Kiel Institute for World Economics
Duesternbrooker Weg 120
24105 Kiel (Germany)

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GEM-PIA: A Real-Financial General Equilibrium Model for Poverty Impact Analysis – Technical Description

by

Manfred Wiebelt

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GEM-PIA: A REAL-FINANCIAL GENERAL EQUILIBRIUM MODEL FOR POVERTY IMPACT ANALYSIS – TECHNICAL DESCRIPTION

Abstract:

This paper provides a technical description of GEM-PIA, a recursive-dynamic computable **G**eneral **E**quilibrium **M**odel for **P**overty **I**mpact **A**nalysis in individual countries. The model combines the optimizing behavior of CGE models with the asset portfolio behavior of macromodels, thereby addressing the role of financial markets. Moreover, the model is linked to household survey information, thereby capturing the socio-economic characteristics of individual households. GEM-PIA can be used for counterfactual analysis of external shocks as well as various policies at the macro and meso level, and to assess their allocational and distributional consequences. The model is calibrated to Bolivian data and its working is illustrated in two scenarios: A permanent rise of gas exports and a temporary devaluation.

Key Words: Computable General Equilibrium Model, Portfolio Choice, Income Distribution, Poverty, Bolivia

JEL Classification: C68, G11, O1, R23

Manfred Wiebelt
Kiel Institute for World Economics
Duesternbrooker Weg 120
24105 Kiel
Phone ++49 431 8814–212
Fax ++49 431 8814–502
e-mail: mwiebelt@ifw.uni-kiel.de

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1. Introduction

This paper describes an applied **g**eneral **e**quilibrium **m**odel (GEM) for **p**overty **i**mpact **a**nalysis (PIA) of external shocks and policy reforms in highly indebted poor countries (HIPC), hereafter referred to as GEM-PIA. The model combines the optimizing behavior of computable general equilibrium (CGE) models with the asset portfolio behavior of macroeconomic models, thereby addressing the role of financial markets in the economy. This real-financial model is recursive-dynamic. That means, the evolution of the economy over time is described by a sequence of single-period static equilibria connected through capital accumulation.

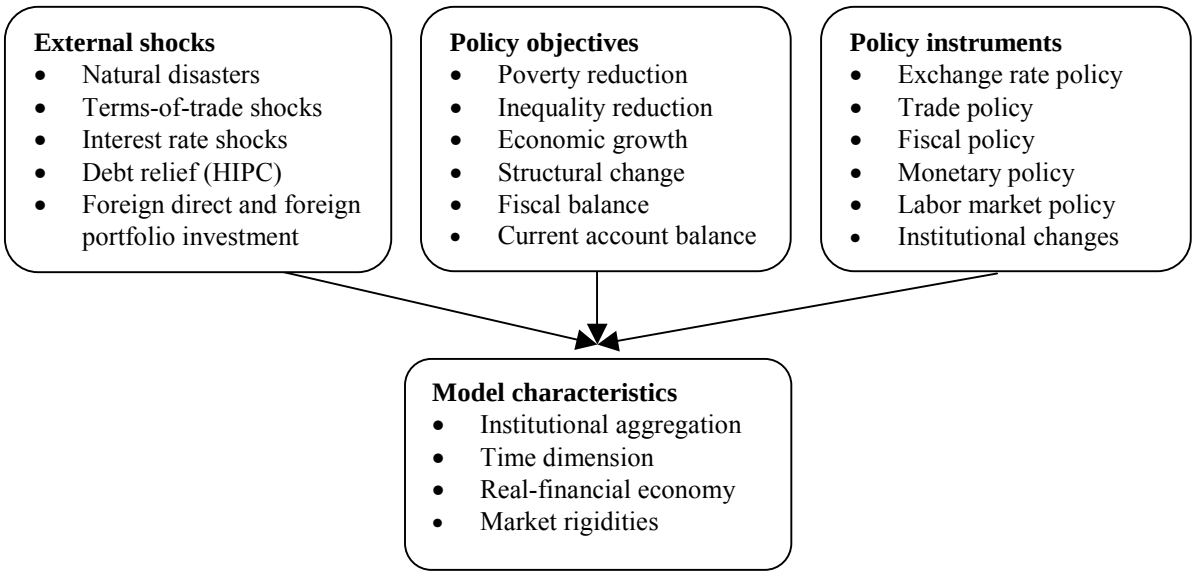
In this model, there are four main mechanisms by which external shocks and policy changes affect the real income and wealth of households. First, changes in factor rewards and public redistribution affect directly household nominal incomes. Second, household real incomes are affected by changes in the respective cost of living indexes. Third, household real incomes are affected by changes in real returns on financial assets and liabilities. Fourth, household wealth is affected by capital gains and losses as well as revaluations of financial assets and liabilities. These changes in income components are linked to household survey information describing the socioeconomic characteristics of individual households, thereby capturing in detail the distributional and poverty effects of shocks and policies.

The modeling of the real side is based on Dervis et al. (1982) and Robinson et al. (1999) whereas the modeling of the financial side follows the work of Rosenzweig and Taylor (1990) and Jemio (2001). The link between GEM and PIA is modeled along the lines of Agénor et al. (2002).

The detailed structure of GEM-PIA is driven by concerns about the links between poverty, inequality and growth (the so-called poverty-growth-inequality triangle; Bourguignon 2004), the types of external shocks affecting growth and poverty, and the

policy instruments and institutional regulations being considered to face the external shocks and to achieve pro-poor growth (Figure 1). The combination of these three factors determines the adequate sectoral and institutional aggregations and indicates the appropriate way of representing time. Moreover, the underlying theoretical paradigm is also affected by these factors.

Figure 1 — Factors Affecting the Structure of the Model



GEM-PIA can be used to project economic activities and macroeconomic variables as well as distributional and income poverty indicators for each of the specified households according to exogenous assumptions about the dynamics of the model. The model can also be used to simulate exogenous shocks (e.g. terms-of-trade and interest-rate shocks) and policy scenarios in various economic fields (e.g. trade policy, fiscal policy, and monetary policy) and to analyze their allocational and distributional impacts. Because of its integrated treatment of the real and financial sides, the model allows policy analysts to study not only the impact of structural reforms (e.g. changes in tariffs, subsidies, and taxes) on relative prices and output, but also the effect of short-term stabilization policies (e.g. cut in domestic credit or rise in deposit rates) as well as international financial flows (e.g. net capital outflows, debt relief or rising international interest rates). Thus, the model can be used to analyze the trade-offs

between stabilization and structural adjustment policies with regard to different policy objectives and the implications of these trade-offs for the sequencing of policy reforms.

The plan of this paper is as follows. Chapter 2 will provide a non-technical overview of GEM-PIA, starting with a short enumeration of the desired model structure and followed by overviews on the real and financial sides, the policy variables included in the model, and a description of the approach to the analysis of the poverty and distributional effects resulting from counterfactual simulations. In Chapter 3, the mathematical model statement is presented in detail, describing equation by equation respectively, the supply and demand side, the income distribution process, the market clearing conditions, the financial system, and the dynamics included in the model. Moreover, the solution strategy to a basic model version is illustrated. In Chapter 4, the model is calibrated to highly indebted, poor Bolivia to assess the properties of the model. The simulation results of two (exogenous and policy-induced) shocks are presented and their real, financial, income distribution and poverty effects are discussed. The last Chapter summarizes main results.

