Analyzing the Impact of Adjustment Policies on the Poor: An IMMPA Framework for Brazil

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Abstract

This paper presents a modifed version of the integrated macroeconomic model for poverty analysis (IMMPA) for Brazil. In addition to keeping some of the characteristics of the basic framework (such as labor market segmentation, disaggregated public expenditure, and credit market imperfections), it introduces bond financing of the budget deficit, unskilled urban unemployment, and a flexible exchange rate. The properties of the model are illustrated by assessing the impact of a rise in offical interest rates on output, wages, unmployment, and poverty.

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1 Introduction

Brazil has achieved much progress in taming inflation since the Real Plan was implemented in July 1994. Despite the currency crisis of January 1999 (which led to the abandonment of the bands regime and the adoption of a flexible exchange rate, and the subsequent introduction of an inflation targeting framework), and the turmoil on world capital markets that followed the Argentina crisis of 2001-02, inflation has remained below double digit levels for the past few years, in large part due to active management of short-term interest rates by the Brazilian central bank. The era of low inflation has been accompanied by improved financial intermediation (as measured by an increase in the share of credit to GDP), significant progress in reducing fiscal deficits and the burden of domestic public debt. On average, the annual growth rate of the economy remained at about 2 percent per annum between 1994 and 2001, despite the recession of 1999 (Da Fonseca (2001)). However, progress in reducing poverty and income inequality has been mixed. Despite a slight reduction in the immediate aftermath of the Real Plan, the Gini coefficient has remained at around 0.6 during the 1990s. Brazil's income inequality indicators remain indeed one of the worst in the world. Significant gains were achieved in reducing poverty after the Real Plan, with the share of the poor in the population falling by 10 percentage points between 1992 and 1995, as a result of the pickup in growth and increase in per capita income that followed. Nevertheless, little progress has been achieved since then; a significant percentage of the population remains in deep poverty, with the headcount poverty index reaching - percent in 1999. Reducing the proportion of the poor remains one of the key policy issues in Brazil.

The purpose of this paper is to develop a quantitative framework for analyzing the impact of adjustment (both structural and macroeconomic) policies on wages, unemployment, poverty and income distribution in Brazil.[1] Our point of departure is the IMMPA prototype model developed by Agénor, Izquierdo, and Fofack (2003) for low-income countries. Without a doubt, the IMMPA prototype captures several important features of the Brazilian economy, which are common to many developing countries: the pervasive role of the informal economy and the relative scarcity of "good jobs" for unskilled workers in the urban sector, labor market segmentation, and the

[1] For a review of CGE models for the Brazilian economy since the mid-1990s, see Domingues (2002). For earlier models, see Guilhoto (1995).

links between the financial sector and the supply side through the credit market. In addition, however, there are several important characteristics of the Brazilian economy that are not well captured in the low-income IMMPA prototype, which therefore needs to be amended or modified to make it useful for policy discussions.

Accordingly, in this paper we extend the low-income IMMPA framework in several directions. First, we allow for open unskilled urban unemployment, by introducing a Harris-Todaro type mechanism to determine the supply of unskilled labor in the formal sector. This extension is very important for a country like Brazil, where unskilled workers account for a large fraction of employment (61.8 percent of total employment in 1996 and 58.5 percent in 1999) and unemployment: in 1999, the overall, open unemployment rate stood at 10.2, up from 7.4 percent in 1996. The skilled unemployment rate amounted to 4.8 percent, whereas the unemployment rate for unskilled labor represented 5.3 percent. Second, we specify a general and highly flexible form for the determination of skilled workers' wage in the private formal sector. This specification incorporates the critical distinction between the product wage (which firms are concerned with) and the consumption wage (which matters for labor suppliers), a *level* effect of unemployment on wages, which is consistent with various forms of efficiency wage theories, such as those emphasizing the wage-productivity link or turnover costs. It is consistent with a negative effect of unemployment on workers' reservation wage, and wage-setting models based on a bargaining framework between firms and trade unions. It also accounts for the effect of payroll taxation on firms' wage bill and the cost of borrowing for financing workers' compensation. Third, we account for the possibility of congestion effects associated with the use of public sector services in the urban sector. Fourth, we introduce the possibility of bond financing of public sector deficits and preclude at the same time borrowing from the central bank. Sustainability of Brazil's public debt remains a key policy issue; during the 1995-2000 period, the net public debt (domestic and external) of the consolidated public sector increased indeed from 30.4 percent of GDP to 46 percent (Bevilaqua and Garcia (2002)). More generally, this modification is important for many middle-income countries, where (in addition to foreign borrowing) governments have increasingly issued domestic bonds to finance their fiscal deficits. Of course, we model not only the "supply" side of the bonds market but also the "demand" side, that is, holdings of bonds by households (capitalists and rentiers) and the financial system. Fifth, we assume that the exchange rate is fully flexible and equi-

librates the balance of payments. Official reserves are therefore exogenous. Finally, we model monetary policy by assuming that the central bank sets a policy interest rate (such as the repurchase rate) and has a perfectly elastic supply curve of liquidity to commercial banks. Continuous equilibrium of the credit market is thus obtained not by foreign borrowing by commercial banks (as in the prototype IMMPA framework), but by domestic borrowing.

We also make other (somewhat less significant) modifications to reflect Brazil's institutional characteristics and the type of policy issues that we want to address. First, we assume that nominal wages are fully flexible in the rural sector and adjusts continuously to equilibrate the supply and demand for labor in the rural labor market. Second, we exclude borrowing from the financial system in the rural sector, given its relatively limited empirical importance. This has an important effect, of course, on the transmission process of financial shocks to rural areas and rural production. Third, we keep public sector wages for skilled workers as exogenous (instead of assuming equality with private sector wages) and assume that there is a non-pecuniary benefit (in terms of, say, increased job security) that leads to zero turnover for that category of workers. Finally, we also introduce payroll taxation on both categories of labor in the private, urban formal sector, in order to analyze the impact of changes in the taxation of firms' wage bill on employment and poverty. The extent to which high payroll taxes have tended to discourage the demand for labor (particularly unskilled labor) has been an important policy issue in Brazil in the past few years; our framework allows us to consider the general implications of changes in these taxes—which operate partly through its "pure" fiscal effects.

The remainder of the paper is organized as follows. Section II describes the "macro" component of the model, whereas Section III explains the data and indicators used for poverty and income distribution analysis. Section IV discusses briefly the calibration and solution procedures, including the structure of the financial SAM that underlies the model. Section V considers as a policy experiment an increase in official interest rates and discusses the response of production, wages, employment, and poverty. Section VI performs some sensitivity analysis The last section summarizes the main results and considers some future extensions of our analysis.

2 An IMMPA Framework for Brazil

In this section we review these various building blocks of the model. We consider in turn the production side, employment, the demand side, external trade, sectoral and aggregate prices, income formation, the financial sector and asset allocation decisions, and the public sector. Throughout the discussion, we often use "generic" forms to specify functional relationships; explicit functional forms (as well as variable names and definitions) are provided in Appendices A and B.

2.1 Production

The basic distinction on the production side is that between rural and urban sectors. Unlike the IMMPA prototype of Agénor, Izquierdo and Fofack (2003), the rural sector produces only one good, which is sold both on domestic markets and abroad. Urban production includes both formal and informal components; in addition, the formal urban economy is separated between production of a private good (sold on both domestic markets and abroad) and a public good.

2.1.1 Rural Production

Land available for production in the rural sector is assumed to be in fixed supply and there is no market to trade property claims on it. Gross output of the rural good, X_A, is given by the sum of value added, V_A, and intermediate consumption:

$$X_A = V_A + X_A \sum_i a_{iA}, \qquad \text{for } i = A, I, P, G \tag{1}$$

where the a_{ij} are conventionally-defined input-output coefficients (sales from sector i to sector j) and A, I, P, G are used in what follows to refer, respectively, to the rural sector, the informal sector, the private urban sector, and the public sector.[2]

Value added is assumed to be produced with a Cobb-Douglas (CD) function of land, $LAND$, and a composite factor, defined as a constant elasticity of substitution (CES) function that depends on the number of unskilled rural

[2] In what follows, whenever the indexes i and j are not explicitly defined, they will be taken to refer to A, I, P, G.

workers employed in the rural sector, U_A, and the economy-wide stock of public physical capital (K_G, which is defined below):

$$V_A = CD[LAND, CES(U_A, K_G)], \tag{2}$$

For simplicity, in what follows we normalize the area of land allocated to production to unity. Given the CD specification, rural production exhibits decreasing returns to scale in the remaining (composite) input.

The presence of K_G in the production functions (2) and (**??**) is based on the view that a greater availability of public physical capital in the economy (roads, power plants, and the like) improves the productivity of private firms and other production units in the rural sector, because it facilitates not only trade and domestic commerce but also the production process itself. Thus, our concept of public capital includes not only roads and public transportation that may increase access to markets, but also power plants and similar public goods that may contribute to an increase in productivity.

Allocation of rural sector output to domestic consumption, D_A, and exports, E_A, occurs according to a production possibility frontier, defined by a constant elasticity of transformation (CET) function:

$$X_A = CET(D_A, E_A). \tag{3}$$

As discussed below, the ratio E_A/D_A depends (in standard fashion) on relative prices.

2.1.2 Urban Informal Production

Gross production in the urban informal sector, X_I, is given as the sum of value added, V_I, and intermediate consumption:

$$X_I = V_I + X_I \sum_i a_{iI}. \tag{4}$$

There is no physical capital in the informal sector, and production requires only unskilled labor. Assuming decreasing returns to scale, value added can thus be written solely as a function of the number of unskilled workers employed in the informal economy, U_I:

$$V_I = \alpha_{XI} U_I^{\beta_{XI}}, \qquad \alpha_{XI} > 0, \quad 0 < \beta_{XI} < 1. \tag{5}$$

From (5), the demand for labor in the informal sector is given by

$$U_I^d = \beta_{XI}(V_I/w_I), \tag{6}$$

where w_I is the product wage given by $w_I = W_I/PV_I$, with PV_I denoting the price of value added in the informal sector (defined below).

2.1.3 Production of public goods and services

Gross production of public goods and services (or public good, for short), X_G, is given by the sum of value added, V_G, and intermediate consumption:

$$X_G = V_G + X_G \sum_i a_{iG}. \tag{7}$$

Production of value added requires both types of labor (skilled and unskilled) and is given by a two-level CES function. At the lower level unskilled workers, U_G, and skilled workers, S_G, combine to produce "effective" employment in the public sector; and at the second level, effective labor and public capital, K_G combine to produce net output:

$$V_G = CES[CES(S_G, U_G), K_G]. \tag{8}$$

Employment levels of both categories of workers are treated as exogenous.

2.1.4 Urban Formal Private Production

Private formal production uses as inputs both skilled and unskilled labor, as well as physical capital. Skilled labor and private physical capital have a higher degree of complementarity (lower degree of substitution) than physical capital and unskilled workers. In order to account explicitly for these differences in the degree of substitutability among inputs, we adopt a nested CES production structure. Specifically gross production of the private formal-urban sector, X_P, is taken to be given by the sum of value added, V_P, and intermediate consumption:

$$X_P = V_P + X_P \sum_i a_{iP}, \tag{9}$$

where

$$V_P = CES\{CES[CES(S_P, K_P), U_P], \frac{K_{G,-1}}{L_{U,-1}^{pc}}\}, \tag{10}$$

where $pc \geq 0$.

At the lowest level of equation (10), skilled labor, S_P, and private capital, K_P, are combined to form the composite input T_2, with a low elasticity of substitution between them. At the second level, this composite input is used together with unskilled labor, U_P, to form the composite input T_1. The elasticity of substitution between T_2 and unskilled workers, U_P, is higher than between S_P and K_P. The final layer involves combining T_1 and the lagged value of the ratio of K_G (the stock of government capital) to the total size of the labor force (or equivalently, the total population) in the urban sector, L_U (defined below). The presence of this ratio can be rationalized as follows. As noted earlier, a greater stock of public capital (roads, power plants, and the like) raises the productivity of private production. However, due to *congestion* effects, this positive externality of public capital decreases as its usage increases.[3] The total level of employment in the urban sector is used as a proxy for usage. When $pc = 0$, public capital is a pure public good. Otherwise, the higher the size of the labor force in urban areas, the lower is the contribution of the public capital stock to private production.

Private firms in the urban formal sector allocate their output to exports, E_P, or the domestic market, D_P, according to a production possibility frontier, which is also defined by a CET function:

$$X_P = CET(E_P, D_P). \tag{11}$$

As shown later, the ratio E_P/D_P depends also on relative prices.

2.2 Wages, Employment, Migration and Skills Acquisition

Unskilled workers in the economy may be employed either in the rural economy, U_R, or in the urban economy, U_U, whereas skilled workers are employed only in the urban economy. We also assume that skilled workers are not employed in the informal economy either—perhaps as a result of signaling considerations, as discussed later.

[3] See Agénor (2002*b*, Chapter 5) for a detailed discussion of the nature of congestion effects associated with public services.

2.2.1 Rural Wages and Employment

The demand for labor in the rural sector consistent with profit maximization, U_A^d, can be derived as

$$U_A^d = \left(V_A^{1+\frac{\rho_{XA}}{1-\eta_{XA}}} \frac{1-\eta_{XA}}{w_A} \cdot \frac{\beta_{XA}}{\alpha_{XA}^{\rho_{XA}}} \right)^{\frac{1}{1+\rho_{XA}}}, \qquad \text{where } w_A = \frac{W_A}{PV_A}, \tag{12}$$

where W_A denotes the nominal wage and PV_A the net output price in the rural sector (both determined below).

Nominal wages in the rural sector adjust to clear the labor market. Let U_R^s denote labor supply in the rural sector; the equilibrium condition is thus given by

$$U_R^s = U_A^d(V_A, \frac{W_A}{PV_A}). \tag{13}$$

The size of the labor force in the rural sector is predetermined at any given point in time. Over time, U_R^s grows at the exogenous population growth rate, g_R, net of worker migration to urban areas, $MIGR$:

$$U_R^s = U_{R,-1}^s(1+g_R) - MIGR. \tag{14}$$

Following Harris and Todaro (1970), the incentives to migrate are taken to depend negatively on the ratio of the average expected *consumption* wage in rural areas to that prevailing in urban areas. Unskilled workers in the urban economy may be employed either in the private formal sector, in which case they are paid a minimum wage, W_M, or they can enter the informal economy and receive the market-determined wage in that sector, W_I.[4] When rural workers make the decision to migrate to urban areas, they are uncertain as to which type of job they will be able to get, and therefore weigh wages in each sector by the probability of finding a job in that sector. Assuming, for simplicity, complete job turnover in the urban sector, these probabilities can be approximated by prevailing employment ratios. Finally, potential migrants also consider what their expected purchasing power in rural and urban areas will be, depending on whether they stay in the rural sector and consume the "typical" basket of goods of rural households, or migrate and consume the "typical" urban basket of goods.

[4] As discussed below, there is no job turnover for either category of workers in the public sector.

The expected, unskilled urban real wage, Ew_U, is thus a weighted average of the minimum wage in the formal sector and the going wage in the informal sector, deflated by an urban consumption price index for unskilled workers, P_{UU} (defined below):

$$Ew_U = \frac{\theta_U W_{M,-1} + (1-\theta_U) W_{I,-1}}{P_{UU,-1}}, \tag{15}$$

where θ_U is the probability of finding a job in the urban formal sector, measured by the proportion of unskilled workers in the private formal sector, relative to the total number of unskilled urban workers (net of government employment) looking for a job, in the previous period:

$$\theta_U = \frac{U_{P,-1}}{U_{F,-1} - U_{G,-1}}. \tag{16}$$

In the rural sector, the employment probability is equal to unity, because workers can always find a job at the going wage. Assuming a one-period lag, the expected rural consumption real wage, Ew_A is thus given by

$$Ew_A = \frac{W_{A,-1}}{P_{R,-1}},$$

where P_R is the composite, rural consumption price index (defined below).

The migration function can therefore be specified as

$$MIGR = U_{R,-1}\lambda_m \left[\sigma_M \ln\left(\frac{Ew_U}{Ew_A}\right)\right] + (1-\lambda_m)\frac{U_{R,-1}}{U_{R,-2}} MIGR_{-1}, \tag{17}$$

where $0 < \lambda_m < 1$ measures the speed of adjustment and $\sigma_M > 0$ measures the elasticity of migration flows with respect to expected wages. This specification assumes that costs associated with migration or other frictions may delay the migration process, introducing persistence in migration flows.

2.2.2 Urban Unskilled Wages, Employment, and Unemployment

Both the government and private firms in the formal and informal urban sectors use unskilled labor in production. The public sector is assumed to hire an exogenous level of unskilled workers, U_G, at the nominal wage rate W_{UG}, whereas the demand for unskilled labor by the formal private sector

is determined by firms' profit maximization subject to the given minimum wage, W_M.[5] Formal private sector firms cannot issue equity claims on their capital and do not issue debt securities; instead, they borrow to finance their wage bill (inclusive of payroll taxes) prior to the sale of output. As a result, the effective price of labor includes the bank lending rate. We assume also that firms pay a payroll tax, at the rate $0 < ptax_U < 1$ for unskilled workers, which is proportional to the wage bill, $W_M U_P$. Unskilled labor demand by the private sector is thus given by

$$U_P^d = T_1 \left(\frac{1}{(1 + IL_{-1})(1 + ptax_U) w_M} \frac{\beta_{XP1}}{\alpha_{XP1}^{\rho_{XP1}}} \right)^{\sigma_{XP1}}, \text{ where } w_M = \frac{W_M}{PT_1}, \quad (18)$$

where IL is the lending rate.[6]

In order to avoid corner solutions, we assume that the wage rate paid to unskilled labor in the formal urban sector is systematically greater than the real wage rate paid in the informal sector. Consequently, unskilled urban workers will first seek employment in the private formal sector. The actual level of employment in that sector is determined according to equation (18).

We also assume that, as a result of relocation and congestion costs, mobility of the unskilled labor force between the formal and the informal sectors is imperfect. Migration flows are determined by expected income opportunities, along the lines of Harris and Todaro (1970).[7] Specifically, the supply of unskilled workers in the formal sector (including public sector workers), U_F^s, is assumed to change gradually over time as a function of the expected wage differential across sectors, measured in real terms. Wage and employment prospects are formed on the basis of prevailing conditions in the labor market. Because there is no job turnover in the public sector, the expected nominal wage in the formal economy is equal to the minimum wage weighted by the probability of being hired in the private sector. Assuming that hiring in that sector is random, this probability can be approximated by the ratio of currently employed workers to those seeking employment at the previous

[5] As discussed below, unskilled workers earn actually a wage that is a multiple of the official minimum wage. Moreover, the wedge has remained stable over time. Consequently, we simply assume that workers earn the legally-set minimum wage.

