each base preference for weights: the average for all of Japan and the average for the city of Tokyo.

The U.S. Inter-Regional Cost-of-Living Index is conducted quarterly by American Chamber of Commerce Researchers Association (ACCRA), an independent professional association of community and economic development researchers. It is a singular index in the sense that data collection is undertaken by voluntary members, who follow ACCRA's standard guidelines, either on a quarterly or biannual basis. Important consequences of this arrangement are: *a*) some subjectivity in selecting outlets—no Point-of-Purchase Survey is undertaken; *b*) local researchers also have some freedom of choice in determining how to contact the informers (in person, by mail, e-mail, fax and phone), depending on the item to be collected; *c*) if the local researcher fails to comply with the guidelines, as understood by the scrutiny of the regional offices, the city, or metropolitan area, is excluded from the sample for the period, and the average price to be used as a base price is, therefore, calculated on a variable number of areas along time. The target population of the index comprises professional or managerial couples with one child, belonging to the upper quintile of the income distribution. The weighting structure is borrowed from 1992 Current Expenditure Survey, a national average. The price set, however, is considerably limited: only 60 items, most of which are quite standardized.

For our own purposes, we use the national average weighting structure observed on the reference date (September 15, 1996) of the POF of 1995-1996. This criterion is the same that was used by Japan's RPDI and by ACCRA's Cost-of-Living Index and has as its main advantage the existence of a base price for each and every subitem used in the already reduced basket.

A.2.2 Limitations of Brazilian Data for Calculating RPDI

The products in Brazil's SNIPC are defined in *each metropolitan area* by a survey named PEPS. These products vary from region to region, so that very few subitems are completely comparable across all metropolitan areas. In some cases, products end up being classified as different subitems. For example, there are six different bean-type and four banana-type subitems. None of these different subitems are present in all areas. This poses an enormous challenge for comparing prices across regions.

Ideally, in order to construct a RPDI, we would need a minimum set of standardized *products* present in all metropolitan areas with their weights provided by a regular (yearly, if possible) household expenditure survey. To circumvent this heterogeneity we had to choose a *core* of comparable products across areas within each subitem (the criteria to choose the products are available from the authors upon request). One caveat is that, since subitem price variations are computed over *all* products of the subitem, using them to chain RPDI is likely to bias regional comparisons along time. The bias becomes greater when we move further away from the date of initial comparison, when there is less correlation of prices between products excluded and products included in the *core*, and when more products are excluded. The only definite solution would be to track individual product variations along time or to release their nominal prices periodically, so that the RPDI could be computed on a regular basis.

What we have so far is a set of nominal prices graciously released by IBGE. However, not all prices in this set are contemporaneous. Food prices had been released earlier by IBGE for 1987, 1990, 1993, 1995, and 1996. The delivered nonfood nominal prices referred to September 1999, the second month of IPC-3 weighting structure. Unfortunately, as IPC-3 has many more subitems than its predecessor, some new subitems (in the index or in some particular region) were missing because there was delay in collecting the data the first time. For this reason, we ordered a new set of nominal prices, collected in February 2000, in order to fill the gap. We then deflated them back to the same reference date. In total, 129 food and nonfood subitems of the current IPCA weighting structure were used, amounting to 73.07 percent of the index. The remaining weights for the subitems were redistributed within each item. Details on deflation are provided below.

Other disadvantages from relying on this price data set are apparent: *a*) hedonic adjustment for housing (size is lower in smaller metropolitan areas), clothing, electronic goods, home appliances, computers and automobiles, etc., is not undertaken; *b*) expenditures on domestic servants, which amount to a high share in the personal service subgroup, are treated by IBGE as if no regional difference existed because it uses the official minimum wage, which is the same for the whole country. However, we know, from outside sources, that in smaller metropolitan areas, the middle class can still afford a relatively cheap monthly maid, whereas, in greater metropolitan areas, most housemaids are paid on a much higher daily basis. The reader should bear these caveats in mind when using the RPDI.

A.3 Two Deflation Approaches

We calculated RPDI for three instants in time: September 1999 being the reference date of the nominal prices; September 1996 and October 1987 being the reference dates of POF 1995-1996 and POF 1987-1988, respectively. All three indexes are based on September 1999-centered prices (deflated at subitem level) and then deflated back using two alternative approaches.