2. Model Overview

2.1 Desired Model Structure

Since the issue is mainly a distributional one, the model should be able to assess the impact of external shocks and policies on the distribution of costs and benefits. An appropriate modeling framework should therefore

- include different representative households, distinguished by their (initial) income levels (rich and poor), regional affiliation (urban and rural), and factor endowments (capital owners and laborers) in order to assess the distributional issues;

- link the distributional results for representative households to household survey information in order to take into account the full functional and spatial characteristics of households in the determination of distributional and poverty results;
- consist of a dynamic framework to differentiate between the impact of short-term stabilization policies and medium to long-term structural adjustment policies;
- consist of a sectoral production and consumption structure to facilitate an appropriate modeling of structural adjustment processes;
- differentiate between formal and informal activities to distinguish between formal and informal employment, and to take account of alternative sources of labor market segmentation, differences in wage formation, and inter-sectoral wage rigidities;
- consist of an open-economy model incorporating the "rest of the world" as an integral component that permits the consideration of worldwide capital and goods flows and consequently their influence on the domestic economy;
- include the financial system to take account of the facts that (1) poor households have access to only a limited range of financial assets, (2) commercial banks play a predominant role in the financial intermediation process, and (3) additional lending to the government may have a crowding-out effect on lending to the private sector;
- be formulated in such a way that it can be used for numerical analysis based on existing datasets.

All these features are included in GEM-PIA which is now described.

2.2 Real Side of the Model

The real side of the model follows the standard neoclassical specification of CGE models (Dervis et al. 1982; Robinson et al. 1999). The model economy is divided into the institutional agents enterprises, households, government, and rest of the world (Table 1). Enterprises themselves consist of producing units (private corporations and non-financial state-owned enterprises) and financial intermediaries (commercial banks and Central Bank). The production sector distinguishes several formal and informal activities. Informal activities are characterized by low integration into the economy, be it as a result of limited backward and forward linkages, segmented factor markets, or limited access to financial markets. In the model, the latter two criteria are used as a dividing line between formal and informal activities. Those sectors employing only informal (household) capital (typically traditional agriculture and informal services) are classified as informal whereas all other sectors, which use formal (corporate) capital are treated as formal activities.

Activities produce a characteristic but not necessarily homogenous good. Rather, the model assumes that domestically produced goods are differentiated according to their destination, i.e., whether they are exported or sold to the domestic market. Producers determine their supply to the domestic and export market by maximizing revenues along the lines of the 1-2-3 model (Devarajan and Lewis 1990). For some activities, e.g. mining, exports may be determined exogenously by contracts with major trading partners.

Enterprises (as well as some households; see Chapter 3 below) are involved in the production of goods and in capital accumulation. Goods are produced with the help of the primary factors labor and capital (including land in agricultural and mining activities) and intermediate goods. Domestically produced and imported intermediates are thereby treated as differentiated goods with limited substitution possibilities.

Table 1 — Classification in GEM-PIA

Activities/Goods and services	***Production factors***	***Agents***
Informal activities : – Traditional agriculture – Informal services Formal activities : – Modern agriculture – Mining – Manufacturing – Nontradables – Formal services	Labor – Smallholder labor – Agricultural unskilled labor – Non-agricultural unskilled labor – Skilled labor – Urban informal labor Capital – Smallholders' capital – Urban informals' capital – Employers' capital – Corporate (formal) capital – Public (infrastructure) capital	Households – Smallholders – Agricultural workers – Non-agric. workers – Employees – Urban informals – Employers Enterprises – Private corporations – State enterprises Financial institutions – Commercial banks – Central Bank Government Rest of the world

This treatment is similar to the modeling of the demand side in the 1-2-3 model. Producers in the individual activities determine their factor demand by minimizing production costs at exogenously given factor prices, goods prices and production taxes.

There are six types of representative households in the model, distinguished by their regional affiliation and factor endowment (see Table 1). Four of these households (smallholders, agricultural workers, non-agricultural workers and urban informals) have to be considered as groups with high incidence of poverty. Three of them, smallholders, urban informals, and employers, are treated as informal producing units. It is a typical characteristic of developing and especially of low-income countries that the informal sector produces a large share of GDP. This sector owns its own capital goods and invests into physical capital. The formal enterprises sector, which consists of private corporations and state enterprises, by contrast, produces with more capital-intensive technologies and (like the government) employs hired workers. Depending on their factor endowment, households earn labor and/or capital income for their

provision of factor services and interest income on financial assets. Moreover, they receive transfers from the government and factor income and remittances from abroad. They use their income for tax payments, interest payments on credits, consumption and savings. Households' demand for consumption goods depends on available nominal income and prices, whereas their demand for investment goods – like that of other institutions, which invest into physical capital – depends on overall savings and the various financing constraints, which they are facing. Domestically produced and imported consumption and investment goods are again assumed to be imperfect substitutes in domestic demand.

The government finances its current expenditures on own consumption, subsidies and transfers, and interest payments on domestic and foreign debt out of direct and indirect tax revenues as well as operating surpluses of public enterprises. The budget surplus is used to finance public investments. Finally, the rest of the world imports and exports goods and services from and to the country under investigation, undertakes direct and portfolio investments, and provides development aid, debt relief, etc. The country's volumes of imports and exports are assumed to be small in relation to total world trade with no impact on world prices. However, we assume price elastic export demand functions. This implies that the country can gain additional world market shares if it reduces its production cost and accepts terms-of-trade losses.

Beside the disaggregation of enterprises and households another distinctive feature of the model is its specification of the product and labor markets. Neoclassical models typically assume perfect substitutability between domestically produced and imported goods for the various goods in domestic demand, on the one hand, and perfect transformability between domestically sold and exported goods in domestic supply, on the other, whereas structuralist models regard home goods and tradable goods as complements with a fixed relationship. In the first case, domestic prices are fully determined by world market prices (and the exchange rate and trade policies), whereas

world market prices do not have a direct influence on domestic prices in the second case.

The model presented here encompasses both extreme positions as well as all intermediate cases by differentiating on the supply side between domestic and export supply and on the demand side between domestically and imported goods. Table 2 provides an overview of the supply and demand side of the goods market. The table shows in the upper part the division of domestic production into export and domestic supply together with their distribution over several demand components whereas the lower part shows the domestic demand for imports.

Table 2 — Components of Supply and Demand

Domestic supply	Intermediate demand Household consumption Government consumption Investment demand
Export supply	Export demand
Import supply	Intermediate demand Household consumption Government consumption Investment demand

Domestic supply and export supply are determined in two steps. In a first step, total supply is determined without differentiating between home supply and export supply. Total supply of individual goods depends on activities' factor use. Given overall supply, its allocation to domestic and foreign markets is determined in the second step with the allocation depending on the initial volume shares, relative prices on domestic and export markets, and a parameter reflecting the homogeneity of the domestically and the exported good (see Section 3.3).

The domestic demand for individual goods consists of five different components with export demand directed exclusively towards domestically produced goods, i.e. there is

no entrepôt-trade in the model. The export demand functions are assumed to be price elastic. The demand of the remaining four domestic demand components is again determined in two steps. In a first step total demand for individual goods is determined without the domestic-imported distinction. The demand for intermediates is assumed to depend linearly on gross production and is determined by fixed input-output coefficients. Households' consumption demand depends on consumption expenditures and goods prices (Linear Expenditure System, LES). The gross fixed investments of those institutions investing in physical capital are determined endogenously by portfolio choice and subject to restrictions on credit availability. Real government consumption is assumed to be a policy variable and determined exogenously.

Starting from total demands so calculated, the domestic and imported demand component for each good is then calculated in the second step, with the initial shares, relative prices and a parameter, which reflects substitution possibilities in domestic demand, determining the final allocation (see Section 3.2). In this context, identical substitution possibilities for all demand components but different substitution possibilities for different goods are assumed.

Import supply is assumed to be perfectly elastic since the country imports only a marginal share of total world supply of the different goods and it is therefore highly unlikely that changes in import demand have an impact on world prices.

To capture the reality of developing countries employment structure and to keep track in a detailed manner of the poors' main income flows, the model assumes a high degree of labor market segmentation. Beside the self-employed labor of smallholders and urban informals, two types of unskilled labor (agricultural and non-agricultural) as well as skilled labor are distinguished. Labor markets are linked via rural-rural and rural-urban migration. While the former involves smallholders becoming hired workers in modern agriculture, the latter involves the absorption of smallholders by the urban informal sector. Along the lines of the Harris-Todaro model, the decision to

migrate depends on wage differentials. For all labor markets, full employment is assumed with wage adjustments clearing the respective markets.