[6] We assume that the cost of credit specified in loan contracts negotiated for the current period is based on the interest rate prevailing at the previous period.

[7] Note that in the present setup the Harris- Todaro framework is used to explain migration flows between the (urban) informal sector and the (urban) formal sector, rather than migration between the rural and the urban sectors.

period, $U^d_{P,-1}/(U^s_{F,-1} - U_{G,-1})$. The expected nominal wage in the informal economy, W_I, is simply the going wage, because there are no barriers to entry in that sector. Assuming a one-period lag, the supply of unskilled workers in the formal sector thus evolves over time according to

$$\Delta U^s_F = \beta_F \left\{ \frac{U^d_{P,-1}}{U^s_{F,-1} - U_{G,-1}} (\frac{W_{M,-1}}{P_{UU,-1}}) - \frac{W_{I,-1}}{P_{UU,-1}} \right\}, \quad \beta_F > 0, \tag{19}$$

where β_F denotes the speed of adjustment.[8] The rate of unskilled unemployment in the formal sector, $UNEMP_U$, is thus given by

$$UNEMP_U = 1 - \frac{(U_G + U^d_P)}{U^s_F}. \tag{20}$$

The supply of labor in the informal economy, U^s_I, is obtained by subtracting from the urban unskilled labor force, U_U, the quantity U^s_F:

$$U^s_I = U_U - U^s_F. \tag{21}$$

The informal labor market clears continuously, so that $U^d_I = U^s_I$. From equations (6) and (21), the equilibrium nominal wage is thus given by

$$W_I = \beta_{XI} (\frac{PV_I \cdot V_I}{U^s_I}). \tag{22}$$

The urban unskilled labor supply, U_U, grows as a result of "natural" urban population growth and migration of unskilled labor from the rural economy, as discussed earlier. Moreover, some urban unskilled workers, SKL, do acquire skills and leave the unskilled labor force to increase the supply of skilled labor in the economy. We make the additional assumption that individuals are born unskilled, and therefore natural urban population growth (not resulting from migration or skills acquisition factors) is represented by urban unskilled population growth only, at the exogenous rate g_U. Thus, the size of the urban unskilled labor supply evolves according to

$$U_U = U_{U,-1}(1 + g_U) + MIGR - SKL. \tag{23}$$

[8] As noted by Agenor (199-), the absence of on-the-job search in the informal sector in the present setup can be justified in a variety of ways. An important consideration is the existence of informational inefficiencies, which may result from the absence of institutions capable of processing and providing in a timely manner relevant information on job opportunities to potential applicants. As a result, search activities for unskilled workers in the formal sector may require, literally speaking, waiting for job offers at factory gates.

2.2.3 Urban Skilled Wages and Employment

As noted earlier, the employment levels of both skilled and unskilled workers in the public (urban) sector are taken as exogenous. We also take as given the real wage rate that skilled workers are paid in the public sector, ω_{SG}. With W_{SG} denoting the nominal wage, and P_{US} the consumption price index for (urban) skilled workers, full indexation therefore implies that[9]

$$W_{SG} = \omega_{SG} P_{US}. \tag{24}$$

We assume again that private urban firms pay a payroll tax, at the rate $0 < ptax_S < 1$, for skilled workers, that is proportional to the wage bill, $W_S S_P$. The wage-setting equation for skilled labor in the private sector is given by

$$W_S = \overline{w}_S (PIND_S)^{ind_S} (UNEMP_S)^{-\phi_U} \Omega_W^{\phi_1} \left(\frac{P_{US}}{PT_2} \right)^{\phi_2}, \tag{25}$$

where $PIND_S = PLEV$ or PT_2 (depending on whether the nominal wage is indexed to the overall level of prices or the composite "product" price), $\Omega_W > 0$ is the reservation rate, $UNEMP_S$ the unemployment rate of skilled labor (defined below), and ϕ_U, ϕ_1, $\phi_2 > 0$.

This specification is quite flexible. For instance, full indexation on the consumer price index only requires setting $PIND_S = PLEV$, $ind_S = 1$, and $\phi_U = \phi_1 = \phi_2 = \phi_3 = 0$. This case is important because it implies that whereas firms are concerned with the *product* wage, workers are concerned with the *consumption* wage. This creates a wedge through which relative prices affect wage-setting decisions. To assume that the product wage depends only on the ratio P_{US}/PT_2 requires setting $PIND_S = PT_2$, $ind_S = 1$, $\phi_2 > 0$, and $\phi_U = \phi_1 = 0$. Note also that in (25), as long as $\phi_U > 0$, the level of skilled unemployment will affect (negatively) the *level* of nominal wages, instead of the *rate of growth* of wages (as would be the case with a Phillips curve-type formulation). This level effect is consistent with various forms of efficiency wage theories (such as those emphasizing the wage-productivity link or turnover costs), in which unemployment acts as a "worker discipline

[9] To avoid a corner solution in which no worker would want to seek employment in the public sector, we assume that working for the government provides a nonpecuniary benefit (perhaps in terms of higher job security or reduced volatility of future earnings) that is sufficiently large to ensure that the differential between W_{SG} and W_S is not "excessive" (in the sense that S_G remains positive at all times).

device", by moderating wage demands, eliciting a higher level of effort, and by reducing the incentive to quit and thus lowering turnover costs (see Agénor (1996)).[10]

From (10), the demand for skilled labor is given by

$$S_P^d = T_2 \kappa_S \left(\frac{1}{(1+IL_{-1})(1+ptax_S)w_S} \cdot \frac{\beta_{XP2}}{\alpha_{XP2}^{\rho_{XP2}}} \right)^{\sigma_{XP2}}, \quad \text{where } w_S = \frac{W_S}{PT_2}. \tag{26}$$

Given that firms set wages and are on their labor demand curve, open skilled unemployment may emerge. The rate of skilled unemployment, $UNEMP_S$, is given by the ratio of skilled workers who are not employed either by the private or the public sector, divided by the total population of skilled workers:

$$UNEMP_S = 1 - \frac{(S_G + S_P^d)}{S}. \tag{27}$$

We assume that skilled workers who are unable to find a job in the formal economy opt to remain openly unemployed, instead of entering the informal economy (in contrast to unskilled workers), perhaps because of adverse signaling effects.

The evolution of the skilled labor force depends on the rate at which unskilled workers choose to acquire skills:

$$S = (1 - \delta_S)S_{-1} + SKL, \tag{28}$$

where $0 < \delta_S < 1$ is the rate of "depreciation" or "de-skilling" of the skilled labor force.

Finally, the total size of the labor force in the urban sector, L_U, is given by

$$L_U = U_U + S. \tag{29}$$

2.2.4 Acquisition of Skills

The acquisition of skills by unskilled workers is assumed to depend on two factors: *a)* relative expected consumption wages of skilled and unskilled urban workers (as a proxy for the future stream of earnings associated with higher

[10] A bargaining framework between firms and a centralized trade union could also lead to a similar wage-setting specification. See Agénor (2003) and Agénor, El Aynaoui, and Abdelkhalek (2003).

levels of education); and *b)* the government stock of education capital, K_E, which limits the ability to invest in skills.

Consider first the effect of wages. In case they acquire skills, current unskilled workers expect to earn wage W_S if they are employed (with probability θ_S) and nothing if they are unemployed. The purchasing power of this wage is obtained by deflating it by a consumption price index for skilled workers, $P_{US,-1}$ (defined below):

$$Ew_S = \theta_S \frac{W_{S,-1}}{P_{US,-1}},$$

where θ_S is measured by the ratio in the previous period of the number of skilled workers employed in the private sector, over the total number of skilled workers that are not employed in the public sector:

$$\theta_S = \frac{S_{P,-1}}{S_{-1} - S_{G,-1}}. \tag{30}$$

If they remain unskilled, workers expect to get the average unskilled wage, which is a weighted average of the minimum wage W_M and the informal wage rate. Assuming, again, that there is no job turnover in the public sector, the average expected real wage is given by (A9), which is repeated here for convenience:

$$Ew_U = \frac{\theta_U W_{M,-1} + (1-\theta_U) W_{I,-1}}{P_{UU,-1}},$$

with θ_U as defined above. Given these effects, the flow increase in the supply of skilled labor can be written as:

$$SKL = \lambda_S \left[\kappa_e \left(\frac{Ew_S}{Ew_U} \right)^{\sigma_W} (K_{E,-1})^{\sigma_E} \right] + (1-\lambda_S) SKL_{-1}, \tag{31}$$

where $0 < \lambda_S < 1$, and κ_e is a shift parameter.[11]

Public investment in education, I_E (which is treated as exogenous), determines the rate at which the stock of public capital in education grows over time:

$$K_E = K_{E,-1}(1-\delta_E) + I_{E,-1}, \tag{32}$$

where $0 < \delta_E < 1$ is a depreciation rate.

[11] Note that we abstract from the cost of acquiring skills (as measured by the number of years of schooling multiplied by the average cost of education per year), which should also affect the propensity to invest in skills acquisition.

2.3 Supply and Demand

Both the informal and public sector goods are nontraded. Total supply in each sector is thus equal to gross production, that is

$$X_I = Q_I^s, \quad X_G = Q_G^s. \tag{33}$$

Rural and private formal urban goods, by contrast, compete with imported goods. The supply of the composite good for each of these sectors consists of a CES combination of imports and domestically produced goods:

$$Q_A^s = CES(M_A, D_A), \tag{34}$$

$$Q_P^s = CES(M_P, D_P). \tag{35}$$

For the rural and informal sectors, aggregate demand (Q_A^d and Q_I^d) consists of intermediate consumption and demand for final consumption (by both the government and the private sector), whereas aggregate demand for the public and private goods (Q_G^d and Q_P^d) consists not only of intermediate consumption and final consumption but also of investment demand:

$$Q_A^d = C_A + INT_A, \tag{36}$$

$$Q_I^d = C_I + INT_I, \tag{37}$$

$$Q_G^d = C_G + Z_P^G + INT_G, \tag{38}$$

$$Q_P^d = (C_P + G_P) + (Z_P^P + Z_G) + INT_P, \tag{39}$$

where INT_j is defined as total demand (by all productions sectors) for intermediate consumption of good j:

$$INT_j = \sum_i a_{ji} X_i. \tag{40}$$

Government spending on goods and services consists only of expenditure on the private formal sector good, in quantity G_P.

Private final consumption for each production sector i, C_i, is the summation across all categories of households of nominal consumption of good i, deflated by the demand price of good i:

$$C_i = \sum_h C_{ih} = \sum_h x_{ih} + \frac{\sum_h cc_{ih}(CON_h - \sum_i PQ_i x_{ih})}{PQ_i}, \tag{41}$$

where C_{ih} is consumption of good i by household h, x_{ih} is the subsistence (or autonomous) level of consumption of good i by household h, CON_h total nominal consumption expenditure by household h, and PQ_i the composite sales price of good i (defined below). Equations (41) are based on the linear expenditure system. Coefficients cc_{ih} indicate how total nominal consumption expenditure by household h, CON_h, is allocated to each type of good and satisfy the restrictions:

$$0 < cc_{ih} < 1, \ \forall i, h, \ \sum_i cc_{ih} = 1.$$

Finally, aggregate investment made by firms, Z_P, consists of purchases of both public and private goods and services (Z_P^G and Z_P^P respectively):

$$Z_P^i = zz_i \frac{PK \cdot Z_P}{PQ_i}, \tag{42}$$

where $zz_G + zz_P = 1$. Coefficients zz_i measure the allocation of total investment demand to public and private goods.

2.4 External Trade

As indicated earlier, firms in the rural and private formal sectors allocate their output to the domestic market or exports according to the production possibility frontier (PPF) specified in equations (**??**) and (11), and the relative price of exports (PE_A and PE_P, respectively) vis-à-vis domestic goods (PD_A and PD_P, respectively). Efficiency conditions require that firms equate this relative price to the opportunity cost in production. This yields:

$$E_A = D_A \left(\frac{PE_A}{PD_A} \cdot \frac{1 - \beta_{TA}}{\beta_{TA}} \right)^{\sigma_{TA}}, \tag{43}$$

$$E_P = D_P \left(\frac{PE_P}{PD_P} \cdot \frac{1 - \beta_{TP}}{\beta_{TP}} \right)^{\sigma_{TP}}. \tag{44}$$

As noted earlier, imports compete with domestic goods in the rural sector as well as in the private formal sector. Making use of Armington functions for the demand for imported vs. domestic goods and relative prices, import demand for both sectors (M_A and M_P) can be written as:

$$M_A = D_A \left(\frac{PD_A}{PM_A} \cdot \frac{\beta_{QA}}{1 - \beta_{QA}} \right)^{\sigma_{QA}}, \tag{45}$$

$$M_P = D_P \left(\frac{PD_P}{PM_P} \cdot \frac{\beta_{QP}}{1 - \beta_{QP}} \right)^{\sigma_{QP}}. \tag{46}$$

These equations show that the ratio of imports to both categories of domestic goods depends on the relative prices of these goods and the elasticity of substitution, σ_{QA} and σ_{QP}, between these goods.

2.5 Prices

The net or value added price of output is given by the gross price, PX_i, net of indirect taxes, less the cost of intermediate inputs (purchased at composite prices):

$$PV_i = V_i^{-1} \left\{ PX_i(1 - dtax_i) - \sum_j a_{ji} PQ_j \right\} X_i, \tag{47}$$

where $dtax_i$ is the rate of indirect taxation of output in sector i (with $dtax_I$ $= 0$ because there is no indirect taxation of informal sector output).

The world prices of imported and exported goods are taken to be exogenously given. The domestic currency price of these goods is obtained by adjusting the world price by the exchange rate, with import prices also adjusted by the tariff rate, tm:

$$PE_i = wpe_i ER, \text{ for } i = A, P, \tag{48}$$

$$PM_i = wpm_i(1 + tm_i)ER, \text{ for } i = A, P. \tag{49}$$

Because the transformation function between exports and domestic sales of the rural and urban private goods is linear homogeneous, the domestic sales prices, PX_A and PX_P, are derived from the expenditure identity:

$$PX_i X_i = PD_i D_i + PE_i E_i, \text{ for } i = A, P,$$

that is,

$$PX_i = \frac{PD_i D_i + PE_i E_i}{X_i}, \text{ for } i = A, P. \tag{50}$$

For the informal and public sectors (both of which do not export and do not compete with imports), the composite price is equal to the domestic market price, PD_i, which is in turn equal to the output price, PX_i:

$$PD_i = PX_i, \text{ for } i = I, G, \tag{51}$$

with both prices determined to clear the market for these goods (see below).

For the rural sector and private urban production, the substitution function between imports and domestic goods is also linearly homogeneous, and the composite market price is determined accordingly by the expenditure identity:

$$PQ_iQ_i = PD_iD_i + PM_iM_i, \text{ for } i = A, P,$$

that is

$$PQ_i = \frac{PD_iD_i + PM_iM_i}{Q_i}, \text{ for } i = A, P. \tag{52}$$

The nested CES production function of private formal urban goods is also linearly homogeneous; prices of the composite inputs are therefore derived in similar fashion:

$$T_1PT_1 = T_2PT_2 + (1 + IL_{-1})(1 + ptax_U)W_MU_P, \tag{53}$$

$$T_2PT_2 = PROF_P + (1 + IL_{-1})(1 + ptax_S)W_SS_P, \tag{54}$$

where $PROF_P$, as defined below, denotes profits of private firms in the urban formal sector. These equations can be solved for PT_1 and PT_2.

The price of capital is constructed as a geometric weighted average of the prices of the goods for which there is investment demand, namely, the public good and private-formal urban good (see equations (38) and (39)):

$$PK = PQ_G^{zz_G} \cdot PQ_P^{zz_G}. \tag{55}$$

Markets for informal goods and government services clear continuously; equilibrium conditions are thus given by

$$Q_I^s = Q_I^d, \quad Q_G^s = Q_G^d.$$

In solving the model, we use equations (33) to determine the equilibrium quantities Q_I and Q_G, that is, equations (4) and (7), respectively. We use the demand equations (37) and (38) to solve residually for C_I and C_G, that is:

$$X_I - INT_I = C_I, \tag{56}$$

$$X_G - Z_P^G - INT_G = C_G. \tag{57}$$

Equation (41) for $i = I, G$, is then solved for $PQ_I = PD_I = PX_I$ and $PQ_G = PD_G = PX_G$, respectively.

Define discretionary consumption expenditure of household h, $COND_h$, as

$$COND_h = CON_h - \sum_i PQ_i x_{ih}, \tag{58}$$

and define the share of autonomous consumption of good i in total consumption of good i, ac_i, as

$$ac_i = \frac{\sum_h PQ_i x_{ih}}{PQ_i C_i} = \frac{\sum_h x_{ih}}{C_i}. \tag{59}$$

Then, from (41), we have

$$PD_i = PX_i = (1 - ac_i)^{-1} \cdot \left\{ \frac{\sum_h cc_{ih} COND_h}{C_i} \right\}, \quad i = I, G. \tag{60}$$

The aggregate price level, $PLEV$, or consumer price index, is a weighted average of individual goods market prices, PQ_i:

$$PLEV = \sum_i wt_i PQ_i, \tag{61}$$

where $0 < wt_i < 1$ denotes the relative weight of good i in the index, and $PQ_I = PD_I$ and $PQ_G = PD_G$. These weights are fixed according to the share of each of these goods in aggregate consumption in the base period.

The consumption price index for the rural sector is given by

$$P_R = \sum_i wr_i PQ_i,$$

whereas the consumption price indexes for urban unskilled and skilled workers are given by

$$P_{UU} = \sum_i wu_i PQ_i, \quad P_{US} = \sum_i ws_i PQ_i, \tag{62}$$

where the wr_i, wu_i and ws_i are relative weights with $\sum_i wr_i$, $\sum_i wu_i$ and $\sum_i ws_i$ summing to unity.

Finally, the deflator of GDP at factor cost is given by

$$PGDP_{FC} = \Sigma_i v_i PV_i, \tag{63}$$

where v_i are base-period weights satisfying $\Sigma_i v_i = 1$.