The first approach uses *group subindexes*. Before having access to individual subitem price variations, we experimented deflationing RPDI through group subindexes, the disadvantage being that weights used to calculate group subindexes vary along time. Reference RPDIs (both general and group) were calculated in August 1999 using weights of that time, and the following subindexes were applied to deflate them back:

$$p_0 = \sum_j w_{j00} \cdot \frac{p_{jr0}}{p_{j00}} \qquad \text{(A.1)}$$

where:

p_0 is the index at reference period $t = 0$;

p_{jr0} is the price of good j in metropolitan area r at reference period;

p_{j00} is the average price of good j in all metropolitan areas where weight greater than zero is observed in the reference period; and

w_{j00} is the subitem j average national weight at reference period $t = 0$, that is, the average share of the subitem expenditure in total (or group, or subgroup, or item) household expenditure over all metropolitan areas

$$p_t = p_0 \,.\, (1 + \pi_{0t}) \qquad \text{(A.2)}$$

where π_{0t} is the cumulated variation of the subindex between time t and 0.

The second approach uses *subitem price variations*. In this case, we use September 1996 as reference base for weights. This weighting structure is kept for the three periods:

$$p_{rt} = \sum_j w_{j00} \cdot \frac{p_{jrt}}{p_{j00}} \qquad \text{(A.3)}$$

where:

p_{rt} is the index for metropolitan area r at time t;

p_{jrt} is price of good j in metropolitan area r at time t;

p_{j00} is average price of good j in all metropolitan areas where weight greater than zero is observed in the reference date; and

w_{j00} is the subitem j average national weight at reference period $t = 0$, that is, the average share of the subitem expenditure in total (or group, or subgroup, or item) household expenditure over all metropolitan areas.

For comparison, Table A.2 displays national average official RPDI subindexes and the “biases” against the official IPCA. Note that the first approach produces figures closer to the official ones. But this is easier to understand, as it takes into

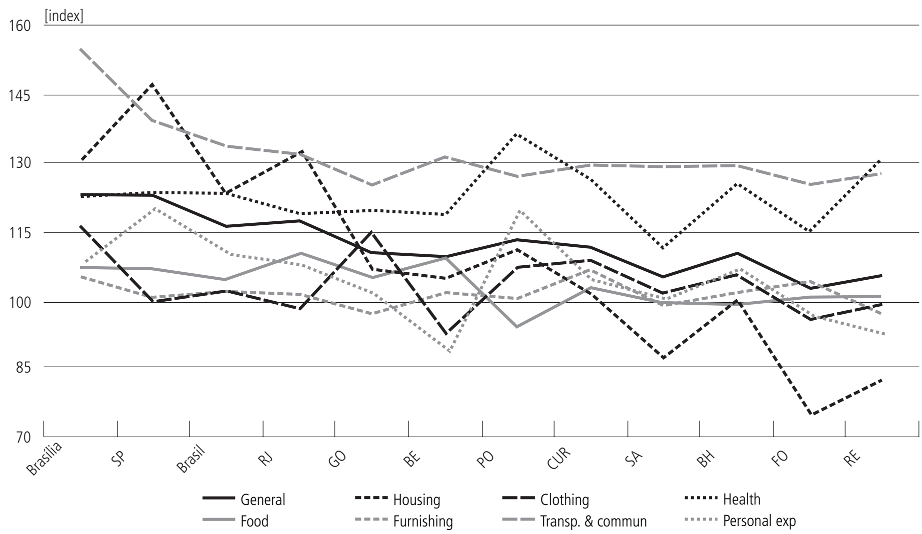
TABLE A.2
OFFICIAL IPCA SUBINDEXES NATIONAL INDEX

Expenditure Group	1987	1996	1999	"Bias" RPDI-S (%)	"Bias" RPDI-G (%)
0.General	2,238.94	100.00	114.62	71.63	1.44
1.Food	2,801.38	100.00	106.68	85.13	0.69
2.Housing	1,335.29	100.00	124.58	15.95	–0.18
3.Furnishings	5,083.78	100.00	106.45	69.56	–1.54
4.Clothing	6,330.79	100.00	107.11	0.88	–4.89
5.Transportation and Communication	2,237.64	100.00	139.51	52.03	–6.08
6.Health Care	1,373.08	100.00	127.87	43.21	–4.47
7.Personal Expenses, Education and Reading	1,364.04	100.00	115.87	100.10	6.43

account changes in weights along time. The second approach is more rigorous, though, because we are comparing a same basket of goods with the same weights. That is why we use the output of this approach in our reported estimations of the Consumer Demand System. The difference between the two results is apparent, especially in 1987. RPDI-S stands for RPDI deflated at subitem level, and RPDI-G for RPDI deflated at group level.

The figure displays the comparative cost of living across regions in September 1999. It allows us to affirm indisputably that São Paulo, Brasília, and Rio de Janeiro are the most expensive areas in Brazil as a whole, especially in the housing and transportation groups. Earlier indexes (not reported here) also show that these rankings have not been altered since 1987. Other areas have alternated in the ranking along time, but a clear pattern was also observed in the fact that Northeastern capitals have long been the cheapest areas.

RPDI SEPTEMBER 1999 (SEPTEMBER 1996/BRAZIL=100)



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