The model also assumes segmented capital markets, with a distinction made between unincorporated and corporate capital. Three household groups (smallholders, urban informals, and employers) own unincorporated capital. While smallholders and urban informals invest exclusively in traditional agriculture and informal services, employers receive capital income from all formal sectors. Corporate capital, by contrast, is owned by private and public enterprises, which accumulate capital in all formal sectors and retain the respective factor income. Finally, the model separates public infrastructure capital, which is assumed to have a crowding-in effect on sectoral production. Public infrastructure is provided costlessly to the different sectors and no market clearing is necessary.

2.3 Financial Side of the Model

The overall growth performance of the economy in GEM-PIA crucially depends on the pattern of institutional investment with the latter determined by the demand for physical capital of each institution and the financing constraints, which they are facing. The accumulation balance adjustment for all institutions is assumed to follow a 'prior-savings' approach in the basic version of GEM-PIA. That means that both, the realized level of physical investment and the accumulation of financial assets adjust to the availability of funds, the latter being determined by each institution's own savings plus credit from the domestic banking system (including foreign portfolio investment, which is channeled through domestic banks; for those institutions having access to the credit market) plus foreign loans (in the case of government) plus FDI (in the case of private and public enterprises). Institutions' decisions about their desired portfolio structure are modeled through stock-adjustment functions of the CES-type depending on profitability differentials between different assets and the initial asset structure.

Thus, the model implicitly assumes a system of supply-led finance and perfectly elastic liability demand.

Households' savings rates are assumed to be constant. Moreover, some households (agricultural and non-agricultural workers) are assumed to have no access to the credit market, while others' access (smallholders or urban informals) might be constrained. For example, in the basic version of GEM-PIA supply of credit to smallholders is determined residually after the demand of all other institutions has been satisfied. Households' total assets are allocated between money in domestic currency and deposits in commercial banks (for all households) and equity shares in private firms and foreign assets (for some, rich, households) and/or productive physical assets (for smallholders, urban informals, and employers).

Private and public enterprises' savings are made of profits net of taxes. Additional available funds are determined either exogenously (FDI) or endogenously by commercial banks, based on relative profitability. Their investment in physical capital depends on the rate of return to capital relative to the rates of return on deposits in the domestic banking system and foreign assets. Finally, government savings is equal to its revenues net of current expenditures. Public investment may either be determined residually, after the decisions on the financial portfolio are taken (default in the basic version) or is a policy variable. In any case, the resulting borrowing requirements are met by three sources: direct credit from the Central Bank, domestic borrowing, and foreign borrowing. In the latter case, the respective shares of these are considered to be policy variables.

Equilibrium on the loanable funds market states that total deposits in the commercial banks, less reserve requirements, equate borrowing from households, enterprises, and government.

The model assumes a budget-constrained situation with the Central Bank determining the amount of foreign exchange reserves necessary to finance the import requirements

for a specific period (number of months). Moreover, the Central Bank provides credit to the government and rediscount to commercial banks. It is assumed that the credit side of the Central Bank accumulation balance is determined by the portfolio decisions of other institutions. That means that Central Bank deposits of the government, reserve holdings of commercial banks and of the rest of the world in the Central Bank as well as households' cash holdings are all determined by these institutions. Since its foreign reserves cannot be run down below the minimum required, the Central Bank has to adjust its credit to public or private institutions. The adjusting variable in this financial constrained situation becomes rediscount to commercial banks.

The important role of the Central Bank in the closure of the financial system, makes reserve management and thus monetary control a central instrument capable of influencing one (and only one) of the constraints (in the above case credit from commercial banks) on investment and growth in the economy.

Finally, the modeling of the external balance assumes a crawling peg (in the basic version of GEM-PIA), i.e., the nominal exchange rate is a policy variable, which is adjusted exogenously.

2.4 Policy Variables

GEM-PIA contains several policy variables and simulation parameters which may be changed in counterfactual simulations in order to investigate the impacts of macroeconomic, structural and institutional reforms. With regard to institutional responsibility variables and parameters can be divided into those influenced by the government, the Central Bank and commercial banks, and the rest of the world (Table 3).

By fixing one or more policy variables the government decides on the amount of resources which are available to other agents for consumption and investment purposes. For example, if income related taxes (income and corporate taxes) are

increased, this reduces the disposable income of private agents. However, additional tax revenues may be used to finance additional public expenditures. The final impacts of such an intervention on total demand and production as well as on the level and distribution of overall real income depends on the adjustment of private agents. The same holds true for indirect taxes (value added, excise, tariffs), export subsidies and transfers to households and enterprises.

Beside economic policy instruments the government also decides on some rules which determine the way domestic agents adjust to policy interventions. Other rules are determined by representatives of different social groupings (e.g., trade unions and management). For example, the institutional environment in developing countries has changed drastically since the introduction of the first stabilization and structural adjustment programs in the early 1980s. The financial sector reforms and the strengthening and Central Bank autonomy in the mid 1980s has reduced the governments' possibilities to get indebted. The restricted access to Central Bank credit may be taken into account in the model by including Central Bank credit as well as commercial credit as a restriction in the accumulation balance of the government. Despite the financial sector reforms, poor households generally still have limited access to the capital market. For the modeling of limited capital market access, this implies that credit of the banking system to poor households should be determined residually after the total demand of all other institutions is satisfied. However, the model is flexible with regard to alternative institutional rules. In order to investigate the impact of a more flexible allocation of credits on income distribution and poverty, this credit restriction can be relaxed.

Table 3 — Policy Variables and Other Simulation Parameters

Government	Banking system	Rest of the world
Income/corporate taxes Export subsidies Import tariffs Excise taxes Value added taxes Transfers to households and enterprises Real government consumption Real government investment Infrastructure projects	Central Bank: – Minimum foreign exchange reserves (in relation to imports) – Central Bank interest rate – Nominal exchange rate Commercial banks: – Access to credits – Flexibility of credit allocation	Development aid Foreign portfolio investment Foreign direct investment Net credit to government Debt relief (HIPC) Foreign interest rate (LIBOR) Factor income from abroad Remittances World prices for exports World prices for imports Grant element of concessional credits

The model assumes that the Central Bank can influence three variables. On the one hand, it determines the stock of US-Dollars to be held as international reserve. On the other hand, it determines the interest rate to be applied by financial transactions with domestic institutions. And finally, the Central Bank determines the yearly devaluation to reach its stability goals and to support the international competitiveness of domestic enterprises. Monetary control can be simulated in the model through manipulation of the reserve position of the Central Bank.

Most institutional parameters and variables of the model are under foreign control. These are important inflows of private capital as either foreign direct or foreign portfolio investment, foreign factor income and remittances, and public inflows as development aid and net credit to the government (e.g., debt relief within the HIPC initiative). Moreover, the model also includes the world market prices at which countries import and export goods and services from and to the rest of the world. Thus, the model can be used to analyze terms-of-trade shocks. Finally, the model includes

the foreign interest rate (LIBOR) at which domestic institutions can get indebted or can invest abroad. Thus, the analysis of interest rate shocks is also possible.

Structural adjustment programs are also directed towards changing the institutional environment from which governments are expecting a strengthening of the private sector and respective trickle-down effects. In the very end, this implies that private enterprises and households react more flexible to economic incentives. GEM-PIA therefore contains a bundle of technical parameters which influence the adjustment flexibility of different agents on the markets for goods, factors and financial assets. This implies that the model can be used in a very flexible manner and under different institutional conditions for the analysis of macroeconomic and social issues.