2.6 Profits and Income

Firms' profits are defined as revenue minus total labor costs. In the case of rural sector firms and urban informal sector firms, profits are given by

$$PROF_i = PV_iV_i - W_iU_i, \text{ for } i = A, I. \tag{64}$$

Profits of private-urban sector firms account for both working capital costs and salaries paid to both categories of workers, as well as payroll taxes:

$$PROF_P = PV_PV_P - (1+IL_{-1})(1+ptax_U)W_MU_P - (1+IL_{-1})(1+ptax_S)W_SS_P. \tag{65}$$

Firms' income is equal to profits minus interest payments on loans for investment purposes. Firms' income and profits are defined separately, because not all sectors are assumed to borrow on the credit market to finance investment. Specifically, we assume that only firms in the formal urban economy accumulate capital. Firms' income can thus be defined as:

$$YF_i = PROF_i, \text{ for } i = A, I, \tag{66}$$

$$YF_P = PROF_P - IL_{-1}DL_{P,-1} - IF \cdot ER \cdot FL_{P,-1} - PRIVR, \tag{67}$$

where IF is the interest rate paid on foreign loans (taken to be exogenous), $PRIVR$ is the flow of privatization expenditures (whose counterpart is a financing item of the government budget deficit), and DL_P and FL_P are the levels borrowed domestically and abroad by private urban firms for physical capital accumulation.[12]

Commercial banks' profits must also be taken into account. They are defined as the difference between revenues from loans to firms (be it for working capital or investment needs), income from government bonds, and interest payments on borrowing from the central bank plus interest payments on both households' deposits and foreign loans:

$$\begin{aligned} YF_{PB} &= IL_{-1}[DL_{P,-1} + (1+ptax_U)W_MU_P + (1+ptax_S)W_SS_P + IB \cdot B_{G,-1} \\ &\quad -IR \cdot DL^{BC}_{-1} - ID\sum_h DD_{h,-1} - IF \cdot ER \cdot FL_{B,-1}, \end{aligned} \tag{68}$$

[12] Note that in the model corporate income taxes on private sector firms (which represented about 2.4 percent of Brazilian GDP in 1996) are not explicitly accounted for in calculating net income. Given our assumption that rentiers and capitalists hold these firms, we have consolidated corporate income taxes and household income taxes for this category of household.

where ID is the interest rate on bank deposits, set by the central bank (see below).

Household income is based on the return to labor (salaries), distributed profits, transfers, and net interest receipts on holdings of financial assets. Households are defined according to the skills composition of the workforce and the sector of employment.

- There is one rural household, comprising all workers employed in the rural sector.
- In the urban sector there are two types of unskilled households, those working in the informal sector and those employed in the formal sector.
- The fourth household consists of skilled workers employed in the formal urban economy (in both the private and public sectors).
- There is a capitalist-rentier household, whose income comes from firms' earnings in the formal private sector, the rural sector, and commercial banks.

We further assume that households in both the rural sector and in the informal urban economy own the firms in which they are employed—an assumption that captures the fact that firms in these sectors tend indeed to be small, family-owned enterprises.

Using (64) and (66), income of the rural and informal sector households is given by

$$YH_i = \gamma_i TRH + PV_i X_i + ID \cdot DD_{i,-1} + IF \cdot ER \cdot FD_{i,-1}, \text{ for } i = A, I \quad (69)$$

where γ_i is the portion of total government transfers (TRH) each group receives, DD_i domestic bank deposits, and FD_i foreign bank deposits.

Income of the urban formal unskilled and skilled households, depends on government transfers, salaries and interests on deposits (domestic and foreign); firms provide no source of income, because these groups do not own the production units in which they are employed:

$$YH_{UF} = \gamma_{UF} TRH + (W_M U_P + W_{UG} U_G) + ID \cdot DD_{UF,-1} + IF \cdot ER \cdot FD_{UF,-1}, \quad (70)$$

$$YH_S = \gamma_S TRH + (W_S S_P + W_{SG} S_G) + ID \cdot DD_{S,-1} + IF \cdot ER \cdot FD_{S,-1}. \quad (71)$$

Firms' income (or net earnings) in the private urban sector goes to the capitalist-rentier household, who also receive commercial bank's income, YF_{PB}, and interest on deposits. Firms retain a portion re of their earnings for investment financing purposes, and transfer the remainder to the capitalist-rentier household. Thus, the capitalist-rentier household's income is:

$$\begin{aligned} YH_{KR} &= \gamma_{KR}TRH + ID \cdot DD_{KR,-1} + IF \cdot ER \cdot FD_{KR,-1} \\ &\quad + IB \cdot BB_{KR,-1} + (1-re)YF_P + YF_{PB}, \end{aligned} \tag{72}$$

where BB_{KR} denote government bond holdings by capitalists and rentiers, who are assumed to be the only category of households to hold such bonds.

2.7 Savings, Financial Wealth, and Investment

Each category of household h saves a fraction, $0 < srate_h < 1$, of its disposable income:

$$SAV_h = srate_h YH_h(1 - itax_h), \tag{73}$$

where $0 < itax_h < 1$ is the income tax rate applicable to household h.

The savings rate is a positive function of the real interest rate on deposits:

$$srate_h = s_{0,h}\left(\frac{1+ID}{1+PINF}\right)^{\sigma_{sav,h}}, \tag{74}$$

where $PINF = \Delta PLEV/PLEV_{-1}$ is the inflation rate in terms of the overall price index.

The portion of disposable income that is not saved is allocated to consumption:

$$CON_h = (1 - itax_h)YH_h - SAV_h.$$

Finally, the total flow of savings of each household is channeled into the accumulation of financial wealth, WT_h, which also accounts for valuation effects on the stock of foreign-currency deposits, FD_h, associated with changes in the nominal exchange rate:

$$WT_h = WT_{h,-1} + SAV_h + \Delta ER \cdot FD_{h,-1}. \tag{75}$$

Capital accumulation occurs only in the private urban sector. The decision to invest is assumed to depend on several factors. First, there is a positive effect of the after-tax rate of return to capital relative to the cost

of funds. Second, there is an accelerator effect, which aims to capture the impact of the desired capital stock on current investment. Third, there is a negative effect of the inflation rate, which may be viewed as a measure of macroeconomic instability, or of increased uncertainty about relative prices under high inflation, which makes investment decisions riskier. And fourth, there is a positive effect of the public capital stock in infrastructure. Formally, the investment function is given by

$$\begin{aligned} \frac{Z_P}{K_{P,-1}} &= \left(\frac{K_{INF}}{K_{INF,-1}}\right)^{\sigma_K} \left\{ (1+\frac{\Delta RGDP_{FC}}{RGDP_{FC,-1}})^{\sigma_{ACC}} \right. \\ &\quad \left. (1+PINF)^{-\sigma_P} \left(\frac{(1+IK)(1-itax_{KR})}{1+IL}\right)^{\sigma_{IK}} \right\}. \end{aligned} \tag{76}$$

where IK is the return to capital, IL the bank lending rate, and $itax_{KR}$ is the net of the income tax rate that capitalists and rentiers are subject to.

The second term in equation (76) captures the accelerator effect on private investment of changes in real GDP measured at factor cost, $RGDP_{FC}$, defined as

$$RGDP_{FC} = \Sigma_i PV_i X_i / PGDP_{FC}, \tag{77}$$

where $PGDP_{FC}$, the deflator of GDP at factor cost, is defined in (**??**).

The rate of return on capital is defined as the ratio of profits to the stock of capital:

$$IK = \frac{PROF_P}{PK \cdot K_P}. \tag{78}$$

Capital accumulation depends on the flow level of investment, Z, and the depreciation rate of capital from the previous period, δ_P:

$$K_P = K_{P,-1}(1-\delta_P) + Z_{P,-1}, \tag{79}$$

where $0 < \delta_P < 1$.

2.8 Financial Sector

In what follows we consider in turn the determination of the portfolio structure of households, the demand for credit by firms, and the behavior of commercial banks.

2.8.1 Households

Each household allocates instantaneously its stock of wealth to either money (in the form of cash holdings that bear no interest), H_h, domestic bank deposits, DD_h, foreign bank deposits, FD_h, or holdings of government bonds, BB_h:

$$WT_h = H_h + ER \cdot FD_h + DD_h + BB_h. \tag{80}$$

We assume that only capitalists and rentiers hold government bonds. Thus, in the above equation, $BB_h = 0$ for $h \neq KR$.

The demand function for currency is taken to be proportional to total consumption, as a result of a "cash-in-advance" constraint:

$$H_h^d = \psi_h CON_h, \tag{81}$$

where $\psi_h > 0$.[13]

The total demand for cash is thus

$$H^d = \sum_h H_h^d. \tag{82}$$

The demand for interest-bearing assets by rentiers and capitalists proceeds in two stages. First, they allocation a fraction of their non-monetary wealth, $WT_{KR} - H_{KR}$, to government bonds. Second, they allocate the remaining part of wealth, between domestic and foreign currency deposits. For all other households, since they do not hold government bonds, their portfolio choices are limited to the second stage.

Formally, the demand for government bonds by the capitalist-rentier household depends on prevailing interest rates, in standard fashion:

$$\frac{BB_{KR}^d}{WT_{KR} - H_{KR}} = \Psi_K \frac{(1+IB)^{\beta_{KB}}}{(1+ID)^{\beta_{KD}}} [(1+IF)(1+depr)]^{-\beta_{KF}}, \tag{83}$$

where IB is the rate of interest on public bonds, Ψ_K a shift factor, and $depr$ the expected rate of depreciation of the nominal exchange rate.

The portion of wealth that is not held in the form of noninterest-bearing currency and government bonds (for rentiers and capitalists) is allocated

[13] The assumption that the demand for cash depends on a "pure" transactions motive is a reasonable one in a low-inflation environment. In addition, we use this specification to estimate individual holdings of cash from the household survey, as explained below.

between domestic and foreign deposits. The relative proportions of holdings of each of these two categories of assets are taken to depend on their relative rates of return:

$$\frac{DD_h}{ER \cdot \ FD_h} = \phi_{Bh} \left(\frac{1 + ID}{(1 + IF)(1 + depr)} \right)^{\sigma_{Bh}}. \tag{84}$$

In solving the model, we use equation (84) to determine the optimal level of domestic bank deposits, whereas we use equation (80) to determine residually the level of foreign deposits, given (81) and (83).

2.8.2 Firms

Firms finance their investment plans, as defined above, through retained earnings and domestic (DL_P) and foreign (FL_P) loans:

$$PK \cdot Z_P = \Delta DL_P + ER \cdot \Delta FL_{P,-1} + re \cdot YF_P.$$

Solving this equation for DL_P gives us the demand for bank loans:

$$DL_P^d = DL_{P,-1} - ER \cdot \Delta FL_{P,-1} + PK \cdot Z_P - re \cdot YF_P. \tag{85}$$

The path of foreign loans is set exogenously. This implicitly accounts for ceilings that firms may face in their access to foreign markets.

2.8.3 Commercial Banks

Commercial banks are required to keep a portion $0 < rreq < 1$ of the deposits that they collect as reserve requirements, denoted RR:

$$RR = rreq \sum_h DD_h. \tag{86}$$

where $\sum_h DD_h$ denote total deposits from households. The balance sheet of commercial banks is

$$NW_B = DL_P + BB^C + RR - \sum_h DD_h - DL^{BC} - ER \cdot FL_B, \tag{87}$$

where NW_B is the net worth of commercial banks, $\sum_h DD_h$ domestic deposits, DL^{BC} borrowing from the central bank, and $ER \cdot FL_B$ foreign loans

(measured in domestic currency terms), DL_P loans to the private sector, and BB^C holdings of government bonds. NW_B changes over time according to

$$NW_B = NW_{B,-1} - \Delta ER \cdot FL_{B,-1}, \tag{88}$$

where the second term on the right-hand side represents capital losses (gains) associated with nominal exchange rate depreciations (appreciations).

Equation (85) represents the demand for loans. We assume that the actual stock of loans is demand determined, and that banks borrow from the central bank, at a given interest rate, the required "shortfall" given their domestic deposit base and foreign borrowing FL_B.[14] From the balance shee constraint (87), together with (86), we therefore have

$$DL^{BC} = DL_P^d + BB^C - (1 - rreq) \sum_h DD_h - ER \cdot FL_B - NW_B. \tag{89}$$

The demand for government bonds by commercial banks is given by

$$\frac{BB^C}{DL_P} = \phi_C (\frac{1 + IB}{1 + IL})^{\sigma_C}, \tag{90}$$

where $\phi_C > 0$. Thus, the demand for bonds by commercial banks (as a ratio of newt wealth) is positively related to the interest rate on these bonds and negatively to their opportunity cost, that is, the lending rate. As discussed below, the supply of loans by the central bank is infinitely elastic at the prevailing interest rate, implying that (89) is always satisfied.[15]

[14] An alternative to treating borrowing by commercial banks from central bank as endogenous and residually determined would be to take borrowing from the central bank as given and assume that excess liquid reserves adjust endogenously.

[15] Note that in the foregoing discussion we abstracted from "excess" liquid reserves, and considered only required reserves. In practice, commercial banks may also seek to hold "discretionary" reserves, in order to meet unexpected deposit withdrawals. Denoting by $ELIQ$, the demand for such reserves, equation (89) would be replaced by

$$\Delta DL^{BC} = \Delta DL_P^d + \Delta BB^C + \Delta ELIQ - (1 - rreq) \sum_h \Delta DD_h - \Delta FL_B \cdot ER,$$

with $ELIQ$ being determined by an equation similar to (90), with a negative sign on IB (as a measure of the opportunity cost of holding liquid assets), or more generally, through a joint process involving the decision to supply credit and to hold government bonds.

Banks set both deposit and lending interest rates. The deposit rate, ID, is set equal to the cost of funds provided by the central bank, IR:

$$ID = IR. \tag{91}$$

This specification implies that banks are indifferent as to their source of domestic funds—or, equivalently, deposits and loans from the central bank are viewed (at the margin) as perfect substitutes.

The loan rate is set as a premium over the marginal cost of funds. We assume that foreign borrowing is at the constrained level, so that marginal borrowing on world capital markets cannot occur. Thus, given (91), the marginal cost of funds is simply the cost of borrowing from the central bank, IR, taking into account as well the (implicit) cost of holding reserve requirements:

$$IL = \frac{IR}{1 - rreq} + PR, \tag{92}$$

where PR denotes the *finance premium*, which is assumed to be set according to:

$$PR = \xi_{pr} \left[\lambda_{pr} \left(\frac{\delta_c (NW_{P,-1} + DL_{P,-1})}{DL_{P,-1}} \right)^{-\gamma_{pr}} \right] + (1 - \xi_{pr}) PR_{-1}, \tag{93}$$

where $\gamma_{pr} > 0$, $0 < \xi_{pr} < 1$ is the speed of adjustment, $0 < \delta_c \leq 1$, and NW_P is the net worth of private urban firms in nominal terms, defined as

$$NW_P = PK \cdot K_P - DL_P - ER \cdot FL_P.$$

This specification captures the impact of collateralizable wealth on bank pricing decisions (see Bernanke, Gertler, and Gilchrist (2000)). The higher the value of the private capital stock net of foreign borrowing (that is, "pledgeable" collateral, $PK \cdot K_P - ER \cdot FL_P$, or an "effective" fraction δ_c of that amount) relative to the amount of domestic loans, DL_P, the higher the proportion of total lending that banks can recoup in the event of default by seizing borrowers' assets. This reduces the finance premium and the cost of borrowing, stimulating the demand for credit. A large nominal exchange rate depreciation (that is, a rise in ER), would reduce firms' net worth, thereby raising the cost of capital and leading to a contraction of

private investment.[16] There has not been much research on the link between collateral and bank interest rate spreads. As shown in the bottom panel of Figure 2, however, these spreads appear to follow a counter-cyclical pattern. This behavior is consistent with the view that in downswings, the value of borrowers' collateral tends to fall and the risk of default increases; as a result, banks tend to charge a higher premium, as hypothesized in (93). In the simulations reported below, we will assess the sensitivity of our results to alternative values of the parameter measuring the sensitivity of the premium to changes in net worth, γ_{pr}.

2.9 Public Sector

The public sector in our framework consists of the government and the central bank. We consider them in turn.

2.9.1 Central Bank and Monetary Policy

To model monetary policy we assume that the central bank exerts a direct influence over the rate at which it supplies (marginal) funds to commercial banks. Thus, monetary policy is operated via the central bank's control over a short-term interest rate, denoted IR. This instrument is the rate at which the central bank elastically supplies loans (or liquidity) to the commercial banking system in order for them to balance their overall sources of funds (including deposits and foreign borrowing) with their desired level of holdings of government bonds and loans to firms (which are demand determined). As noted earlier, the bank deposit rate is modeled as having a fixed relationship (in fact, one to one) with the official rate. Evidence of this relationship for Brazil is shown in the upper panel of Figure 1, which displays the behavior of deposit rates and the money market rate (itself closely linked to the

[16] An alternative justification for the finance premium equation (93) can be found in the models of credit market imperfections recently developed by Agénor and Aizenman (1998, 1999*b*). These models, following Townsend (1979), emphasize the importance of monitoring and enforcement costs of loan contracts that lenders face in a weak legal environment—as is so often the case in developing countries. In such an environment, these costs may be an *increasing* function of the amount lent (even against "good" collateral) because of congestion in courts and the difficulty of settling legal claims, which make it hard for lenders to actually seize borrowers' assets in case of default. This approach amounts to specifying the premium as a positive function of the ratio of the amount lent DL_P over "effective" collateral.

Bank of Brazil's repurchase rate) over the period 1995-2003. Monetary policy therefore operates to a large extent through commercial banks.

Note also that we could endogenize the official interest rate by specifying a monetary policy rule that relates IR to deviations of output from target, as well as an output target, along the lines of the "flexible inflation targeting framework" that Brazil has adopted since June 1999 (see Bogdanski, Tombini, and Werlang (2000)). Such a rule could be specified, for instance, as

$$\Delta IR = \kappa_1(PINF_{-1} - PINF^*) - \kappa_2 \ln(\frac{RGDP_{-1}}{RGDP^T_{-1}}) + \kappa_3 \Delta \ln ER_{-1}, \quad (94)$$

where $\kappa_1, \kappa_2, \kappa_3 > 0$, $PINF^*$ is the government's inflation target, $\Delta \ln ER$ the rate of depreciation of the nominal exchange rate, and $RGDP$ and $RGDP^T$ denote the actual and trend values of real GDP. Such a rule would be defined as "backward-looking"; by using the one-period ahead inflation rate, $PINF_{+1}$, instead of $PINF$ would make it forward-looking and more consistent with a "true" inflation targeting rule (see Agénor (2002*b*)).

From the balance sheet of the central bank, its net worth, NW_{CB}, is given by

$$NW_{CB} = DL^{BC} + ER \cdot FF - MB, \quad (95)$$

where DL^{BC} denotes loans to commercial banks, and FF the stock of foreign reserves, taken as exogenous.

Assuming no operating costs, net profits of the central bank, $PROF^{CB}$, are given by the sum of interest receipts on loans to commercial banks (at the rate IR, treated as exogenous) and interest receipts on holdings of foreign assets:

$$PROF^{CB} = IR \cdot DL^{BC}_{-1} + IF_G ER \cdot FF. \quad (96)$$

where IF_G is the interest rate on government foreign loans. We assume in what follows that net profits of the central bank are transferred entirely to the government. Given (96), the central bank's net worth evolves over time according to:

$$NW_{CB} = NW_{CB,-1} + \Delta ER \cdot FF, \quad (97)$$

where the last term represents valuation effects. Put differently, the capital gains and losses on the domestic-currency value of foreign reserves associated

with exchange rate changes are absorbed via changes in the central bank's net worth, and do not affect the monetary base.