2.5 Poverty and Income Distribution Indicators

There are several alternative approaches to the analysis of the poverty and distributional effects of policy and exogenous shocks in applied general equilibrium models (see e.g., Roland-Holst 2004). A popular approach in the CGE literature consists in specifying a relatively large number of homogeneous household groups and calculating average income for each group following a shock and treating the group as a whole as being poor if average income is lower than a given poverty line. This is the procedure followed, for instance, by Adelman and Robinson (1978), in their pioneering CGE analysis of income distribution policies in Korea.[1] In GEM-PIA, the distributional and poverty effects of shocks are rather assessed by linking the simulation results of the general equilibrium model to the results of a household survey. This approach involves 5 steps:

Step 1: The information in the household survey is used to classify the available sample into categories of households contained in the model (based on

[1] Recently, Rutherford et al. (2004) have constructed a model for Russia that endogenously includes over 55,000 households.

information on the main source of income of household heads) so as to establish an interface between the model's predictions and actual household income.

Step 2: Following a shock, the model generates indices on (1) different types of factor income, (2) net interest income and transfers from abroad, and (3) public transfers up to the end of the simulation horizon. These income components can also be identified in household surveys for developing countries.

Step 3: These indices are applied separately to the households groups in the household survey taking into account that different household members may earn different types of factor income.[2] The remaining two components of household income are given by household group in the CGE model and are applied to the survey information at the household level.[3] In addition, relative goods price changes affect the real income positions of households. Household nominal incomes in the survey are therefore deflated by household specific goods price indices from the CGE simulation. Together, these scaling procedures give real income levels for each group following the shock, for all periods of the simulation horizon.

Step 4: Assuming different initial poverty lines for the rural and urban sectors and using the new real income levels of income for each group, the model calculates a poverty headcount index, a poverty gap index, a poverty severity index as well as several indicators of income distribution (e.g., the Gini coefficient and the Theil inequality index).

Step 5: Finally, the post-shock poverty and income distribution indicators are compared with the baseline values to assess the impact of the shock on the poor. These comparisons are based on the assumption that the poverty line is constant in real terms in both the rural and urban areas.

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[2] For example, the household head may be self-employed (urban informal in the CGE model) and his/her spouse may work as a worker (unskilled worker in the CGE model).

[3] The procedure so far does not consider direct taxes as household surveys for developing countries typically do not contain the necessary information. The treatment of indirect taxes and their incidence does not pose a problem, as they are accounted for in the household specific composite goods price index.

3. Mathematical Structure

In this section, the mathematical model statement is presented, equation by equation. In its mathematical form, the model is a system of simultaneous, non-linear equations. The model is square, i.e., the number of equations is equal to the number of variables. In this class of models, this is a necessary (but not a sufficient) condition for the existence of a unique solution. In the statement, the equations are divided into nine sections.

The presentation of the theoretical structure of the model follows the general description of the model overview. The following sections first provide the hypotheses on the real (Sections 3.1 to 3.4) and financial side (Section 3.6) of the model. The model also includes a set of constraints that have to be satisfied by the system as a whole but which are not necessarily considered by any individual actor. These constraints apply to markets for factors, commodities, loanable funds and money, and to macroeconomic aggregates such as balances for savings and investment, the government budget, and the balance of payments (Sections 3.5, 3.7 and 3.8). The formal presentation of the model closes with a description of a typical solution strategy (Section 3.9).

The model includes several domestic production sectors identified by their principal product (see e.g., Table 1; index i or j). Moreover, there are 10 types of production factors (index f):

- Smallholder labor (index SHLab, supplied by smallholder households)
- Agricultural unskilled labor (index RULab, supplied by rural worker households)
- Non-agricultural unskilled labor (index UULab, supplied by urban worker households)
- Skilled labor (index SLab, supplied by employee households)

- Urban informal labor (index UILab, supplied by urban informals households)
- Smallholders' capital (index SHCap, real capital provided by smallholder households)
- Urban informals' capital (index ICap, real capital provided by urban informal households)
- Employers' capital (index ERCap, real capital provided by urban employer households)
- Corporate (formal) capital (index FCap, real capital provided by private and public enterprises)
- Public (infrastructure) capital (K_{GV}, real capital provided by the government)

Moreover, there are 7 types of institutions in the model (index d or e; sub-indexes are used for model-technical reasons and consist of one of the first letters together with another letter):

- Households (index dh; consuming institutions, some of them also producing and investing)
- Private formal enterprises (index PC; producing and investing institution)
- Public enterprises (index SE; producing and investing institution)
- Government (index GV; consuming, producing and investing institution)
- Commercial banks (index PB; financial offset account for intermediation; interest payments are made via the private formal enterprises' account to which private banks belong)
- Central Bank (index CB; financial offset account for intermediation; interest payments are made via the public enterprises' account to which the Central Bank belongs)

- Rest of the world (index RW; trading goods and services, capital transactions, also settling foreign assets and liabilities)

There are 6 representative household groups in the model, differentiated by factor endowment and regional affiliation (index h):

- Smallholders (index SH; consuming, producing and investing institution)
- Agricultural workers (index AW; consuming institution)
- Non-agricultural workers (index NAW; consuming institution)
- Employees (index EE; consuming institution)
- Urban informals (index UI; consuming, producing and investing institution)
- Employers (index ER; consuming, producing and investing institution)

A few notational rules will be generally observed. Italic capital letters without bars are endogenous variables. All other characters denote pre-determined variables. Variables taken from the **p**re-**p**eriod, which are exogenous in the current period do have the extension PP. Subscripts i and j indicate activities and commodities, respectively. In the case of two indices, the first describes the sector of origin, and the second the sector of destination. Subscripts fl stand for labor categories, fc for capital categories, h for households, and d and e for institutions. Here the first subscript describes a receiving and the second a spending institution. The meaning of other symbols is explained in the text.

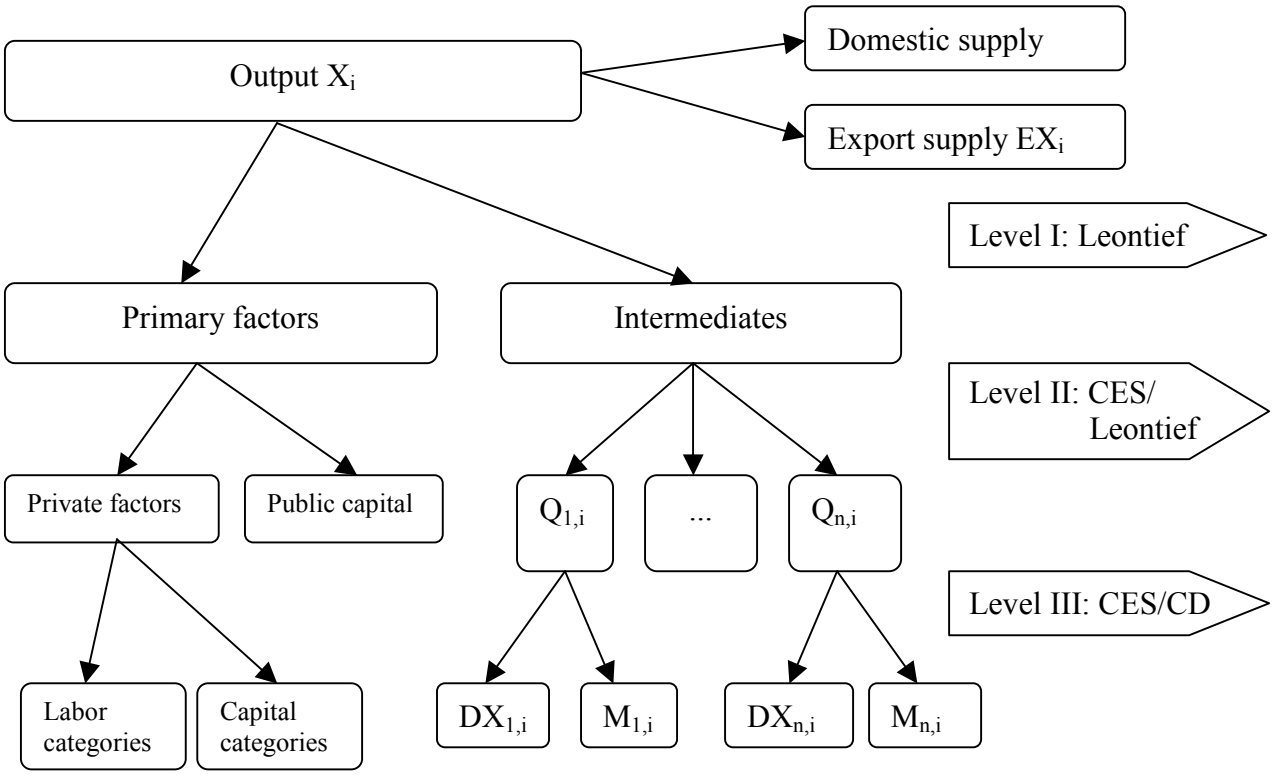
3.1 Production and Input Demand

The volume of production in each activity is determined by a three-level nested production function, as shown in Figure 2. At the first level, a Leontief function combines a bundle of primary factors with a bundle of intermediates in order to produce output. There are no substitution possibilities between intermediates and

primary factors. Nor is it possible to substitute between individual intermediates (Level II). Rather all intermediates are used in fixed proportions ($a_{i,j}$) to produce one unit of output (X_j). Thus, total demand of all activities j for intermediate good i (INT_i) equals:

[1] $INT_i = \sum_j a_{ij} \cdot X_j$

Figure 2 — Structure of the Production and Supply Functions



Substitution possibilities in individual activities i between the stock of public capital (K_{GV}) – which is provided costlessly – and a bundle of private primary factors (VA_i) are described by a (constant elasticity of substitution) CES function at the second level

[2] $X_i = ax_i \left[\delta_i^x \cdot K_{GV}^{\rho_i^x} + \left(1 - \delta_i^x\right) \cdot VA_i^{-\rho_i^x} \right]^{-\frac{1}{\rho_i^x}} \qquad \sigma_i^x = \frac{1}{1+\rho_i^x};\ \sigma_i^x > 0$

The introduction of public capital in the production functions is based on the view that (cumulative) public investment in the economy improves the productivity of activities, 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, dams and similar public goods that may contribute to an increase in productivity.

Substitution possibilities between different primary factors ($FD_{f,j}$) are described by CES functions[4] for formal production activities and Cobb-Douglas functions for informal activities at the third level. Thus, it is assumed that labor can fairly easily substitute for the very basic capital goods used in informal activities

[3a] $VA_i = ava_i \prod_f FD_{f,i}^{\alpha_{f,i}} \qquad \sum_f \alpha_{f,i} = 1$

[3b] $VA_i = ava_i \left[\sum_f \delta_{f,i}^{va} \cdot FD_{f,i}^{-\rho_i^{va}} \right]^{-\frac{1}{\rho_i^{va}}} \qquad \sigma_i^{va} = \frac{1}{1+\rho_i^{va}};\ \sigma_i^{va} > 0$

Finally, at the third level CES functions describe substitution possibilities between imported ($M_{j,i}$) and domestically produced ($DX_{j,i}$) goods in domestic intermediate demand. The model assumes different substitution possibilities for different goods but identical substitution possibilities for all domestic demand components[5]. Thus the decision of producers to use imported or domestically produced intermediates in production does not differ from the decision of consumers and investors to consume

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[4] The exponent (ρ^x) in the CES function [2b] is a transformation of the elasticity of substitution (σ^x) between primary factors: the higher this elasticity, the smaller the value of the exponent and the larger the optimal change in factor rations in response to changes in their relative prices.

[5] Intermediate demand, private and public consumption, investment demand.

and accumulate home goods or imported goods. The demand for imported intermediates can therefore be described together with total import demand in section 3.2 below.

The demand for primary factors is derived under the assumption that producers minimize their production costs subject to the production technologies described above. Under this assumption the demand for factors is given by the marginal conditions (factor price equals marginal value product)

[4a] $$WF_f \cdot \overline{WFDIST}_{f,i} = PV_i(1-tvx_i)\alpha_{f,i}\frac{X_i}{FD_{f,i}}$$

[4b] $$WF_f \cdot \overline{WFDIST}_{f,i} = PV_i(1-tvx_i)\cdot X_i\left[\sum_f \delta^x \cdot FD_{fi}^{-\rho_i^x}\right]^{-1}\cdot \delta_{fi}^x \cdot FD_{fi}^{-\rho_i^x-1} \quad \text{with}$$

[5] $$PV_i = PX_i(1-txx_i) - \sum_j PQ_j \cdot a_{j,i}$$

where PV_i describes the net price or unit value added, PX_i the producer price, and PQ_i the consumer price. Indirect taxes are assumed to be paid by producers (at a rate txx_i) and are shifted uniformly to all consumers. Thus, the model excludes the possibility that different demand components are taxed differently. Value-added taxes are treated similarly and are introduced into the model with a tax rate tvx_i.

The factor demand equations [4] assume that primary factors are paid the same average rental or wage (WF_f) regardless of sector. To capture the fact that wage rates and returns to capital differ across sectors, the model allows for distortions in factor markets. This is represented by a sector-specific parameter ($WFDIST_{i,j}$) for each factor that measures the extent to which the sectoral marginal revenue product of the factor deviates from the average return across the economy. If there are no distortions in a particular factor market, this parameter equals one for all sectors.

At given producer tax rates, given input-output coefficients, and given product and factor prices, factor demand is unequivocally determined by equations [4]. Producers' factor demand is directed towards the factor markets, where the average nominal wage rates and rental rates are determined, which producers – together with producer prices and consumer prices (from goods markets) – receive as signals. Only in connection with the factor supply can be determined which labor quantities are finally used in production (see Section 3.5).

3.2 Import Supply and Import Demand

In the classical theory of international trade, a traded good is assumed to be one for which (i) the country is a price-taker in the world market and (ii) the domestically produced good is a perfect substitute for that sold in world markets. This specification leads to the result that the domestic price of a traded good is equal to its world price. Now, for developing countries, the second assumption is particularly troublesome. First, quality differences are frequently observed between imports and domestic substitutes. Second, at a level of aggregation typical for CGE models, each sector actually represents a bundle of different goods. For example, the capital goods sector may include some goods (like machine tools) produced in the country itself and others (like heavy machinery) which are not. In our model, we resolve this problem by relaxing assumption (ii) for imported goods. Instead, we postulate that for any traded good, imports M_i and domestically produced goods DX_i are imperfect substitutes (the Armington assumption; Armington 1969). The demand for imports is derived under the assumption that domestic consumers minimize the cost of consuming a "composite good" Q_i, which is composed of imported M_i and domestically produced goods DX_i

[6] $PQ_i \cdot Q_i = PM_i \cdot M_i + PD_i \cdot DX_i$

subject to a CES aggregation function

$$[7]\quad Q_i = aq_i\left[\delta_i^q \cdot M_i^{-\rho_i^q} + (1-\delta_i^q)\cdot DX_i^{-\rho_i^q}\right]^{-\frac{1}{\rho_i^q}} \qquad \rho_i^q = \frac{1}{\sigma_i^q} - 1; \sigma_i^q > 0$$

where aq_i and $\delta^q{}_i$ are constants and $\rho^q{}_i$ is a transformation of the elasticity of substitution $\sigma^q{}_i$, which describes substitution possibilities between imported and domestically produced goods in domestic demand.