Given that (97) determines changes in NW_{CB}, and that loans to commercial banks are endogenous (as a result of the assumption of a perfectly elastic supply of liquidity at the prevailing official interest rate) the base money stock is also endogenously determined and its evolution can be derived from the balance sheet equation (**??**):

$$MB = DL^{BC} + ER \cdot FF - NW_{CB}. \tag{98}$$

2.9.2 Government

We assume that government expenditures consist of government consumption, which only has demand-side effects, and public investment, which has both demand- and supply-side effects. Public investment consists of investment in infrastructure, education, and health.[17] We define investment in infrastructure as the expenditure affecting the accumulation of public infrastructure capital, which includes public assets such as roads, power plants and railroads. Investment in education affects the stock of public education capital, which consists of assets such as school buildings and other infrastructure affecting skills acquisition, but does not represent human capital. In a similar fashion, investment in health adds to the stock of public assets such as hospitals and other government infrastructure affecting health.

Government saving is defined as minus the government budget deficit:

$$\begin{aligned} -DEF &= (PV_G V_G - W_{UG} U_G - W_{SG} S_G) + PROF^{CB} \\ &\quad + TXREV - TRH - PQ_P(G_P + Z_G) \\ &\quad - IF \cdot ER \cdot FL_{G,-1} - IB \cdot BB_{-1}, \end{aligned} \tag{99}$$

where BB denotes the total stock of bonds held by banks and households:[18]

$$BB = BB_{KR} + BB^C. \tag{100}$$

[17] It should be noted that this treatment of public investment differs from standard data classification reported in national accounts; in many instances these investments are classified as current expenditures.

[18] Note that in the above setting total demand for government bonds consists of demand by capitalists and commercial banks. Neither the central bank, nor non-residents, are assumed to hold government bonds. These modifications can be easily added.

The term in parentheses represents profits by the government from sales of the public good. $TXREV$ denotes total tax revenues whereas TRH is total government transfers to households. G represents government spending on goods and services. $PROF^{CB}$ represent profits from the central bank. The final two terms in the government budget include interest payments on loans from abroad, and interest payments on government bonds held by commercial banks and the public.

Using the definition of net profits of the central bank given in equation (96), government saving can be rewritten as

$$\begin{aligned} -DEF &= (PV_G X_G - W_{UG} U_G - W_{SG} S_G) + TXREV \\ &\quad -TRH - PQ_P(G_P + Z_G) - IF \cdot ER(FL_{G,-1} - FF) \\ &\quad +IR \cdot DL_{-1}^{BC} - IB \cdot BB_{-1}. \end{aligned} \tag{101}$$

Total tax revenues, $TXREV$, consist of revenue generated by import tariffs, sales taxes, income taxes, and payroll taxes:

$$\begin{aligned} TXREV &= ER \sum_{i=A,P} wpm_i tm_i M_i + \sum_i dtax_i PX_i X_i + itax_{KR} YH_{KR} \\ &\quad +itax_r(YH_{AT} + YH_{AN}) + itax_{UU}(YH_{UF} + YH_S) \\ &\quad +ptax_U W_M U_P + ptax_S W_S S_P. \end{aligned} \tag{102}$$

Public investment, Z_G, is the sum of public investment in infrastructure, I_{INF}, in health, I_H, and in education, I_E, all of them considered exogenous:

$$Z_G = I_{INF} + I_E + I_H. \tag{103}$$

Government investment increases the stock of public capital in either infrastructure, education or health. The stock of public capital in education includes items such as school buildings, whereas the stock of health capital includes hospitals and the like. Infrastructure capital includes all other stocks of public property, such as roads, railroads, and power plants.

Accumulation of each type of capital is defined as:

$$K_i = K_{i,-1}(1 - \delta_i) + I_{i,-1}, \quad i = INF, H, E, \tag{104}$$

where $0 < \delta_i < 1$.

Infrastructure and health capital affect the production process in the private sector as they both combine to produce the stock of government capital, K_G:

$$K_G = CES(K_{INF}, K_H). \tag{105}$$

The government deficit, net of privatization revenues, $PRIVR$, is financed by either an increase in foreign loans, or by issuing bonds:

$$DEF - PRIVR = ER \cdot \Delta FL_G + \Delta BB. \tag{106}$$

Equivalently, the supply of government bonds is given by

$$BB^s = BB^s_{-1} + DEF - PRIVR - ER \cdot \Delta FL_G. \tag{107}$$

Finally, the net worth of the government, NW_G, is defined as:

$$NW_G = PK(K_G + K_E) - BB^s - ER \cdot FL_G. \tag{108}$$

From (95) and (108), the net worth of the consolidated public sector, NW_{PS}, is given by

$$NW_{PS} = PK(K_G + K_E) + DL^{BC} - BB^s + ER \cdot (FF - FL_G) - MB. \tag{109}$$

2.10 Balance of payments and the exchange rate

Because foreign reserves are constant, the balance of payments constraint implies that any current account surplus (or deficit) must be compensated by a net flow of foreign capital, given by the sum of changes in households' holdings of foreign assets, $\sum_h \Delta FD_h$, changes in foreign loans made to the government, ΔFL_G, and to private firms, ΔFL_P (both taken to be exogenous), changes in loans to domestic banks, ΔFL_B,all measured in foreign-currency terms:[19]

$$\begin{aligned} 0 \;=\; & \sum_{i=A,P} (wpe_i E_i - wpm_i M_i) + IF \sum_h FD_{h,-1} \\ & -IF \cdot FL_{P,-1} - IF_G(FL_{G,-1} - FF) - IF \cdot FL_{B,-1} \\ & - \sum_h \Delta FD_h + \Delta FL_G + \Delta FL_P + \Delta FL_B. \end{aligned} \tag{110}$$

[19] It is not necessary, in fact, to set ΔFF equal to zero; it can simply be made exogenous. Doing so would allow the model to account for central bank intervention aimed at managing the exchange rate.

Equation (110) determines implicitly the equilibrium nominal exchange rate. When solving the model, we actually use (110) to solve for E_P; the equation for E_P, (44) is then used to solve for PE_P and the identity (48) is used to obtain the nominal exchange rate as $ER = PE_P/wpe_P$.

Another issue related to the exchange rate is the treatment of the expected nominal depreciation rate, *depr*, which affects portfolio decisions and the pricing rule of commercial banks. We assume that the expected rate of depreciation is a weighted average of last period's expected depreciation rate and the lagged change in the real exchange rate, defined as the difference between domestic inflation (given in (**??**)) and foreign inflation, $FINFL$, measured in domestic-currency terms:

$$depr = \chi depr_{-1} + (1-\chi)[PINF_{-1} - (FINFL_{-1} + \Delta ER_{-1}/ER_{-2})], \quad (111)$$

where $0 < \chi < 1$.[20]

2.11 Currency and Bond Market Equilibrium

The monetary base, MB, consists of the supply of currency in circulation, H^s, and reserve requirements, RR. Because we assume that the supply of loans to commercial banks by the central bank is infinitely elastic at the interest rate IR, and that DL^{BC} is determined by (89), the supply of currency is given by, using (86):

$$H^s = MB - rreq \sum_h DD_h.$$

Equality between the supply and demand for cash requires that, using (82):

$$H^s = H^d = \sum_h H_h^d. \quad (112)$$

When solving the model, the equilibrium condition (112) is dropped from the system as a result of Walras' law—if all other markets but the money market are in continuous equilibrium, then the money market must be in

[20] Alternatively, it could be assumed that expectations are forward looing (or, more precisely, model consistent), so that the expected depreciation rate is equal to the one-period ahead "actual" rate, as derived from the model itself. This, however, is a lot more involved from a computational standpoint; see for instance Thissen and Lensink (2001).

continuous equilibrium as well.[21] That this is indeed the case is checked automatically in the numerical solutions that we report below.

Finally, the interest rate that equilibrates the market for government bonds, IB, is given as the solution of

$$BB^s = BB^d_{KR} + BB^C, \tag{113}$$

or, using (83) and (90):

$$\begin{aligned} BB^s &= \phi_C DL_P \left(\frac{1+IB}{1+IL}\right)^{\sigma_C} \\ &\quad + \Psi_K (WT_{KR} - H_{KR}) \frac{(1+IB)^{\beta_{KB}}}{(1+ID)^{\beta_{KD}}} [(1+IF)(1+depr)]^{-\beta_{KF}}. \end{aligned} \tag{114}$$

In the actual solution of the model, we use (83) to solve for BB^d_{KR}, and equation (107) for BB^s. We then use the identity (113) to solve for BB^C, and invert equation (90) to solve for IB.

The financial balance sheets of each group of agents are presented in summary form in Table 1. The logical structure of IMMPA-Brazil is summarized in Figure 2.

3 Poverty and Income Distribution Indicators

Two measures of income distribution are generated directly from IMMPA: the Gini coefficient and the Theil inequality index.[22] Both are based on the six categories of households that were identified earlier, that is, workers located in the rural sector, urban (unskilled) informal economy, urban unskilled formal sector, urban skilled formal sector, and capitalists-rentiers. Formally, they are defined as

$$\text{Gini} = \frac{1}{2n^2 \cdot YH_M} \sum_h \sum_j |YH_h - YH_j|, \qquad h, j = A, UI, UF, S, KR,$$

[21] Note that alternatively, we could have dropped the equilibrium condition of the bonds market and solved the money market equilibrium condition for interest rate on government bonds.

[22] Other commonly-used indicators include the Atkinson index which, like the Gini index, range from 0 to 1. For a detailed analytical discussion of the pros and cons of various measures of income inequality, see Cowell (1998).

where $n = 6$ is the number of household categories and $YH_M = YH_i/n$ is the arithmetic mean level of disposable income for household categories.

The Theil inequality index is measured as

$$\text{Theil} = \frac{1}{n}\sum_h \frac{YH_h}{YH_M}\log(\frac{YH_h}{YH_M}), \qquad h = A, UI, UF, S, KR,$$

and other variables are as defined above. We also calculate these two indicators using consumption, instead of disposable income.

Following a shock, IMMPA generates three measures for these indicators (as well as those derived from household surveys, as discussed below): a *short-term* measure (first two periods following a shock), a *medium-term* measure (between 3 and 5 periods), and a *long-term* measure (between 6 and 10 periods).[23]

To assess the poverty effects of alternative shocks, we link IMMPA to a household income and expenditure survey. Our poverty indexes are the poverty headcount index (the ratio of the number of individuals in the group whose income is below the poverty line to the total number of individuals in that group. The poverty gap index is defined as:

$$P_G = \frac{1}{n \cdot YH^*}\sum_{k=1}^{n}(YH^* - YH_k),$$

where k is an individual whose income is below the poverty line, n is the total number of people in the group below the poverty line, YH_k is the income of individual k, and YH^* is the poverty line.

The procedure for calculating these poverty and distributional indicators is described at length in Agénor, Izquierdo, and Fofack (2003) and Agénor and Grimm (2003). It can be summarized as follows:

- **Step 1**. Classify the data in the household survey into the categories of households contained in mini-IMMPA. Here, in contrast to the low-income IMMPA prototype, there are only five categories of households—workers in the rural sector, those in the urban (unskilled) informal economy, urban unskilled workers in the formal sector, urban skilled workers in the formal sector, and capitalists-rentiers.

[23] See Agenor, Izquierdo and Fofack (2001) for a more detailed description of the way these indicators are derived.

- **Step 2**. Following a shock, generate real growth rates in per capita consumption and disposable income for all five categories of households, up to the end of the simulation horizon (say, T periods).
- **Step 3**. Apply these growth rates separately to the per capita (disposable) income and consumption expenditure for each household in the survey. This gives a new vector of absolute income and consumption levels for each group.
- **Step 4**. Calculate poverty and income distribution indicators, using the new absolute nominal levels of income and consumption for each individual and each group, and after updating the initial rural and urban poverty lines to reflect increases in rural and urban price indexes.
- **Step 5**. Compare the post-shock poverty and income distribution indicators with the baseline values to assess the impact of the shock on the poor.

4 Data and Calibration

This section briefly reviews the structure of the financial SAM that underlies IMMPA-Brazil, the household survey data that we use to link the macro component to our poverty and income distribution assessments, and the parameter values that we used to calibrate the behavioral equations. A detailed description of the data and adjustment procedures used to construct the financial SAM are provided in Haddad, Fernandes, Domingues, Perobelli, and Afonso (2003). The model itself is solved using a combination of GAMS and Excel; the computer programs that we use are described in a separate note (see van der Mensbrugghe (2003)).

4.1 The Financial SAM

To build the necessary data to calibrate IMMPA-Brazil involved two steps. First, a balanced aggregate SAM was constructed. Second, using the aggregate SAM and additional structural data, we constructed a balanced disaggregated SAM. This procedure guarantees that the disaggregated SAM matches the aggregate SAM, and provides controls over totals for each block.

Brazilian national accounts data for 1996 were used to compile the macro data for the real part of the SAM. We collected aggregate data for intermediate consumption, exports, imports, investment (capital formation plus inventory changes), output taxes, import taxes, household consumption, government consumption, wage taxes, wages, and profits. Wage taxes are the required and imputed payments over labor and other payments to workers. Wages are the sum of labor payments and payments to autonomous workers. Profits are the total of gross surplus by activities. Working capital requirements were obtained as a residual. Information about direct taxes and property taxes, transfers to households (social security payments and other benefits) and interest payments (domestic and foreign) were taken from public administration accounts. Government financial allocation on domestic banks and foreign banks were also obtained, related to domestic interest payments and foreign interest payments.

Financial data used in the aggregate SAM were obtained from the database of the Central Bank of Brazil: currency in circulation, domestic deposits and bonds held by households; and domestic banks' holdings of domestic bonds. The allocation of domestic banks assets' were completed with information about profits, credit to the private sector, changes in bank reserves and holdings of foreign bonds. Foreign financing to domestic firms (the variable FL_P defined above) is calculated in "net" terms by adding loans by foreign banks to domestic firms (for investment purposes) plus foreign direct investment (plus stocks and derivatives) minus domestic bonds issued by domestic firms. Foreign loans to government are obtained directly from the balance of payments.

The initial (unbalanced) aggregate SAM was obtained from the initial data, then a posterior (balanced) aggregate SAM was obtained by the application of a RAS procedure, to square out statistical errors. Changes in each cell, from the unbalanced to the balanced aggregate SAM, were checked to ensure consistency. The second step was to obtain a more detailed financial SAM, disaggregating relevant cells into their components. As noted earlier, in IMMPA-Brazil, households are separated in five groups (rural household, urban informal household, urban unskilled labor household, urban skilled labor household and rentier household). Goods are disaggregated into four sectors: agriculture (or rural), informal sector, private formal sector and public sector. Labor payments are disaggregated in two components, skilled and unskilled labor.

The main data sources for compiling the disaggregated and sectoral infor-

mation are the available input-output tables for Brazil. Sales and purchases for up to 42 sectors were available; this information was mapped into the four IMMPA sectors. The agriculture and public sectors were mapped directly to the IMMPA classification. A mapping structure was created from PNAD household survey data (see the description below) in order to separate formal and informal activities. Shares in the industry and services sectors were used to measure the informal economy; the private formal sector was constructed as a residual. This mapping was also used to establish the distribution of household consumption and the composition of foreign trade. Production taxes by sector were derived from the estimated production, taking into account that the informal activity pays no taxes. Import taxes were allocated to reflect import flows. Wage taxes were allocated to sectors using the effective tax rate for agriculture, with the residual tax revenue allocated to the private and public sectors, in line with labor payments in these sectors (by definition, the informal economy pays no wage taxes). Borrowing for short-term working capital needs by the urban private sector was calculated by taking into account the sector's wage payments.

Following the cash-in-advance specification of money demand by households described above (see (81)), the allocation of currency in circulation and domestic bank deposits followed household consumption shares. Direct taxes were allocated in the same way, taking into account that urban informal sector households do not pay direct taxes. By assumption, all government bonds were assumed to be held by capitalists-rentiers. Finally, PNAD survey data were used to derive the composition of government transfers to households.

A preliminary, unbalanced disaggregate SAM showed differences in rows and column sums in the various sectors and households blocks. An important discrepancy was between households' income and expenditures. The estimated income for each household group was used as a benchmark to adjust the expenditure on goods. A RAS procedure was implemented to adjust the household consumption block, and subsequently the intermediate consumption block.

Other stock data, on household financial wealth and physical capital of the government and the private sector, were also necessary to calibrate IMMPA-Brazil. Some information on these stocks was obtained from the same sources from which the flow data were taken. Data for the stock of public capital in infrastructure, and the private capital stock, were taken from the IPEA (*Instituto de Pesquisa Economica Aplicada*) database. To calculate data for the stock of public capital in education and health, we used flow data from the

government budget on these components, and a perpetual inventory method (with an annual depreciation rate set at 4 percent) to calculate them.

4.2 The Household Survey Data

To simulate the impacts of policy and exogenous shocks on poverty and income distribution in the IMMPA-Brazil we used two Brazilian household surveys: the *Pesquisa Nacional por Amostra de Domicílios – PNAD* (National Household Survey) and the *Pesquisa de Padrões de Vida – PPV* (Living Standard Survey). The PNAD is the main Brazilian household survey, conducted by the *Instituto Brasileiro de Geografia e Estatística* – IBGE since 1976. The interviews are carried out in October and the information is relative to September. In each year the PNAD interviews around 100,000 households, randomly selected, in the whole country. The number of visits to households in PNAD is limited to one, making it difficult for someone to capture short run fluctuations in the household income. Even though PNAD does not investigate consumption expenditures patterns of households, it contains a very rich information set on personal and household characteristics, such as those related specifically to housing (e.g. quality, size and ownership), durable goods, family composition, income, location, demography, education, and work status for each member of the family. The information set on work status permits us to classify the households into the income groups of IMMPA-Brazil. The PPV was carried out by IBGE in 1996. It contains information (also available in PNAD) on personal and household characteristics. Moreover, it has rich information on patterns of households consumption expenditures. PPV, however, has a limited coverage when compared to PNAD: it has been conducted only in the Southeast and Northeast regions (urban and rural areas), and the sample size is relatively small (around 5,000 households). Estimates from PNAD for the year 1996 are used in simulations for income-based indicators, while PPV is used in simulations for consumption-based poverty and inequality measures. When using PPV, the entire sample was considered, but in the PNAD case, for operational reasons, a representative sub-sample of 10% of the original sample was drawn. The size of the sub-sample from PNAD includes around of 10,000 households and the whole PPV sample 5,000 households. To classify the samples into the categories of households used in IMMPA-Brazil, we used information on years of schooling and occupational status for the head each household. The division between skilled and unskilled workers was based on

the years of schooling variable. Those workers with, at least, one year of high school (9 or more years of schooling) were considered skilled, and those with less than 9 years of schooling were considered unskilled. To distinguish between rural and urban workers we used the activity sector (agriculture vs. non-agriculture), instead of residence area (rural vs. urban). Finally, the nature of urban employment was considered formal or informal according to both occupational status and years of schooling of the workers. When the head of the household was unemployed, we used information on the last job. So, the household classification into the IMMPA-Brazil income categories is as follows:

- *Rural sector group.* It is formed by all households whose head works in agricultural activities.
- *Unskilled informal group.* It is formed by all households whose head is unskilled, works in non-agricultural activities and does not have a formal labor contract.
- *Unskilled formal group.* It is formed by *a*) all households whose head is unskilled and has a formal labor contract and his job is in the non-agricultural and non-public sector; and *b*) all households whose head is an unskilled public server.
- *Skilled group.* It is formed by *a*) all households whose head is skilled, works in the non-agricultural and non-public sector; *b*) all households whose head is a skilled public server.
- *Capitalists-rentiers group.* It is formed by all households whose head is an employer.