From the first-order conditions for cost minimization follows the import demand function

$$[8]\quad M_i = DX_i\left[\frac{PD_i \cdot \delta_i^q}{PM_i(1-\delta_i^q)}\right]^{\sigma_i^q}$$

In classical trade theory, $\sigma^q{}_i$ is infinity, so that domestic prices equal import prices, since if PD_i ever exceeded PM_i, the demand for the domestically produced good would have to be zero. The Armington assumption allows for a richer set of responses, but as $\sigma^q{}_i$ gets larger, the sensitivity of the import-to-domestic-supply ratio to changes in relative prices rises. Also, as a result of this specification, domestic prices no longer equal import prices; rather PD_i is endogenously determined in the model. The domestic price for imports, however, is linked to the exogenous world price in dollars pwm_i by the exchange rate ER and tariff rates tmx_i

$$[9]\quad PM_i = pwm_i(1+tmx_i)\,ER$$

i.e., we retain the price-taker assumption of classical trade theory.

3.3 Export Demand and Export Supply

Classical trade theory also assumes a small country faces a perfectly elastic demand for its exports. Again, this assumption may not be realistic for many developing countries. While they may not be able to affect the world market price with their exports, such countries may register a declining market share as, say, their domestic

prices rise. To reflect this, we specify exports as facing a constant-elasticity demand function

$$[10] \quad EX_i = econ_i \left[\frac{PWE_i}{pwse_i} \right]^{-\varepsilon_i}$$

where $econ_i$ is the exogenous world demand if PWE_i equals $pwse_i$ and ε_i is the price elasticity of export demand. $pwse_i$ is a weighted average of the world price for good i and PWE_i is the dollar fob-export price which depends on the domestic export price

$$[11] \quad PWE_i = \frac{PE_i}{(1+tex_i)ER}$$

The latter results from equalizing export supply (discussed below) and export demand. Thus export demand increases with increasing world demand, increasing world market prices, increasing export subsidies (tex_i), and an increasing exchange rate (devaluation) whereas increasing domestic prices and increasing export taxes reduce export demand.

Furthermore, export supply may exhibit an excessively strong response to changes in domestic prices. As a domestic price rises, producers are induced to increase supply and domestic consumers to reduce their demand. The net result is a dramatic increase in exports (the difference between supply and domestic demand). However, in reality, exports may not rise this fast, because the domestically consumed and exported commodities in the same sector may be quite different. For example, intermediate goods may include both electricity (which is not traded) and chemicals (which is). To get around this problem, the determination of domestic supply and export supply follows Powell and Gruen (1968) assuming that producers in individual activities determine their level of exported and domestically supplied quantities (see Figure 2) in such a way as to maximize total revenues

$$[12] \quad PX_i \cdot X_i = PD_i \cdot DX_i + PE_i \cdot EX_i$$

under the condition of a (constant elasticity of transformation) CET function, which reflects the homogeneity of exported and domestically supplied goods in each activity

$$[13]\quad X_i = at_i\left[\delta_i^t \cdot EX_i^{\rho_i^t} + (1-\delta_i^t)\cdot DX_i^{\rho_i^t}\right]^{\frac{1}{\rho_i^t}} \qquad \sigma_i^t = \frac{1}{\rho_i^t - 1}; \sigma_i^t > 0$$

where a^t_i, δ^t_i, and ρ^t_i describe the scaling, distribution, and transformation parameters, respectively.

From the first-order conditions for revenue maximization follow the export supply functions

$$[14]\quad EX_i = DX_i\left[\frac{PE_i(1-\delta_i^t)}{PD_i \cdot \delta_i^t}\right]^{\sigma_i^t}$$

According to equation [14], export supply of individual activities depends on the distribution of supplied quantities in the initial situation (δ^t_i), on the relative price of exported and domestically supplied goods, and on the transformation elasticity (σ^t_i). Note that with perfectly elastic export demand, equation [14] assures that an increase in the export-domestic price ratio will generate an increase in the export-domestic demand ratio (i.e., a shift toward the destination that offers a higher return). In this case, equation [10] is dropped from the system of equations and terms-of-trade effects are neglected.

3.4 Income Distribution and Expenditures

This section describes the distributional process of the model, i.e., the distribution of value added to factors of production, the distribution of factor incomes to institutions as well as the redistribution process via the government and the financial system, and the spending of the institutions' income. Many of the equations in this section will be specific to the structure of a particular economy.

Factor income

Total factor income of production factor *f* (YF_f) from domestic sources equals the sum of sectoral factor income

[15] $YF_f = \sum_i WF_f \cdot \overline{WFDIST}_{f,i} \cdot FD_{f,i}$

Total labor income of the different labor categories *fl* consist of domestic labor income plus labor income from abroad (yfa_{fl}). The latter is fixed in foreign currency and transformed into domestic currency by multiplying by the exchange rate

[16] $YL_{fl} = YF_{fl} + yfa_{fl} \cdot ER$

Total formal capital income (YF_{FCap}) is distributed to private (*PC*) and public (*SE*) enterprises according to their shares in the total formal capital stock, which implies that for both institutions the same productivity and factor remuneration is assumed:

[17] $YFC_{dg} = \frac{YF_{FCap} \cdot K_{dg}}{\sum_{eg} K_{eg}} \qquad dg = PC, SE$

By contrast, informal capital is viewed as specific capital with limited intersectoral mobility, depending on the owner of the respective informal capital stock. For example, smallholders are assumed to be tied to their land and therefore invest exclusively in agricultural sectors, mostly traditional agriculture and to a lesser extent in modern agriculture. The same holds true for urban informals who are assumed to invest mainly in the informal services sector and to a lesser extent into maintenance activities in manufacturing sectors and construction. Income from informal capital is distributed to households according to their capital endowment. Let $shh_{fc,dh}$ and $shh_{fl,dh}$ denote the shares of household *dh* in capital and labor categories *fc* and *fl*, respectively. Then total household factor income is given by

[18] $YHF_{dh} = \sum_{fc} shh_{fc,dh} \cdot YF_{fc} + \sum_{fl} shh_{fl,dh} \cdot YL_{fl}$

Sources and use of institutional income

Households: The gross income of households (Y_{dh}) consists of factor income, financial payments, public transfers, and remittances from abroad. Households receive interest payments on their financial assets ($RT_{dh,PC}$), social payments such as transfers, pensions etc. (SUB_{dh}) from the government, and remittances from family members living abroad ($yrem_{dh}$). On the other hand, households pay interest on their financial liabilities ($RT_{PC,dh}$).

[19] $$Y_{dh} = YHF_{dh} + SUB_{dh} + yrem_{dh} \cdot ER + RT_{dh,PC} - RT_{PC,dh}$$

All financial assets and liabilities of households (and other institutions) are determined at the end of each period according to the portfolio choices described in the financial submodel (section 3.6) below ($V_{d,e}$, $V_{e,d}$, etc.). These stocks also represent the beginning-of-year stocks in the new period, but are treated as end of **p**re-**p**eriod stock data ($VPP_{d,e}$, $VPP_{e,d}$, etc.) on which interest payments (interest rate: R) in the current period are based.[6]

It is generally assumed that interest payments between the banking system ($RT_{d,e}$ for commercial banks and $RR_{d,e}$ for Central Bank) and other institutions are made by private and public enterprises – to which commercial banks and the Central Bank belong – and the respective institutions (the bank clients). The financial sector's accounts simply serve as inter-institutional resource transfers accounts, collecting deposits of the institutions and channeling these deposits to institutions as loans.

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[6] The interest rate R is either fixed or determined endogenously by the portfolio determination of the institutions. If it is fixed this implies a closing of the financial sector. If the interest rate is determined endogenously, another variable is needed to close the formal financial market. In this case R is the closing variable for the formal financial market. This implies that the interest payments to be paid during the current period are unknown at the end of the pre-period when the investment decision is taken.

Households' interest receipts and interest payments as a result of banking businesses and equity share holdings are calculated as follows (including the correction factors $cx_{d,e}$):[7]

[20] $RT_{dh,df} = cx_{dh,df} \cdot R \cdot \sum_{df} VPP_{df,dh} \qquad df = PC, PB$

[21] $RT_{PC,dh} = cx_{PC,dh} \cdot R \cdot VPP_{dh,PB}$

Public transfers are assumed to be proportional (cz_{dh}) to public consumption expenditures (CNG)

[22] $SUB_{dh} = cz_{dh} \cdot CNG$

Foreign exchange holdings of households (outside the domestic banking system) are assumed to be in the form of non-interest bearing cash holdings implying that there are no interest payments. Households' total consumption expenditures are calculated residually by deducting income taxes (TD_{dh}) and savings (SV_{dh}) from gross income[8]

[23] $CNH_{dh} = Y_{dh} - TD_{dh} - SV_{dh}$

Income tax payments of households are based on gross income minus nominal depreciation at a tax rate tdx_{dh}, with nominal depreciation calculated as real depreciation times the actual capital goods price (see subsections on *Sources and use of government income* and *Investment and depreciation* below)

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[7] The model does not differentiate between deposit and lending rates. Nor does it take into account the variety of interest rates which prevail in reality. This implies that the interest payments, if calculated on the basis of pre-period assets and applying a single interest rate do not yield the interest payments shown in a Social Accounting Matrix. The calibrated parameters $cx_{d,e}$ and $cy_{d,e}$ correct for these differences.

[8] Note that we do not account for any real balances effect (or wealth effect) on consumption, as in Easterly (1990) or Jemio (2001) and others. This effect can be, however, easily added if warranted by the empirical evidence – for instance by making the savings rate a function of wealth as well. It could prove important in assessing the effects of exchange-rate induced valuation changes on domestic expenditure.

Household savings is described by an income elastic savings function. If autonomous savings (sa_{dh}) are negative, increasing real incomes will yield increasing percentage savings

$$[24] \quad SV_{dh} = \frac{sa_{dh} + ms_{dh} \cdot Y_{dh}}{PDX}$$

It is assumed that each household maximizes a Stone-Geary utility function subject to a consumption expenditure constraint. The resulting first-order conditions in equation [25] are referred to as LES (Linear Expenditure System) functions since spending on individual commodities is a linear function of total consumption spending

$$[25] \quad CH_{i,dh} = \theta_{i,dh} + \mu_{i,dh} \frac{CNH_{dh} - \sum_i PQ_i \cdot \theta_{i,dh}}{PQ_i} \qquad \text{with}$$

$\theta_{i,dh}$ is the subsistence consumption of commodity i for household dh and
$\mu_{i,dh}$ is the marginal share of consumption spending on commodity i by household dh

Besides consuming goods, some households also invest into physical capital. It is assumed that the levels of households' investment expenditures (as well as their accumulation of financial assets) adjust to the availability of funds, i.e., they are determined by other institutions' portfolio decisions. The modeling of households' investment demand is described below together with other institutions' investment demand. Finally, the total flow of savings of each household is channeled into the accumulation of financial wealth (see Section 3.6).

Private enterprises: Gross income of private enterprises (Y_{PC}) consists of their share in formal capital income and several financial payments from and to other domestic institutions and the rest of the world

$$[26] \quad Y_{PC} = YFC_{PC} + SUB_{PC} + \sum_{da} RT_{da,PC} - \sum_{da} RT_{PC,da} + RR_{PC,SE} - RR_{SE,PC} + RT_{PC,RW} - RT_{RW,PC}$$

on deposits in and loans from commercial banks ($RT_{PC,da}$, $RT_{da,PC}$) and the Central Bank ($RR_{PC,SE}$, $RR_{SE,PC}$) as well as on foreign deposits ($RT_{PC,RW}$) and enterprises' external debt ($RT_{RW,PC}$). Interest payments between private corporations and commercial banks are not included because these are payments within the same institution. However, interest, which households, state enterprises, and the government pay for their credits and receive for their deposits are fully included at the market interest rate (R). Moreover, private enterprises receive and pay interest on their Central Bank deposits and credits at the Central Bank interest rate (rcx).

[27] $RT_{da,PC} = cx_{da,PC} \cdot R \cdot VPP_{PC,da}$ $\quad da = all\ domestic\ institutions$

[28] $RT_{PC,da} = cx_{PC,da} \cdot R \cdot VPP_{da,PC}$

[29] $RR_{PC,SE} = cy_{PC,SE} \cdot rcx \cdot VPP_{CB,PB}$

[30] $RR_{SE,PC} = cy_{SE,PC} \cdot rcx \cdot VPP_{PB,CB}$

Interest-bearing transactions of private enterprises with the rest of the world include deposits of private corporations and commercial banks in foreign banks and foreign portfolio investment in domestic banks. These transactions are undertaken on a Dollar basis at international conditions (foreign interest rate rex). Thus, in order to determine interest payments, a correction factor ($ER/ERPP$) is included to account for possible exchange-rate changes.

[31] $RT_{PC,RW} = cx_{PC,RW} \cdot rex \cdot \sum_{df} VPP_{RW,df} \cdot \frac{ER}{ERPP}$ $\quad df = PC, PB$

[32] $RT_{RW,PC} = cx_{RW,PC} \cdot rex \cdot VPP_{PB,RW} \cdot \frac{ER}{ERPP}$

Beside interest income, private enterprises receive subsidies from the government. As in the case of household subsidies, these are assumed to be proportional to government consumption expenditure

[33] $SUB_{PC} = cz_{PC} \cdot CNG$

Corporate tax payment of private enterprises – as in the case of households – are based on gross income minus nominal depreciation (see below). The difference between gross income and tax payments equals private enterprises' savings, which is channeled into the accumulation of financial wealth.

[34] $SV_{PC} = Y_{PC} - TD_{PC}$

State enterprises: State enterprises' gross income (Y_{SE}) is made up of their share of formal capital income and several financial payments from other domestic institutions and the rest of the world

[35] $Y_{SE} = YFC_{SE} + SUB_{SE} + RT_{SE,PC} - RT_{PC,SE} + RR_{SE,PC} - RR_{PC,SE} + RR_{SE,GV} + RR_{GV,SE} + RR_{SE,RW} - RR_{RW,SE}$

Here too, interest payments between state enterprises and the Central Bank can be neglected as these are payments between the same institution. However, interest payments of the Central Bank to private enterprises and to the government on their deposits and interest payments on these institutions' loans are fully included as well as Central Bank foreign interest receipts on foreign exchange reserves and payments on foreign debt.

[36] $RR_{SE,GV} = cx_{SE,GV} \cdot rcx \cdot VPP_{GV,SE}$

[37] $RR_{GV,SE} = cx_{GV,SE} \cdot rcx \cdot VPP_{SE,GV}$

[38] $RR_{SE,RW} = cx_{SE,RW} \cdot rex \cdot VPP_{RW,SE} \cdot \frac{ER}{ERPP}$

[39] $RR_{RW,SE} = cx_{RW,SE} \cdot rex \cdot VPP_{SE,RW} \cdot \frac{ER}{ERPP}$

Moreover, state enterprises receive subsidies from the government, which are assumed to be proportional to government consumption expenditure

[40] $SUB_{SE} = cz_{SE} \cdot CNG$

Corporate tax payment of public enterprises are based on gross income minus nominal depreciation (see below). The difference between gross income and tax payments equals state enterprises' savings and is channeled into the accumulation of financial wealth.

[41] $SV_{SE} = Y_{SE} - TD_{SE}$

Government: Government revenues consist of the sum of import taxes (*TM*), the sum of indirect taxes (*TX*), the sum of value added taxes (*TV*), the sum of corporate taxes of formal enterprises and direct taxes of households (*TD*), as well as foreign development aid (*AID*). Moreover, interest receipts on government deposits in commercial banks ($RT_{GV,PC}$) and in the Central Bank ($RR_{GV,SE}$) have to be taken into account

[42] $Y_{GV} = TM + TX + TV + \sum_{db} TD + AID + \sum_{dg} RT_{GV,dg} + RR_{GV,SE}$

Import tax revenues are equal to the sum of sectoral tariff revenues (TMI_i). The same holds true for indirect taxes (TXI_i) and value added taxes (TVI_i). Similarly total direct taxes consist of corporate taxes and household income taxes (TD_{db}).