The urban poverty line was fixed in R$ 56,00, corresponding to half minimum wage of September 1996. In the rural area the poverty line was fixed in 60 percent of the urban poverty line (R$ 33,60). Figure 3 shows the average household per capita income for each IMMPA income category for 1992, 1996 and 2001. Between 1992 and 1996, real income increased for all groups, whereas between 1996 and 2001 it went down. For the whole period, formal workers' income (skilled and unskilled) recorded the smallest growth rate (about 10 percent), whereas the capitalists-rentiers group was the group that experienced the largest increase: a growth rate of about 42

percent of income. An interesting aspect refers to the fact that income for informal workers household is very close of income for unskilled formal workers household, indicating that the main difference is due to the qualification of workers, instead of the position in the urban labor market. It is worth to point out, however, that the household income includes the income of all the members of the household, as well as all the sources.

Figures 4 to 6 show the distribution of income within each group, as constructed from our sample of observations. The figures indicate that the log-normal distribution provides an adequate characterization of income dispersion within each group.

4.3 Parameter Values

We have estimated elasticities for the investment function (equation (76)). Annual data for the period 1970-2000 were collected from the IPEA database. The capital stock of the public administrations in construction was taken as a proxy for capital stock in infrastructure, K_{INF}, and the capital stock of firms and households was taken as a proxy for the private capital stock, K_P. Private fixed capital formation was used as a proxy for private investment, Z. Data on the operating surplus of firms was used to calculate the rate of return to private capital, IK (see (78)). The net income tax rate that capitalists-rentiers are subject to, $itax_{KR}$, was obtained from the actual taxes paid by firms on their operating surplus, divided by firms' total revenue. Changes in the general price index (IGP-DI) was used to calculate the inflation rate, $PINF$. A log-linear transformation of equation (76) was estimated using an error-correction framework, following standard techniques (see for instance Greene (2000)). The estimated results (which are discussed in more detail in Haddad, Fernandes, Domingues, Perobelli, and Afonso (2003)) yield the following elasticities: $\sigma_K = 0.860$, $\sigma_{ACC} = 2.054$, $\sigma_P = -0.021$, and $\sigma_{IK} = 0.022$. All these estimates are significant and have the expected sign, although the coefficient measuring the accelerator effect appears to be on the high side, compared to other estimates for Brazil.[24]

[24] Melo and Rodrigues (1998), in particular, found an elasticity of 1.157 for output growth.

5 High Interest Rates, Unemployment and Poverty

This section examines the impact of a transitory (one-period only) increase in the refinance rate that the central bank charges commercial banks, IR.[25] In what follows, we assume that both the minimum wage, W_M and the wage rate paid to unskilled labor in the public sector, W_{UG}, are fully indexed to the consumer price index:

$$W_M = \omega_M \cdot PLEV, \quad W_{UG} = \omega_{UG} \cdot PLEV, \tag{115}$$

where ω_M and ω_{UG} measure real wages in constant terms.

A rise in the cost of liquid resources from the central bank leads commercial banks to raise by the same amount the interest rate on bank deposits (see 91); at the initial level of the risk premium (as given in (92)), the lending rate increases. This has two types of effects. First, because the effective cost of labor rises, firms in the urban formal sector reduce the demand for skilled and unskilled. This increases on impact the open unemployment rate for both categories of workers. Second, the higher cost of borrowing tends to lower private investment and capital accumulation. At the same time, the reduced demand for labor puts downward pressure on wages, mitigating therefore the increase in unemployment. The fall in the expected urban wage also lowers migration flows from rural areas; the supply of labor in the urban informal sector falls, pushing wages up. The reduction in wages in the rural sector (due to the relative increase in the supply of labor) stimulates output. The net effect is an increase in disposable income in the rural sector and a reduction in income for both skilled and unskilled workers in urban areas.

[TO BE COMPLETED]

6 Conclusions

In this paper we have developed a quantitative framework for analyzing the impact of adjustment policies on output, wages, unemployment, poverty and income distribution in Brazil. In doing so we modified and extended in

[25] Since the implementation of the Real Plan in July 1994, the manipulation of short-term interest rates has been the major instrument through which Brazil's central bank conducts its monetary policy.

several directions the low-income IMMPA prototype developed by Agénor, Izquierdo, and Fofack (2003). Specifically, we introduced several features that we believe are important to capture some of the most salient structural characteristics of the Brazilian economy, namely, open unskilled urban unemployment, congestion effects associated with the use of public infrastructure in urban areas, bond financing of public sector deficits, a flexible exchange rate, an interest rate-based monetary policy rule, and payroll taxation. After explaining in detail the components of the model, we described its underlying accounting framework (namely, the financial SAM on which it is based), the household survey data used to assess poverty and distributional effects, the choice of parameters, and the solution procedure. The properties of the model were illustrated by describing the effects of a temporary (one-period only) increase in the short-term official interest rate. We also performed some sensitivity analysis of the base case and highlighted the important role played by the commercial banks' premium-setting equation, which relates the lending rate (determined as a markup over refinancing costs) to firms' net worth.

The model can be used to address a variety of issues that are at the forefront of the policy agenda in Brazil. In particular, it can be used to examine the growth, employment, and poverty effects of a reallocation of public expenditure, with a comparison between changes in transfers, spending on infrastructure, and spending on education or health (as in Agénor, Izquierdo, and Fofack (2003)), an increase in the minimum change (as in Foguel, Ramos, and Carneiro (2001), and a reduction in the payroll tax rate on unskilled labor.

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Appendix A
List of Equations

PRODUCTION[26]

$$X_j = V_j + \sum_i a_{ij} X_j \tag{A1}$$

$$V_A = \left[\alpha_{XA}\{\beta_{XA} U_A^{-\rho_{XA}} + (1-\beta_{XA}) K_G^{-\rho_{XA}}\}^{-\frac{1}{\rho_{XA}}}\right]^{1-\eta_{XA}} \tag{A2}$$

$$X_i = \alpha_{Ti}\{\beta_{Ti} E_i^{\rho_{Ti}} + (1-\beta_{Ti}) D_i^{\rho_{Ti}}\}^{\frac{1}{\rho_{Ti}}} \quad \text{for } i = A, P \tag{A3}$$

$$V_I = \alpha_{XI} U_I^{\beta_{XI}} \tag{A4}$$

$$\begin{aligned} V_G \;=\; & \alpha_{XG}\{\beta_{XG1}[\beta_{XG2} S_G^{-\rho_{XG2}} + (1-\beta_{XG2}) U_G^{-\rho_{XG2}}]^{\frac{\rho_{XG1}}{\rho_{XG2}}} \\ & +(1-\beta_{XG1}) K_G^{-\rho_{XG1}}\}^{-\frac{1}{\rho_{XG1}}} \end{aligned} \tag{A5}$$

$$V_P = \alpha_{XP}\{\beta_{XP} T_1^{-\rho_{XP}} + (1-\beta_{XP})(\frac{K_{G,-1}}{L_{U,-1}^{pc}})^{-\rho_{XP}}\}^{-\frac{1}{\rho_{XP}}} \tag{A6}$$

$$T_1 = \alpha_{XP1}\{\beta_{XP1} T_2^{-\rho_{XP1}} + (1-\beta_{XP1}) U_P^{-\rho_{XP1}}\}^{-\frac{1}{\rho_{XP1}}} \tag{A7}$$

$$T_2 = \alpha_{XP2}\{\beta_{XP2} S_P^{-\rho_{XP2}} + (1-\beta_{XP2}) K_P^{-\rho_{XP2}}\}^{-\frac{1}{\rho_{XP2}}} \tag{A8}$$

$$RGDP_{FC} = \Sigma_i PV_i X_i / PGDP_{FC} \tag{A9}$$

EMPLOYMENT

$$U_A^d = \left(V_A^{1+\frac{\rho_{XA}}{1-\eta_{XA}}} \frac{(1-\eta_{XA}) PV_A}{W_A} \cdot \frac{\beta_{XA}}{\alpha_{XA}^{\rho_{XA}}}\right)^{\frac{1}{1+\rho_{XA}}} \tag{A10}$$

$$U_R^s = U_A^d(V_A, \frac{W_A}{PV_A}) \tag{A11}$$

$$U_R^s = U_{R,-1}^s(1+g_R) - MIGR \tag{A12}$$

$$MIGR = \lambda_m \left[U_{R,-1}\sigma_M \ln\left(\frac{Ew_U}{Ew_A}\right)\right] + \frac{U_{R,-1}}{U_{R,-2}}(1-\lambda_m) MIGR_{-1} \tag{A13}$$

[26] The index i or j (respectively, h) is used below to refer to all production sectors (household groups, respectively), that is, A, G, I, P (A, I, UF, S, KR, respectively), unless otherwise indicated.

$$Ew_U = \frac{\theta_U W_{M,-1} + (1-\theta_U) W_{I,-1}}{P_{UU,-1}} \tag{A14}$$

$$\theta_U = \frac{U_{P,-1}}{U_{F,-1} - U_{G,-1}} \tag{A15}$$

$$Ew_A = \frac{W_{A,-1}}{P_{R,-1}} \tag{A16}$$

$$U_P^d = T_1 \left(\frac{\beta_{XP1}}{\alpha_{XP1}^{\rho_{XP1}} w_M (1+IL_{-1})(1+ptax_U)} \right)^{\sigma_{XP1}} \tag{A17}$$

$$U_U = U_{U,-1}(1+g_U) + MIGR - SKL \tag{A18}$$

$$U_I^s = U_U - U_F^s \tag{A19}$$

$$\Delta U_F^s = \beta_F \left\{ \frac{U_{P,-1}^d}{U_{F,-1}^s - U_{G,-1}} (\frac{W_{M,-1}}{P_{UU,-1}}) - \frac{W_{I,-1}}{P_{UU,-1}} \right\} \tag{A20}$$

$$UNEMP_U = 1 - \frac{(U_G + U_P^d)}{U_F^s}. \tag{A21}$$

$$S_P^d = T_2 \kappa_s \left(\frac{\beta_{XP2}}{\alpha_{XP2}^{\rho_{XP2}} w_S (1+IL_{-1})(1+ptax_S)} \right)^{\sigma_{XP2}} \tag{A22}$$

$$S = (1-\delta_S) S_{-1} + SKL \tag{A23}$$

$$L_U = U_U + S. \tag{A24}$$

$$UNEMP_S = \frac{S - S_G - S_P^d}{S} \tag{A25}$$

$$W_M = w_M (PLEV)^{ind_M} \tag{A26}$$

$$W_I = \beta_{XI} \frac{V_I}{U_I^s} PV_I \tag{A27}$$

$$W_{SG} = \omega_{SG} P_{US} \tag{A28}$$

$$W_S = w_S (PIND_S)^{ind_S} (UNEMP_S)^{-\phi_U} \Omega_W^{\phi_1} \left(\frac{P_{US}}{PT_2} \right)^{\phi_2} \tag{A29}$$

$$SKL = \lambda_S \left[\kappa_e \left(\frac{Ew_S}{Ew_U} \right)^{\sigma_W} (K_{E,-1})^{\sigma_E} \right] + (1-\lambda_S) SKL_{-1} \tag{A30}$$

$$Ew_S = \theta_S \frac{W_{S,-1}}{P_{US,-1}} \tag{A31}$$

$$\theta_S = \frac{S_{P,-1}}{S_{-1} - S_{G,-1}} \tag{A32}$$

SUPPLY AND DEMAND[27]

$$INT_i = \sum_j a_{ij} X_j \tag{A33}$$

$$Q_i^s = \alpha_{Qi}\{\beta_{Qi} M_i^{-\rho_{Qi}} + (1-\beta_{Qi}) D_i^{-\rho_{Qi}}\}^{-\frac{1}{\rho_{Qi}}} \quad \text{for } i = A, P \tag{A34}$$

$$Q_i^s = X_i \quad \text{for } i = I, G \tag{A35}$$

$$Q_i^s = Q_i^d \quad \text{for } i = G, I \tag{A36}$$

$$Q_A^d = C_A + INT_A \tag{A37}$$

$$Q_I^d = C_I + INT_I \ \ \text{(solved for } C_I) \tag{A38}$$

$$Q_G^d = C_G + Z_P^G + INT_G \tag{A39}$$

$$Q_P^d = (C_P + G_P) + (Z_P^P + Z_G) + INT_P \tag{A40}$$

$$C_i = \sum_h x_{ih} + \frac{\sum_h cc_{ih}(CON_h - \sum_j PQ_j x_{jh})}{PQ_i} \tag{A41}$$

$$Z_i = zz_i \frac{Z \cdot PK}{PQ_i} \quad \text{for } i = G, P \tag{A42}$$

TRADE

$$E_i = D_i \left(\frac{PE_i}{PD_i} \cdot \frac{1-\beta_{Ti}}{\beta_{Ti}} \right)^{\sigma_{Ti}} \quad \text{for } i = A, P \tag{A43}$$

$$M_i = D_i \left(\frac{PD_i}{PM_i} \cdot \frac{\beta_{Qi}}{1-\beta_{Qi}} \right)^{\sigma_{Qi}} \quad \text{for } i = A, P \tag{A44}$$

PRICES

$$PV_i = V_i^{-1} \left\{ PX_i(1 - dtax_i) - \sum_j a_{ji} PQ_j \right\} X_i \tag{A45}$$

$$PE_i = wpe_i ER, \ \text{for } i = A, P \tag{A46}$$

[27] As indicated in the text, in solving the model, given that equations (**??**) and (A36) determine quantities Q_I and Q_G, respectively, we use equations (A38) and (A40) to solve residually for C_I and C_G, respectively. Equations (A41) are then solved for $PQ_I = PX_I$ and $PQ_G = PX_G$, respectively.

$$PM_i = wpm_i(1 + tm_i)ER, \text{ for } i = A, P \tag{A47}$$

$$PX_i = PQ_i \quad \text{for } i = I, G \tag{A48}$$

$$PD_i = PX_i, \text{ for } i = I, G \tag{A49}$$

$$PX_i = \frac{PD_iD_i + PE_iE_i}{X_i}, \text{ for } i = A, P \tag{A50}$$

$$PQ_i = \frac{PD_iD_i + PM_iM_i}{Q_i}, \text{ for } i = A, P \tag{A51}$$

$$PT_1 = \frac{PT_2T_2 + (1 + IL_{-1})(1 + ptax_U)W_MU_P}{T_1} \tag{A52}$$

$$PT_2 = \frac{PROF_P + (1 + IL_{-1})(1 + ptax_S)W_SS_P}{T_2} \tag{A53}$$

$$PK = PQ_G^{zzG} \cdot PQ_P^{zzG} \tag{A54}$$

$$PINF = \frac{PLEV - PLEV_{-1}}{PLEV_{-1}} \tag{A55}$$

$$PLEV = \sum_i wt_iPQ_i \tag{A56}$$

$$P_R = \sum_i wr_iPQ_i \tag{A57}$$

$$P_{UU} = \sum_i wu_iPQ_i \tag{A58}$$

$$P_{US} = \sum_i ws_iPQ_i \tag{A59}$$

$$PGDP_{FC} = \sum_i v_iPV_i \tag{A60}$$

INCOME

$$PROF_i = PV_iV_i - W_iU_i, \text{ for } i = A, I \tag{A61}$$

$$PROF_P = PV_PV_P - (1+IL_{-1})(1+ptax_U)W_MU_P - (1+IL_{-1})(1+ptax_S)W_SS_P \tag{A62}$$

$$YF_i = PROF_i, \text{ for } i = A, I \tag{A63}$$

$$YF_P = PROF_P - IL_{-1}DL_{P,-1} - IF \cdot FL_{P,-1}ER - PRIVR \tag{A64}$$

$$YF_{PB} = IL_{-1}[DL_{P,-1} + (1+ptax_U)W_M U_P + (1+ptax_S)W_S S_P] + IB \cdot BB^C_{-1} - IR \cdot DL^{BC}_{-1} - ID \sum_h DD_{h,-1} - IF \cdot ER \cdot FL_{B,-1} \quad \text{(A65)}$$

$$YH_i = \gamma_i TRH + PV_i X_i + ID \cdot DD_{i,-1} + IF \cdot ER \cdot FD_{i,-1}, \text{ for } i = A, I \quad \text{(A66)}$$

$$YH_{UF} = \gamma_{UF} TRH + (W_M U_P + W_{UG} U_G) + ID \cdot DD_{UF,-1} + IF \cdot ER \cdot FD_{UF,-1} \quad \text{(A67)}$$

$$YH_S = \gamma_S TRH + (W_S S_P + W_{SG} S_G) + ID \cdot DD_{S,-1} + IF \cdot ER \cdot FD_{S,-1} \quad \text{(A68)}$$

$$YH_{KR} = \gamma_{KR} TRH + ID \cdot DD_{KR,-1} + IF \cdot ER \cdot FD_{KR,-1} + IB \cdot BB_{KR,-1} + (1-re)YF_P + YF_{PB} \quad \text{(A69)}$$

CONSUMPTION, SAVINGS, AND INVESTMENT

$$CON_h = (1 - itax_{h)} YH_h - SAV_h \quad \text{(A70)}$$

$$SAV_h = srate_h (1 - itax_h) YH_h \quad \text{(A71)}$$

$$srate_h = s_{o,h} \left(\frac{1+ID}{1+PINF} \right)^{\sigma_{Sav,h}} \quad \text{(A72)}$$

$$WT_h = WT_{h,-1} + SAV_h + \Delta ER \cdot FD_{h,-1} \quad \text{(A73)}$$

$$Z = K_{P,-1} \left(\frac{K_{INF}}{K_{INF,-1}} \right)^{\sigma_K} \left\{ (1 + \frac{\Delta RGDP_{FC}}{RGDP_{FC,-1}})^{\sigma_{ACC}} (1+PINF)^{-\sigma_P} \left(\frac{(1+IK)(1-itax_{KR})}{1+IL} \right)^{\sigma_{IK}} \right\} \quad \text{(A74)}$$

$$IK = \frac{PROF_P}{PK \cdot \ K_P} \quad \text{(A75)}$$

$$K_P = K_{P,-1}(1-\delta_P) + Z_{P,-1} \quad \text{(A76)}$$

FINANCIAL SECTOR

$$H^d_h = \psi_h CON_h \quad \text{(A77)}$$

$$H^s = \sum_h H^d_h \quad \text{(A78)}$$

$$\frac{BB^d_{KR}}{WT_{KR} - H_{KR}} = \Psi_K (1+IB)^{\beta_{KB}} (1+ID)^{-\beta_{KD}} [(1+IF)(1+depr)]^{-\beta_{KF}} \tag{A79}$$

$$\frac{DD_h}{ER \cdot \ FD_h} = \phi_{Bh} \left(\frac{1+ID}{(1+IF)(1+depr)} \right)^{\sigma_{Bh}} \tag{A80}$$

$$FD_h = (WT_h - H^d_h - DD_h - BB_h)/ER \tag{A81}$$

$$DL^d_P = DL_{P,-1} - ER\Delta FL_{P,-1} + PK \ \cdot Z - re \ YF_P \tag{A82}$$

$$RR = rreq \sum_h DD_h \tag{A83}$$

$$NW_B = NW_{B,-1} - \Delta ER \cdot FL_{B,-1} \tag{A84}$$

$$DL^{BC} = DL^d_P + BB^C - (1 - rreq) \sum_h DD_h - ER \cdot FL_B - NW_B \tag{A85}$$

$$\frac{BB^C}{DL_P} = \phi_C (\frac{1+IB}{1+IL})^{\sigma_C} \tag{A86}$$

$$ID = IR \tag{A87}$$

$$IL = \frac{IR}{1 - rreq} + PR \tag{A88}$$

$$PR = \xi_{pr} \left[\lambda_{pr} \left(\frac{\delta_c (NW_{P,-1} + DL_{P,-1})}{DL_{P,-1}} \right)^{-\gamma_{pr}} \right] + (1 - \xi_{pr}) PR_{-1} \tag{A89}$$

$$NW_P = PK \cdot K_P - DL_P - ER \cdot FL_P \tag{A90}$$

PUBLIC SECTOR

$$NW_{CB} = NW_{CB,-1} + \Delta ER \cdot FF \tag{A91}$$

$$MB = DL^{BC} + ER \cdot FF - NW_{CB} \tag{A92}$$

$$PROF^{CB} = IR \cdot DL^{BC}_{-1} + IF_G ER \cdot FF \tag{A93}$$

$$\begin{aligned} -DEF \ = \ & (PV_G X_G - W_{UG} U_G - W_{SG} S_G) + TXREV \\ & -TRH - PQ_P (G_P + Z_G) - IF_G \cdot ER(FL_{G,-1} - FF) \\ & +IR \cdot DL^{BC}_{-1} - IB \cdot BB_{-1} \end{aligned} \tag{A94}$$

$$Z_G = I_{INF} + I_H + I_E \tag{A95}$$

$$TXREV = ER \sum_{i=A,P} wpm_i tm_i M_i + \sum_i dtax_i PX_i X_i + itax_r(YH_{AT} + YH_{AN}) + itax_{UU}(YH_{UF} + YH_S) + itax_{KR} YH_{KR} + ptax_U W_M U_P + ptax_S W_S S_P \quad \text{(A96)}$$

$$NW_G = PK(K_G + K_E) - BB^s - ER \cdot FL_G$$

$$K_i = K_{i,-1}(1 - \delta_i) + I_{i,-1}, \text{ with } i = INF, H, E \quad \text{(A97)}$$

$$K_G = \alpha_G \{\beta_G K_{INF}^{-\rho_G} + (1 - \beta_G) K_H^{-\rho_G}\}^{-\frac{1}{\rho_G}} \quad \text{(A98)}$$

$$NW_{PS} = PK(K_G + K_E) + DL^{BC} - BB^s + ER \cdot (FF - FL_G) - MB \quad \text{(A99)}$$

BALANCE OF PAYMENTS AND THE EXCHANGE RATE

$$0 = \sum_{i=A,P} (wpe_i E_i - wpm_i M_i) + IF \sum_h FD_{h,-1} - IF \cdot FL_{P,-1} - IF_G(FL_{G,-1} - FF) - IF \cdot FL_{B,-1} - \sum_h \Delta FD_h + \Delta FL_G + \Delta FL_P + \Delta FL_B \quad \text{(A100)}$$

$$depr = \chi depr_{-1} + (1 - \chi)[PINF_{-1} - (FINFL_{-1} + \Delta ER_{-1}/ER_{-2})] \quad \text{(A101)}$$

CURRENCY AND BOND MARKET EQUILIBRIUM

$$H^s = MB - rreq \sum_h DD_h \quad \text{(A102)}$$

$$BB^d = BB_{KR} + BB^C. \quad \text{(A103)}$$

$$BB^s = BB^s_{-1} + DEF - PRIVR - ER \cdot \Delta FL_G \quad \text{(A104)}$$

$$BB^s = DL_P \phi_C \left(\frac{1 + IB}{1 + IL}\right)^{\sigma_C} + \Psi_K (WT_{KR} - H_{KR}) \frac{(1 + IB)^{\beta_{KB}}}{(1 + ID)^{\beta_{KD}}} \cdot [(1 + IF)(1 + depr)]^{-\beta_{KF}} \quad \text{(A105)}$$

Appendix B
Variable Names and Definitions

Endogenous Variables

Name	Definition
ac_i	Share of autonomous consumption of good i in total consumption of good i
BB	Total stock of bonds held by banks and households
BB_h	Holding of government bonds by household h
BB^C	Holding of government bonds
BB^s	Supply of government bonds
BB^d_{KR}	Demand for government bonds by capitalists
C_{ih}	Consumption of good i by household h
C_i	Aggregate consumption of good i
CON_h	Consumption by household h
$COND_h$	Discretionary consumption for household h
D_i	Domestic demand for domestic good $i = A, P$
DD_h	Domestic deposits by households h
DEF	Government deficit
$depr$	Expected devaluation rate
DL^{BC}	Borrowing from the central bank
DL_P	Domestic loan by private urban (formal) firm
DL^d_P	Demand for bank loans by the private sector
E_i	Export of good $i = A, P$
Ew_U	Expected urban unskilled wages
Ew_A	Expected rural sector wages
Ew_S	Expected skilled wages
FD_h	Foreign deposits by household h
FF	Foreign reserves
FL_B	Banks' foreign liabilities
G_P	Real government spending on goods and services
H^d	Total demand for money
H^d_h	Demand for currency by household h
H^s	Money supply
H_h	Money held by household h

IB	Rate of interest on public bonds
IR	Cost of funds provided by the central bank
IK	Return from equities
IL	Interest rate for domestic loan
INT_i	Intermediate good demand for good i
K_E	Capital in education
K_G	Public capital
K_H	Capital in health
K_{INF}	Capital in infrastructure
K_P	Private capital stock
L_U	Total size of the labor force in the urban sector
$LAND$	Land used in rural production
M_i	Import of good $i = A, P$
MB	Money base
$MIGR$	Migration to urban area
NW_B	Net worth of commercial banks
NW_{CB}	Net worth of the central bank
NW_G	Net worth of the government
NW_P	Net worth of private urban formal firms
NW_{PS}	Net worth of the consolodated public sector
Ω_W	Reservation wage of skilled workers
PD_i	Domestic price of domestic sales of good i
PE_i	Price of exported good $i = A, P$
$PGDP_{FC}$	Price deflator fo RGDP at factor cost
$PIND_S$	Price index to which nominal wage of skilled labor in the private sector is indexed
$PINF$	Inflation rate
$PINF^*$	Government's inflation target
PK	Price of capital
$PLEV$	Price level
PM_i	Price of imported good $i = A, P$
PQ_i	Composite good price of good i
PR	Premium
$PRIVR$	Flow of privatization expenditure
$PROF_i$	Profit by good i firm for $i = A, I, P$
$PROF^{CB}$	Net profits of the central bank
PT_1	Price of T1
PT_2	Price of T2

P_h	Price index for household $h = US, UU, R$
PV_i	Value added price of good i
PX_i	Sale price of good i
Q_i	Demand of composite good i
Q_i^d	Aggregate demand for good i
Q_i^s	Quantity supplied of good i
$RGDP_{FC}$	Real GDP at factor cost
$RGDP_{FC}^T$	Trend value of real GDP
RR	Reserve requirements
S	Number of skilled workers
S_P^d	Demand for skilled labor
SAV_h	Saving by household h
$Srate_h$	Saving rate for household h
SKL	New skilled workers
S_P	Skilled labor employed in private urban formal
T_1	Composite input from T_2 and unskilled labor
T_2	Composite input from capital and skilled labor
TRH	Transfers to households
$TXREV$	Tax revenues
U_i	Unskilled labor employed in sector i
U_F	Unskilled labor supply in the urban formal sector
U_R	Unskilled workers in rural economy
U_U	Unskilled workers in urban economy
U_i^d	Demand for labor in sector i
U_F^s	Supply of unskilled workers in the formal sector
U_I^s	Supply of labor in the informal sector
U_R^s	Labor supply in the rural sector
$UNEMP_U$	Rate of unskilled unemployment in the urban formal sector
$UNEMP_S$	Rate of skilled unemployment
V_i	Value added in good i
W_i	Nominal wage in sector $i = A, I$
w_i	Real wage rate in sector $i = A, I$
W_M	Nominal wage rate for unskilled labor in the urban private formal sector
w_M	Real wage rate for the unskilled labor in the urban formal private sector

W_S	Nominal wage rate for the skilled labor in the private formal sector
w_S	Real wage rate for the skilled labor in the private formal sector
W_{SG}	Nominal wage rate for the skilled labor in the public sector
w_{SG}	Real wage rate for the skilled labor in the public sector
W_{UG}	Nominal wage rate for the unskilled labor in the public sector
WT_h	Total wealth by household h
x_{ih}	Subsistence level of consumption of good i by household h
X_i	Production of good i
YF_i	Firms' income in sector $i = A, I, P$
YF_{PB}	Income by private banks
YH_h	Income of household h
Z_G	Public investment
Z_P^i	Investment demand for good $i = G, P$ by private formal sector firms

Exogenous Variables

Name	**Definition**
$dtax_i$	Indirect taxation of output in sector i
ER	Nominal exchange rate
$FINFL$	Foreign inflation
FL_i	Foreign loans to sector $i = P, G$
NG_{OTH}	Public spending (other than salaries, transfers, interest payments)
g_R	Population growth in rural economy
g_U	Population growth in urban economy
ID	Interest rate on domestic deposits
IF	Interest rate on foreign deposit
IF_G	Interest rate on government foreign loans
I_E	Investment in education
I_H	Investment in health
I_{INF}	Investment in infrastructure
$itax_h$	Income tax rate for households h
$ptax_S$	Payroll tax rate on skilled labor in the private formal sector
$ptax_U$	Payroll tax rate on unskilled labor in the private formal sector
S_G	Skilled workers in public sector
tm_i	Import tariff for good $i = A, P$
U_G	Unskilled workers in public sector
wpe_i	World price of good i export for $i = A, P$
wpm_i	World price of good i import for $i = A, P$

Parameters

Name	Definition
a_{ij}	Input-output coefficient
α_{edu}	Elasticity of skills acquisition to cost of education
α_G	Shift parameter for public capital
α_{Qi}	Shift parameter in composite good $i = A, P$
α_{Ti}	Shift parameter in transformation function between exported and domestic good i production for $i = A, P$
α_{Xi}	Shift parameter in good i production for $i = A, G, I, P$
α_{XP1}	Shift parameter in composite input of unskilled and skilled/capital composite input
α_{XP2}	Shift parameter in composite input of skilled workers and private capital
β_F	Speed of adjustment for the supply of unskilled labor in the formal urban private sector
β_G	Shift parameter for public capital
β_{Qi}	Shift parameter in composite good $i = A, P$
β_{Ti}	Shift parameter between exported and domestic production of good $i = P, A$
β_{Xi}	Shift parameter in production of good $i = A, P, I$
β_{XG1}	Shift parameter between labor and public capital in public production
β_{XG2}	Shift parameter between skilled and unskilled workers in public production
β_{XP1}	Share parameter between unskilled and skilled/capital composite input
β_{XP2}	Share parameter between skilled workers and private capital
β_{KB}	Money demand elasticity on government bonds
β_{KD}	Money demand elasticity on domestic rate
β_{KF}	Money demand elasticity on foreign rate
cc_{ih}	Allocation to good i of nominal consumption by household h
$\varkappa$	Shift parameter of depreciation
ψ_h	Share of household h in total consumption
δ_c	Collateral parameter
δ_E	Depreciation rate of education capital
δ_H	Depreciation rate of health capital

δ_{INF}	Depreciation rate of infrastructure capital
δ_P	Depreciation rate of private capital
δ_S	Rate of depreciation or "de-skilling" of the skilled labor force
ξ_{pr}	Partial adjustment coefficient for risk premium
η_{XA}	Coefficient of returns to scale
γ_{Bh}	Share of domestic deposits in total deposits for household h
γ_h	Share of transfers allocated to household $h = KR, S, A, UF, I$
γ_{pr}	Elasticity of premium to firms' net worth position
gg_i	Share of government expenditure on ggod $i = A, G, P$
ind_S	Parameter used in determining nominal wage of skilled labor in the private sector
κ_e	Shift parameter in skills acquisition function
κ_S	Shift parameter for skilled private sector employment
λ_m	Partial adjustment coefficient on migration
λ_{pr}	Premium shift parameter
λ_s	Partial adjustment coefficient on skills acquisition
ϕ_{Bh}	Proportion of domestic deposits held in total deposits
ϕ_C	Shift parameter for the demand for government bonds
ϕ_i	Parameters used in the calculation of nominal wage for skilled labor in the private sector for $i = u, 1, 2$
pc	Parameter used in the value added function of urban formal private goods
re	Percentage of profits retained
ρ_G	Substitution parameter for public capital
ρ_{Qi}	Substitution parameter in composite good $i = A, P$
ρ_{Ti}	Parameter in production of good $i = A, P$
ρ_{Xi}	Substitution parameter in production of good $i = A, P$
ρ_{XG1}	Substitution parameter between workers and public capital in public production
ρ_{XG2}	Substitution parameter between skilled and unskilled workers in public production
ρ_{XP1}	Substitution parameter between unskilled and skilled/capital composite input
ρ_{XP2}	Substitution parameter between skilled workers and private capital
$rreq$	Reserve requirement ratio

σ_{ACC}	Elasticity of investment to growth rate of real GDP at factor cost
σ_C	Parameter in demand for government bonds equation
σ_{Bh}	Domestic/foreign deposits elasticity for household h
σ_E	Elasticity of skills acquisition to capital in education
σ_{IK}	Elasticity of investment to return to capital
σ_K	Elasticity of investment to gross growth rate of infrastructure capital
σ_M	Elasticity of migration to wage differentials
σ_P	Elasticity of inflation on investment
σ_{Qi}	Elasticity of composite good $i = A, P$
$\sigma_{sav,h}$	Parameter in the saving rate equation for household h
σ_{Ti}	Elasticity of transformation between exported and domestic production of good $i = A, P$
σ_W	Elasticity of skills acquisition to wage differential
σ_{XP1}	Elasticity of substitution between unskilled workers and composite input of skilled workers and private capital
σ_{XP2}	Elasticity of substitution between skilled workers and private capital
$s_{0,h}$	Saving coefficient for household h
Ψ_K	Shift parameter determining demand for bonds
θ_U	Share of urban unskilled workers employed in formal sector
θ_s	Initial ratio of the number of workers employed in the private sector
v_i	Weight for sector i real GDP at factor cost price deflator
wt_i	Initial share of good i in aggregate consumption
wr_i	Initial share of good i in rural consumption
ws_i	Initial share of good i in skilled workers' consumption
wu_i	Initial share of good i in urban unskilled workers' consumption
zz_i	Share of investment expenditure on good $i = P, G$

Table 1
Financial Balance Sheets
(in domestic-currency terms, at current prices)

Households

Assets	Liabilities
Cash holdings (H)	Financial wealth (WT)
Domestic bank deposits (DD)	
Foreign bank deposits ($ER \cdot FD$)	
Government bonds (BB_{KR})	

Firms

Assets	Liabilities
Stock of private capital ($PK \cdot K_P$)	Domestic borrowing (DL_P)
	Foreign borrowing ($ER \cdot FL_P$)
	Net worth (NW_P)

Commercial Banks

Assets	Liabilities
Government bonds (BB^C)	Domestic bank deposits (DD)
Loans to domestic firms (DL_P)	Foreign liabilities ($ER \cdot FL_B$)
Reserve requirements (RR)	Borrowing from central bank (DL^{BC})
	Net worth (NW_B)

Central Bank

Assets	Liabilities
Loans to commercial banks (DL^{BC})	Cash in circulation (H)
Foreign reserves ($ER \cdot FF$)	Reserve requirements (RR)
	Net worth (NW_{CB})

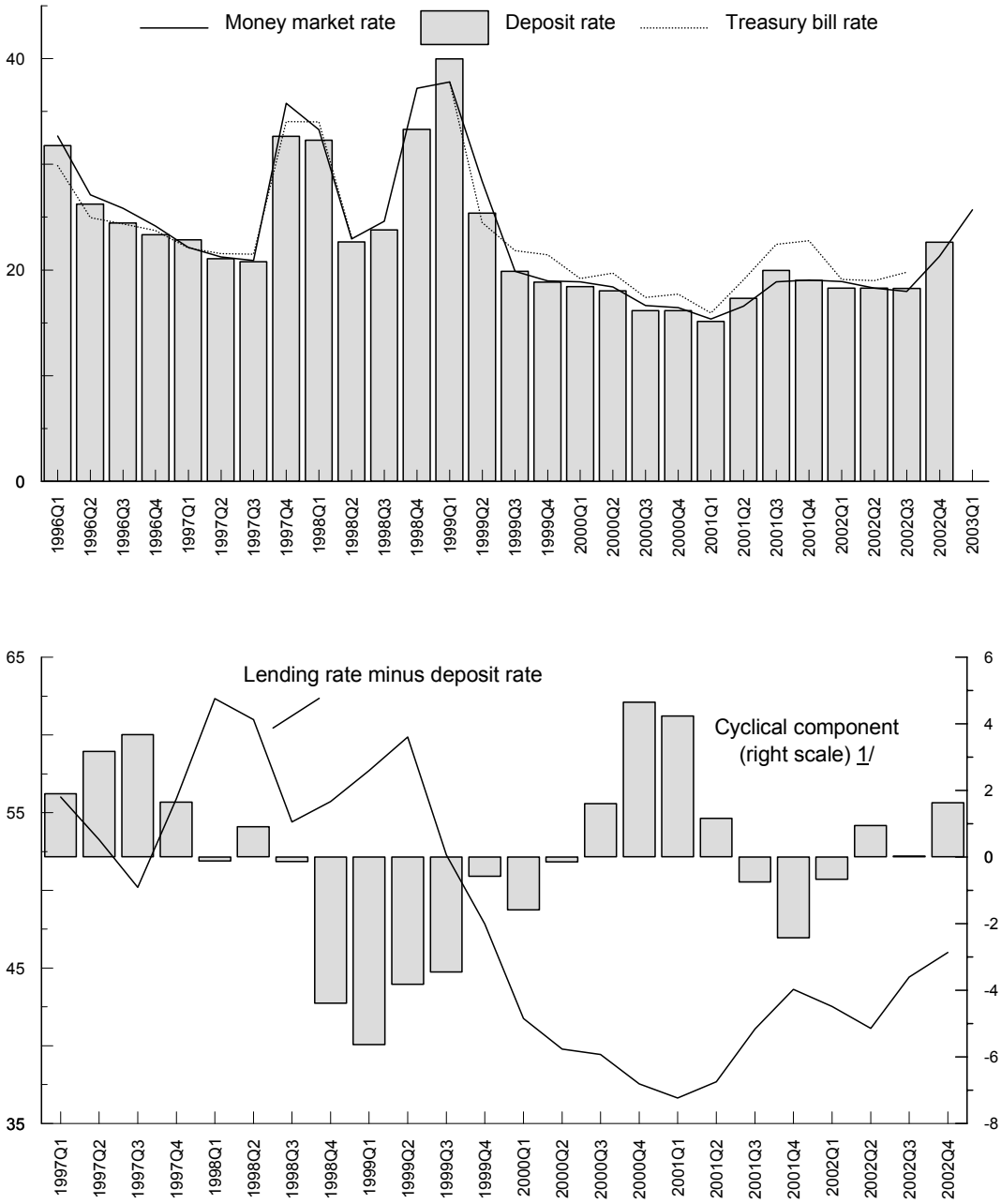
Government

Assets	Liabilities
Capital in education ($PK \cdot K_E$)	Government bonds (BB)
Capital in health ($PK \cdot K_H$)	Foreign borrowing ($ER \cdot FL_G$)
Capital in infrastructure ($PK \cdot K_{INF}$)	Net worth (NW_G)

Consolidated Public Sector

Assets	Liabilities
Loans to commercial banks (DL^{BC})	Cash in circulation (H)
Foreign reserves ($ER \cdot FF$)	Reserve requirements (RR)
Capital in education ($PK \cdot K_E$)	Government bonds (BB)
Capital in health ($PK \cdot K_H$)	Foreign borrowing ($ER \cdot FL_G$)
Capital in infrastructure ($PK \cdot K_{INF}$)	Net worth (NW_{PS})

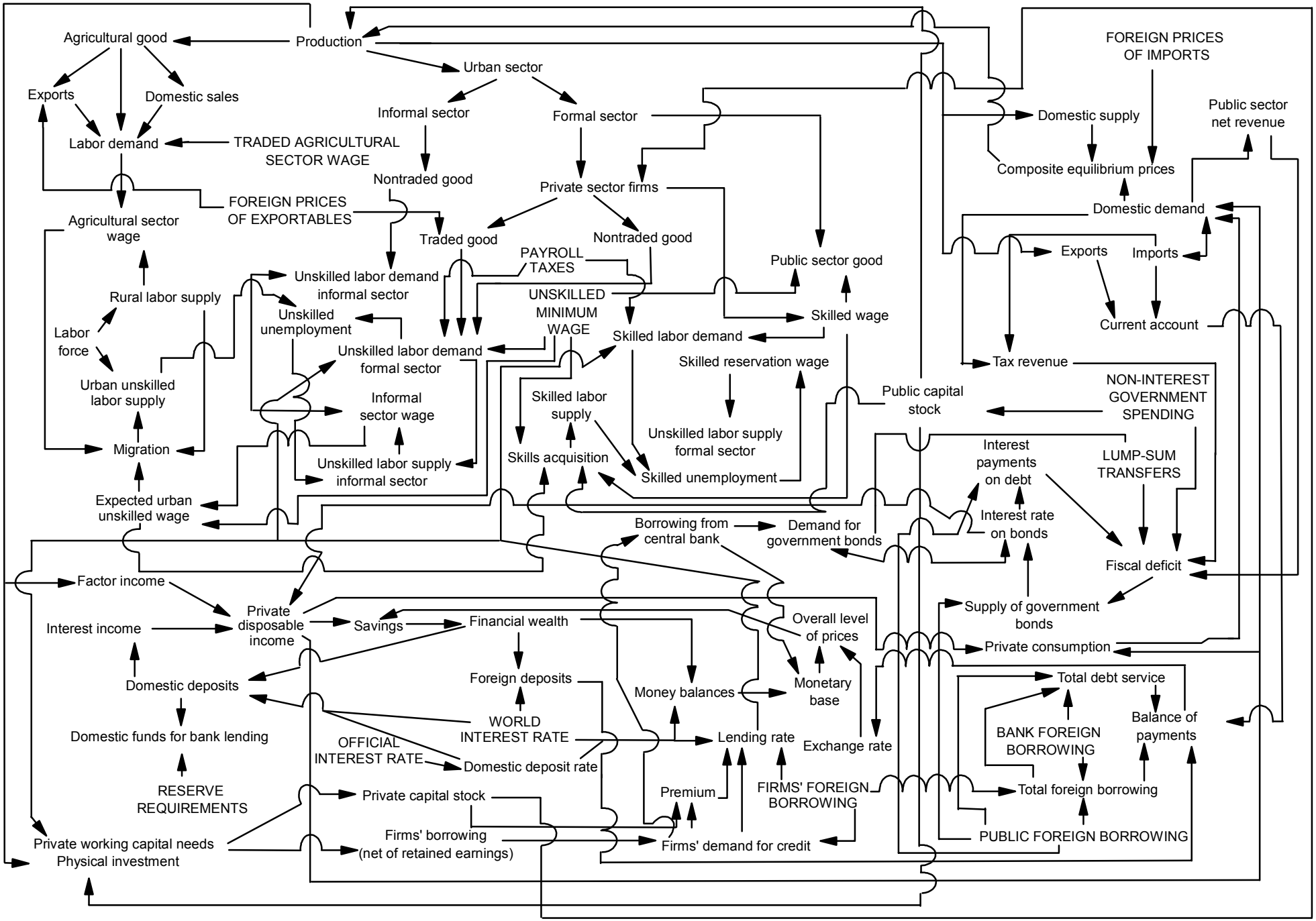
Figure 1
Brazil: Interest Rates and Cyclical Output, 1995-2003
(quarterly data)



Source: International Monetary Fund.

1/ Cyclical component is the log difference between manufacturing production and the Hodrick-Prescott trend of it.

Figure 2. IMMPA-Brazil: Analytical Structure

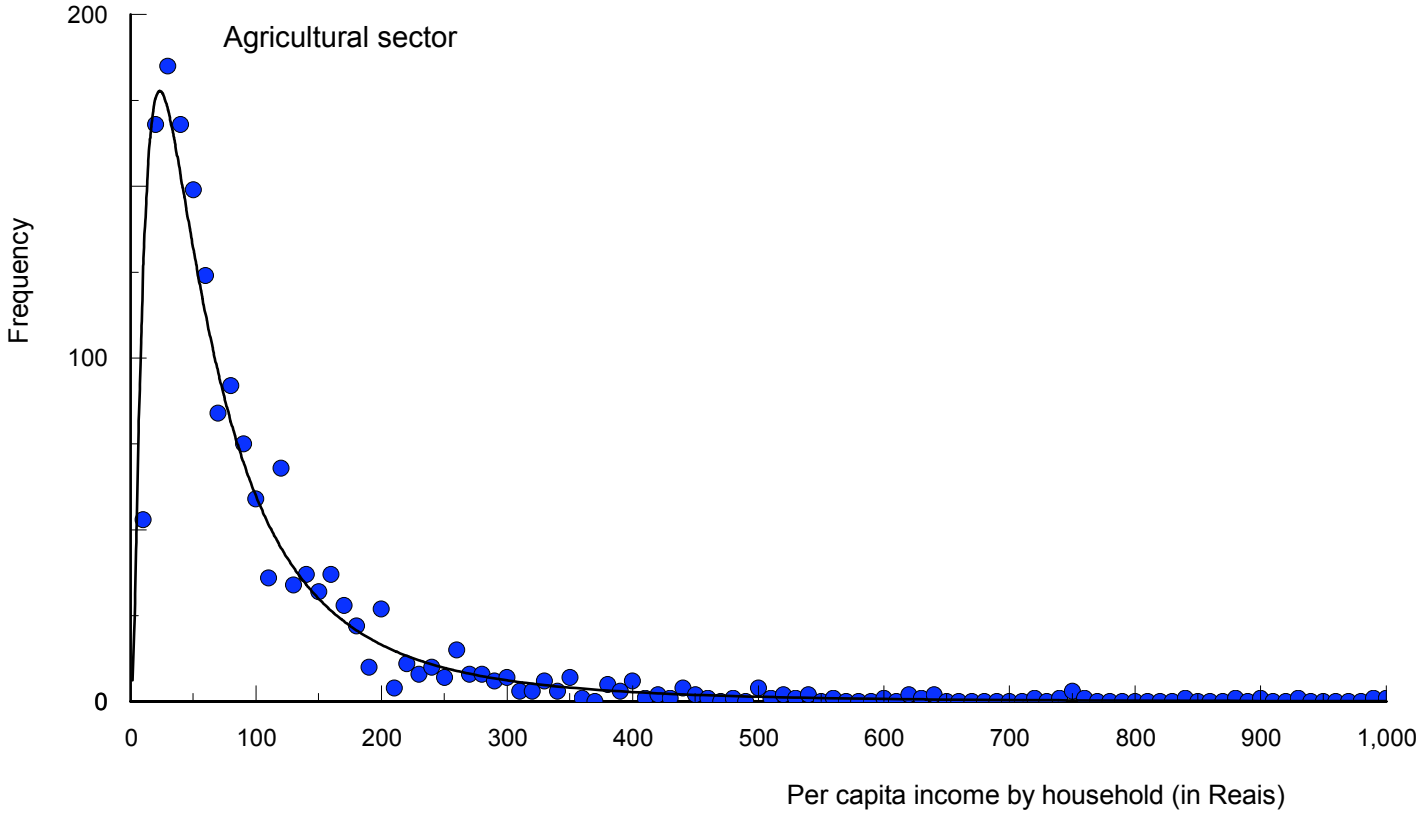


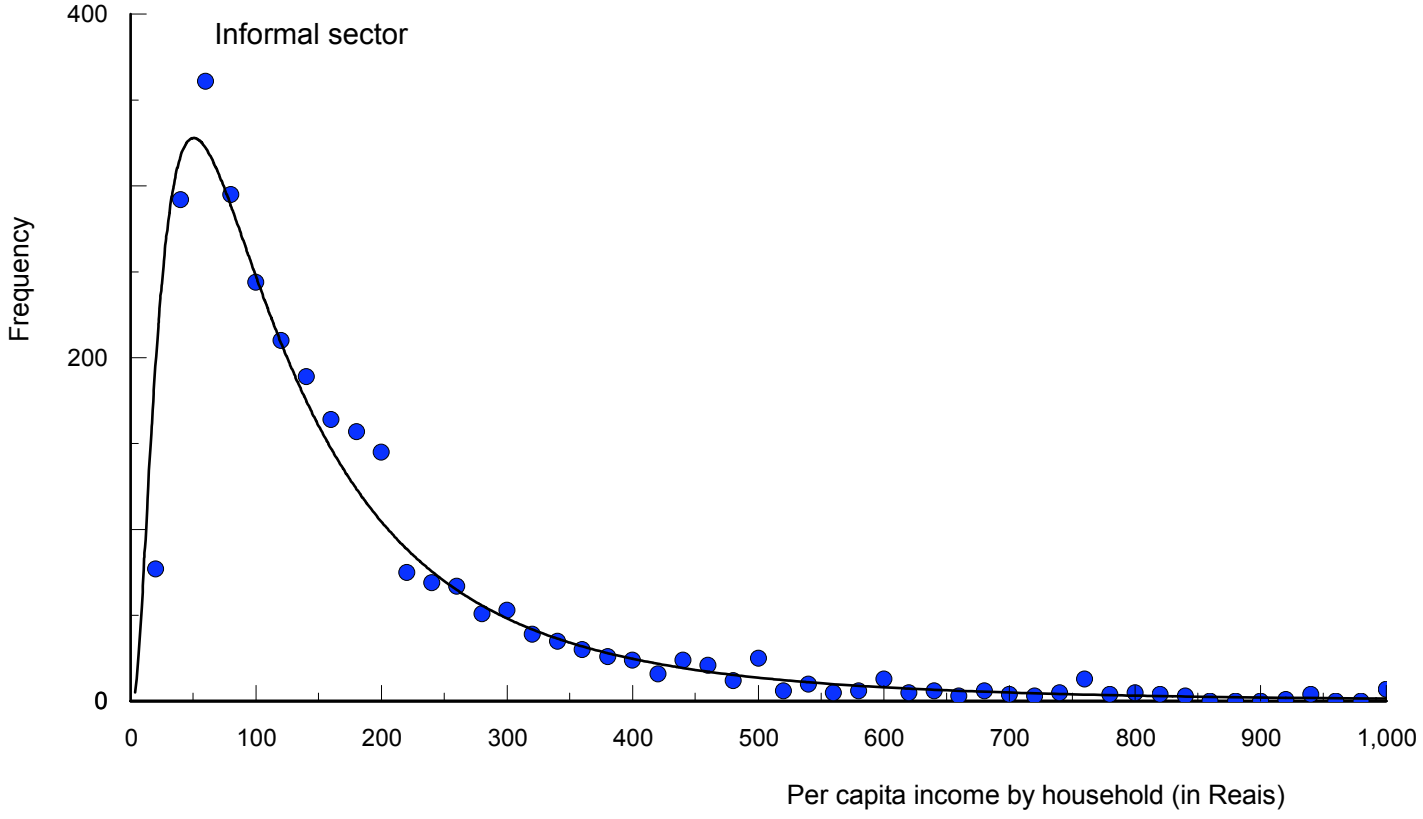
Note: Exogenous variables are in capital letters.

Figure 3
Brazil: Average Household Income
(in Reais, at 2001 prices)

Source: Authors' calculations.

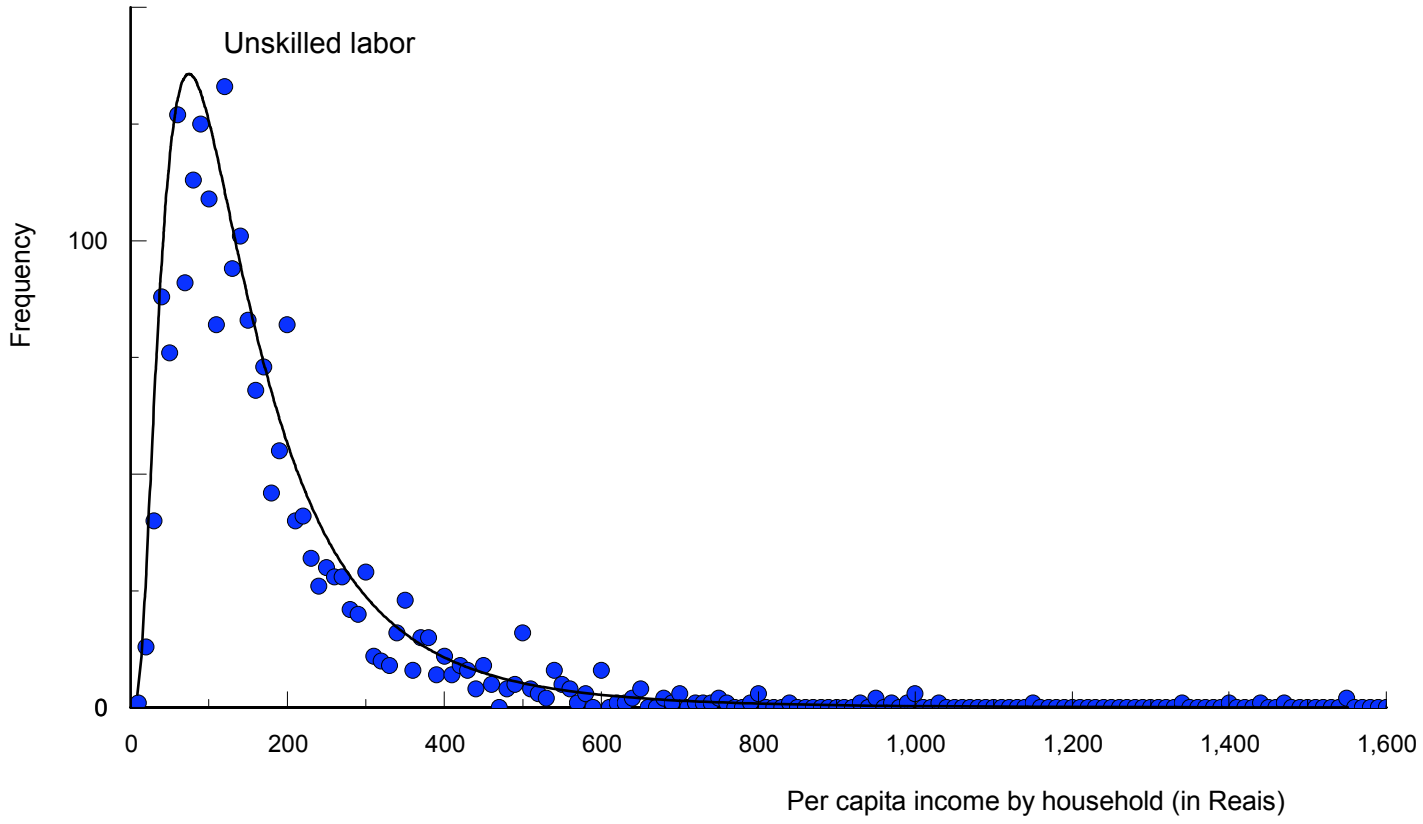
Figure 4
Brazil: Frequency Distributions of Households by Income Per Capita
in Agriculture and the Informal Sector

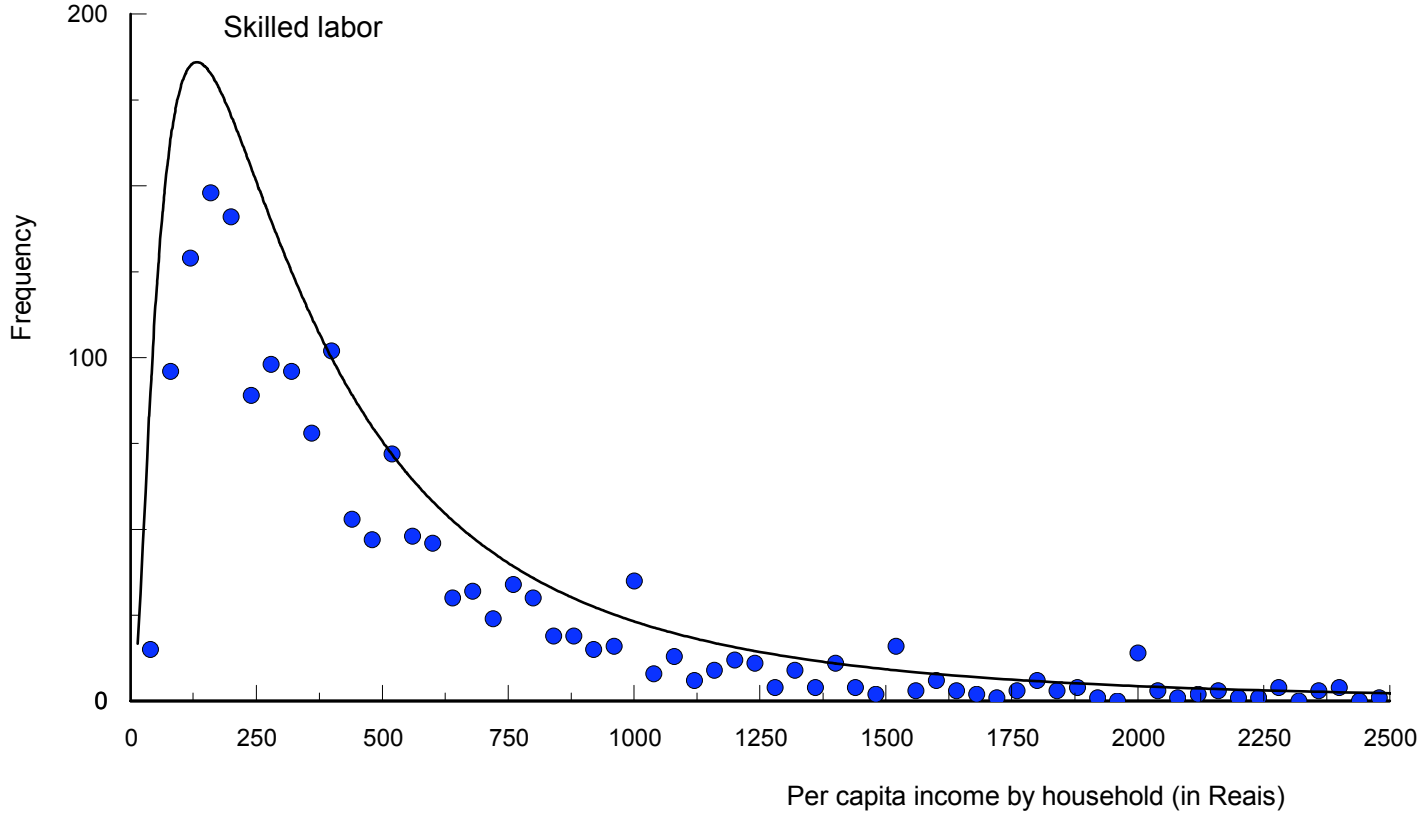




Source: Authors' calculations.

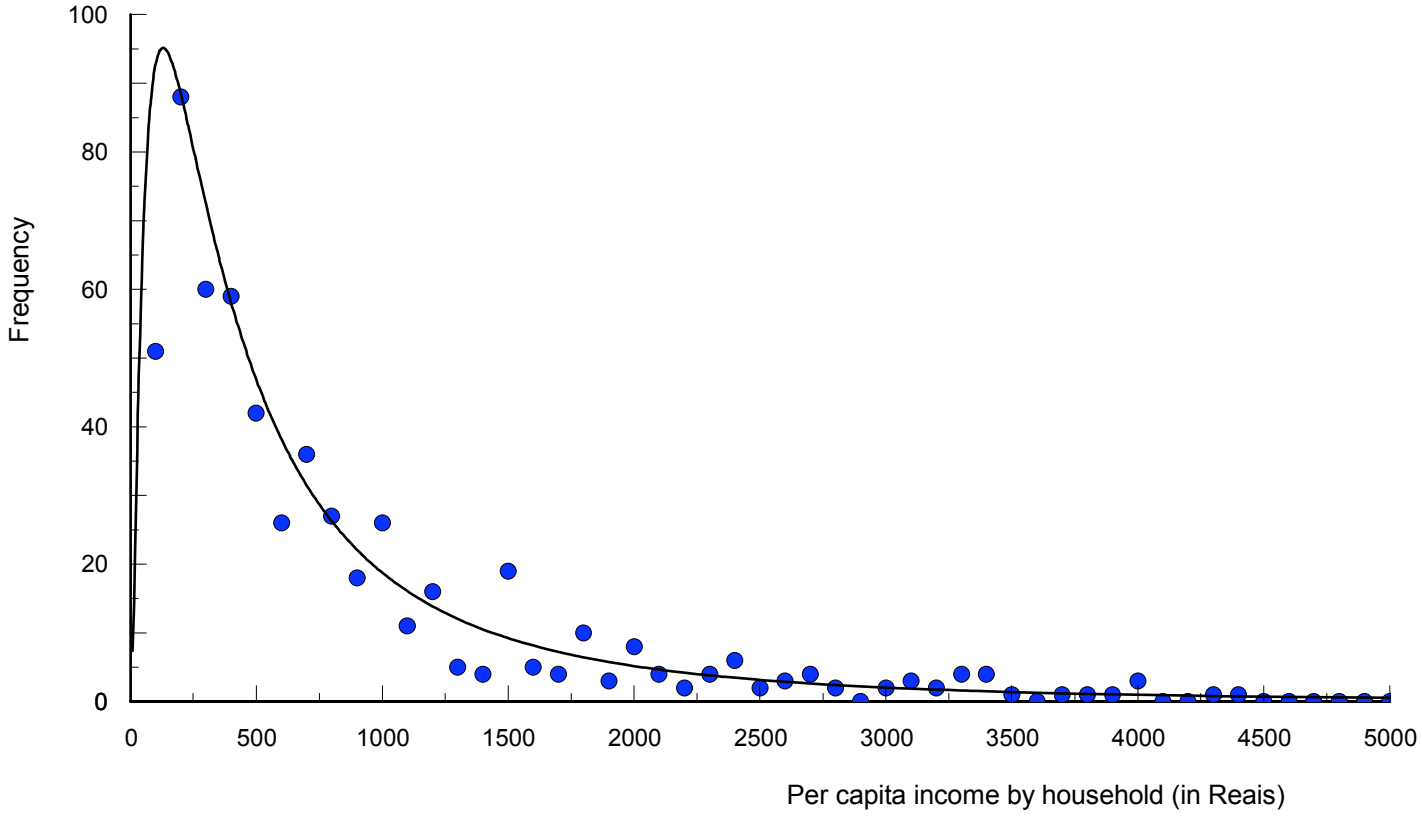
Figure 5
Brazil: Frequency Distributions of Households by Income Per Capita in Urban Formal Sector





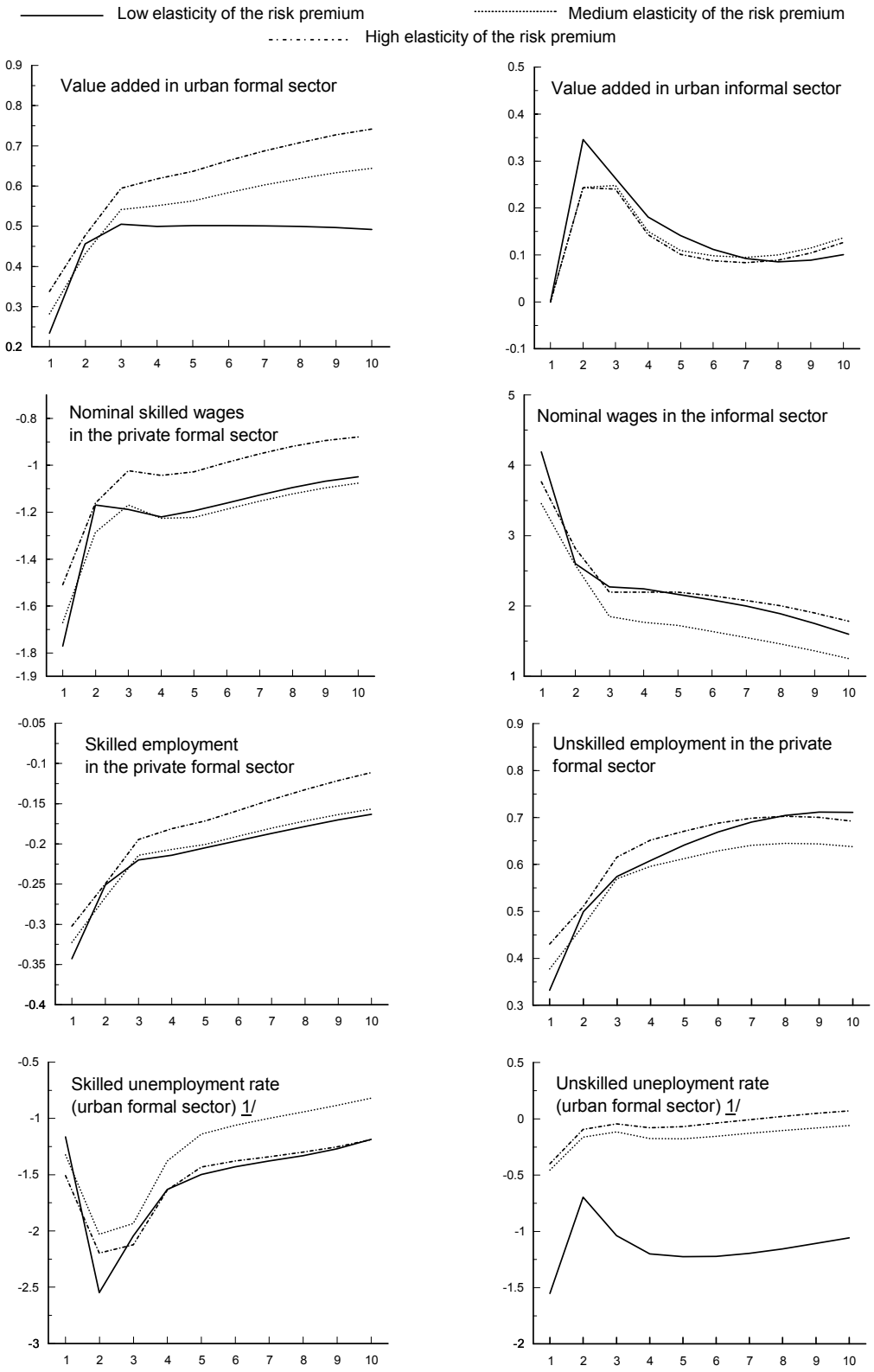
Source: Authors' calculations.

Figure 6
Brazil: Frequency Distributions of Capitalists and Rentiers
by Income Per Capita



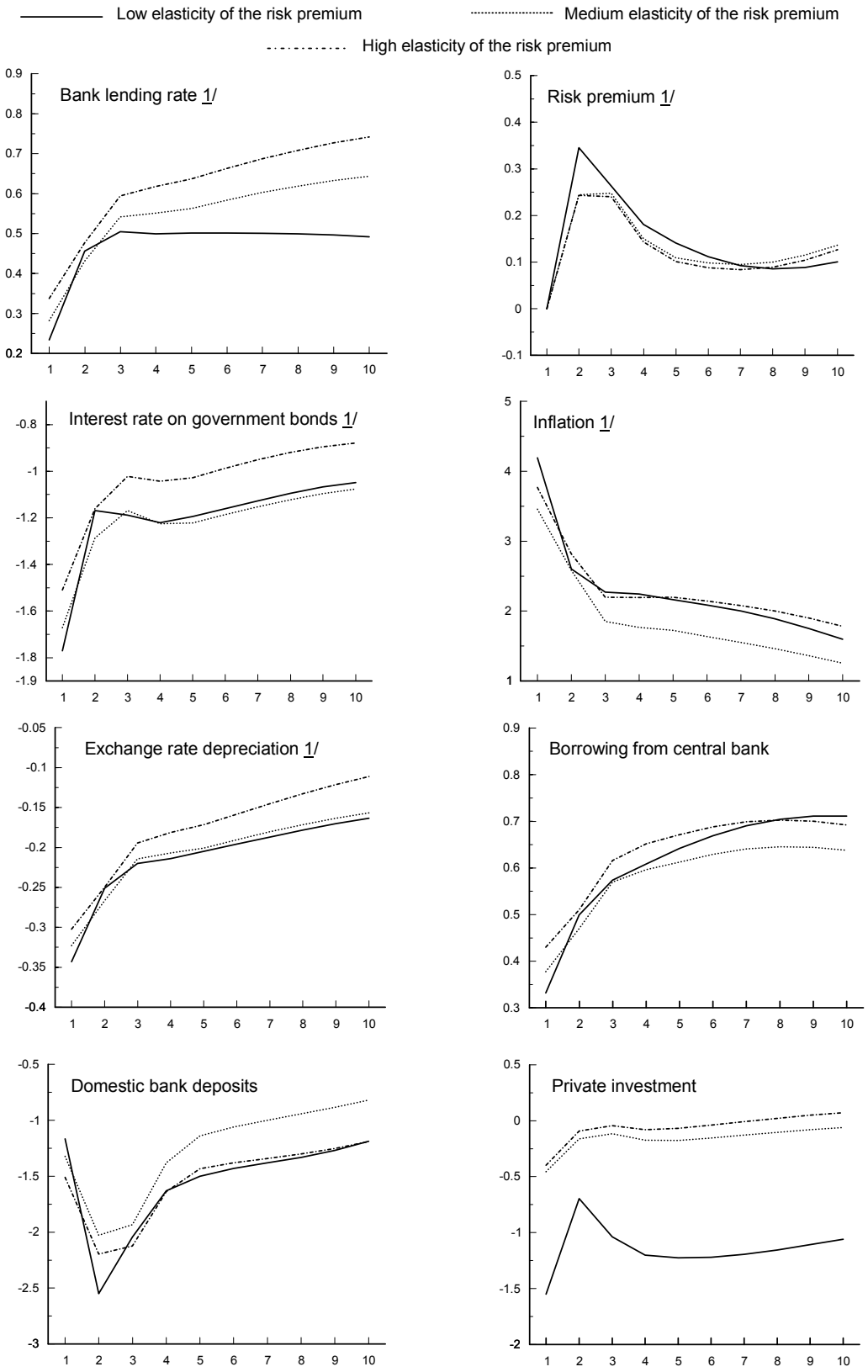
Source: Authors' calculations.

Figure 7
5 Percentage Point Increase in Official Interest Rates
(Percentage deviations from baseline, unless otherwise indicated)



1/ Absolute deviations from base line.

Figure 7 (concluded)
5 Percentage Point Increase in Official Interest Rates
(Percentage deviations from baseline, unless otherwise indicated)



1/ Absolute deviations from base line.

SAM for Brazil model		AG	I	P	G	U	S	Profit	wkap	ptax	wtax	etax	dtax	mtax	HH_AG	HH_UI	HH_UF	HH_US	HH_KAP	Gov	Inv	ROW	Money	DBanks	CBank	FBanks	GBonds	Total
		Agriculture	Informal sector	Private formal sector	Public sector	Unskilled labor	Skilled labor	Profit or operating surplus	Working capital	Output tax	Wage tax	Export tax	Direct tax	Import tax	Rural household in Agriculture	Urban informal household	Urban unskilled labor household	Urban skilled labor household	Rentier household	Government	Investment	Rest of the world	Money	Domestic banks	Central bank	Foreign banks	Government bonds	
AG	Agriculture	20,297	700	81,139	6,599										4,515	5,860	5,228	5,683	2,680	0	5,561	1,851						140,113
I	Informal sector	2,899	9,147	67,734	39,259										3,515	4,563	4,070	4,424	2,087	0	0	0						137,698
P	Private formal sector	16,150	28,582	275,795	68,623										83,352	108,201	96,517	104,916	49,480	0	156,078	53,400						1,041,093
G	Public sector	430	797	5,805	4,490										429	557	497	540	255	138,111	491	0						152,402
U	Unskilled labor	21,298	47,777	96,419	5,212																							170,705
S	Skilled labor	0	0	81,785	16,634																							98,419
Profit	Profit or operating surplus	69,487	50,694	219,889	0																			29,419				369,489
wkap	Working capital	855	0	7,158	0																							8,013
ptax	Output tax	4,822	0	71,666	3,394																							79,882
wtax	Wage tax	1,002	0	66,823	8,192																							76,017
etax	Export tax	0	0	0	0																							0
dtax	Direct tax														11,927	0	13,352	12,930	17,223									55,432
mtax	Import tax	173	0	4,019	0																							4,192
HH_AG	Rural household in Agriculture					21,298	0	69,487												12,498				603		67	0	103,953
HH_UI	Urban informal household					47,777	0	50,694												20,091				822		91	0	119,476
HH_UF	Urban unskilled labor household					101,630	0	0												15,444				3,440		382	0	120,897
HH_US	Urban skilled labor household					0	98,419	0												23,657				8,524		947	0	131,548
HH_KAP	Rentier household					0	0	49,981												7,248				14,489		1,610	24,724	98,052
Gov	Government							0		79,882	76,017	0	55,432	4,192								4,740		3,663	530	19,030	27,576	271,061
Inv	Investment							134,334																2,490	0	25,305	0	162,130
ROW	Rest of the world	2,699	0	62,862	0																				530		0	66,091
Money	Money														28	39	162	401	682									1,313
DBanks	Domestic banks							52,775	8,013						188	256	1,071	2,653	4,510	4,615					1,121	0	10,995	86,197
CBank	Central bank																						1,313	868				2,181
FBanks	Foreign banks							12,218							0	0	0	0	0	13,678		6,100		15,437				47,432
GBonds	Government bonds														0	0	0	0	21,135	35,719		0		6,441				63,295
Total		140,113	137,698	1,041,093	152,402	170,705	98,419	369,489	8,013	79,882	76,017	0	55,432	4,192	103,953	119,476	120,897	131,548	98,052	271,061	162,130	66,091	1,313	86,197	2,181	47,432	63,295	