[43] $TM = \sum_i TMI_i$

[44] $TMI_i = pwm_i \cdot M_i \cdot tmx_i \cdot ER$

[45] $TX = \sum_i TXI_i$

[46] $TXI_i = PX_i \cdot X_i \cdot txx_i$

[47] $TV = \sum_i TVI_i$

[48] $TVI_i = PV_i \cdot X_i \cdot tvx_i$

[49] $TD_{db} = (Y_{db} - DEP_{db} \cdot PKI_{db}) \cdot tdx_{db} \quad db = PC, SE, dh$

Foreign development aid in Dollar (*ad*) is exogenous and converted into domestic currency by the exchange rate

[50] $AID = ad \cdot ER$

Government expenditures (*EXG*) consist of consumption expenditures (*CNG*), export subsidies and subsidies to enterprises and households, and interest payments

[51] $EXG = CNG + TE + \sum_{db} SUB_{db} + RT_{PC,GV} + RR_{SE,GV} + RT_{RW,GV}$

With regard to interest payments on foreign debt it has to be recognized that developing countries typically receive concessionary credits. Thus, the pre-period stock of public foreign debt ($VPP_{GV,RW}$) is multiplied by the foreign interest rate (*rex*). However, the interest payments are lower than those on private debt as a result of the grant element (*grant*)

[52] $RT_{RW,GV} = rex \cdot (1 - grant) \cdot VPP_{GV,RW} \cdot \frac{ER}{ERPP}$

Total government consumption expenditures are determined by the sum of sectoral expenditures

[53] $CNG = \sum_i PQ_i \cdot CG_i$

It is assumed that government total real expenditures (*gc*) are determined exogenously and that the composition of government real consumption is fixed over time, thus government sectoral demand equals

[54] $CG_i = \beta_i \cdot gc \qquad \sum_i \beta_i = 1$

Total export subsidies (*TE*) are equal to the sum of sectoral subsidies (TEI_i).

[55] $TE = \sum_i TEI_i$

[56] $TEI_i = pwe_i \cdot EX_i \cdot tex_i \cdot ER$

Again, public savings (SV_{GV}) are defined as the difference between revenues and expenditures

[57] $SV_{GV} = Y_{GV} - EXG$

and are channeled into financial wealth.

Rest of the world: Receipts of the rest of the world consist of the import value and domestic interest payments

[58] $Y_{RW} = \sum_i M_i \cdot pwm_i \cdot ER + RT_{RW,PC} + RR_{RW,SE} + RT_{RW,GV}$

Expenditures of the rest of world consist of the export value, labor income and remittances from abroad, interest payments to foreign financial institutions and development aid

[59] $ERW = \sum_i EX_i \cdot PWE_i \cdot ER + yfa \cdot ER + yrem \cdot ER + RT_{PC,RW} + RR_{SE,RW} + AID$

The difference between receipts and expenditures equals the current account balance

[60] $SV_{RW} = Y_{RW} - ERW$

and is channeled into financial wealth.

Investment and depreciation

There are six institutions (subscript *de*) – three households, private and public enterprises, and the government – which invest into physical capital. For all these institutions, it is assumed that their investment expenditures are determined residually after the decisions on financial portfolios are taken. Moreover, it is assumed that the sectoral composition of the capital stock is unaffected by changes in sectoral prices. Thus, the institutional capital goods prices (PKI_{de}) are determined by fixed capital composition coefficients ($b_{i,de}$)

[61] $PKI_{de} = \sum_i PQ_i \cdot b_{i,de} \qquad \sum_i b_{i,de} = 1$

This implies that institutional real investment (IR_{de}) is also determined residually. Thus, the basic version of the model is savings driven with the sum of institutional savings determining overall real investment.

[62] $$IR_{de} = \frac{IN_{de}}{PKI_{de}}$$

Real investment of institutions is split up into sectoral investment demand ($IRQ_{i,de}$) using the fixed capital composition coefficients. Nominal investment demand ($INQ_{i,de}$) equals real investment demand evaluated at current capital goods prices.

[63] $$IRQ_{i,de} = IR_{de} \cdot b_{i,de}$$

[64] $$INQ_{i,de} = PQ_i \cdot IRQ_{i,de}$$

Real institutional depreciation (DEP_{de}) is computed by multiplying pre-period institutional capital stocks (KPP_{de}) by the depreciation rates (ab_{de})

[65] $$DEP_{de} = ab_{de} \cdot KPP_{de}$$

Gross domestic product

Equations [67] and [68] define real and nominal GDP, which are used to calculate the aggregated price level (*PDX*), defined as

[66] $$PDX = \frac{GDPN}{GDPR}$$

Real GDP (*GDPR*) is defined from the expenditure side, with imports valued at world prices.

[67] $$GDPR = \sum_i (\sum_{dh} CH_{i,dh} + CG_i + \sum_{de} IRQ_{i,de} + EX_i - pwm_i \cdot M_i \cdot ER)$$

Nominal GDP (*GDPN*) is generated from the value added side. Recall that value added prices (PV_i) in equation [5] are calculated after subtracting away intermediate input

costs (valued at PQ_i), and that these intermediate input prices include tariffs (since PM_i is used in the calculation of PQ_i). Thus, since tariffs have already been subtracted from value added, in order for expenditure and value added GDP to be comparable, these tariffs need to be added back in for the calculation of nominal GDP. Similarly, export subsidies have to be netted out. Thus, nominal GDP is the sum of nominal value added, indirect taxes, and tariffs, and net of export subsidies

[68] $GDPN = \sum_i PV_i \cdot X_i + TX + TM - TE$

3.5 Market Clearing Conditions

The real side of the model is completed by market clearing conditions for the goods and factor markets. The markets for goods are cleared if the following condition holds

[69] $Q_i = INT_i + \sum_{dh} CH_{i,dh} + CG_i + \sum_{de} IRQ_{i,de}$

Equation [69] states that the sectoral supply of composite commodities must equal demand, and thus defines market-clearing equilibrium in the product markets.[9] The equilibrating variables are sectoral prices. There are nine prices in the model which have sectoral subscripts: *pwm, pwse, PWE, PM, PE, PX, PQ, PV,* and *PD*. The world prices for imports and export substitutes (*pwm, pwse*) are exogenously given while *PE* is determined endogenously by equalizing export supply and export demand. Of the remaining six, five (*PM, PWE, PX, PQ, PV*) appear on the left hand side of price equations, leaving *PD* as the variable "free" to adjust.

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[9] There is also an analogous sectoral market-clearing equation for domestically produced goods sold on the domestic market (DX_i). However, from equation [8] it is evident that the ratio of imports to domestic sales is the same for all categories of imports. Thus, at the sectoral level, specifying a separate market-clearing condition for domestically produced goods sold on the domestic market amounts to multiplying through both sides of equation [69] by the ratio DX_i/Q_i Since, if [69] holds, so will this new equation in which both sides are multiplied by the same number, no separate equation is needed. The same reasoning can be used to justify why there is no separate market-clearing condition for domestic output (X_i), since this involves adding exports to both sides of this adjusted market-clearing condition.

To capture the reality of developing countries employment structure and to keep track in a detailed manner of the poors' main income flows, the model assumes a high degree of labor market segmentation. Beside the self-employed labor of smallholders and urban informals, two types of unskilled labor (agricultural and non-agricultural) as well as skilled labor are distinguished. Labor markets are linked via rural-rural and rural-urban migration. While the former involves smallholders becoming hired workers in modern agriculture, the latter involves the absorption of smallholders by the urban informal sector. Along the lines of the Harris-Todaro model, the decision to migrate depends on wage differentials. For all labor markets, full employment is assumed with wage adjustments clearing the respective markets.

[70] $\sum_i FD_{i,fl} = FS_{fl}$

The model also assumes segmented capital markets, with a distinction made between unincorporated and corporate capital. Three household groups (smallholders, urban informals, and employers) own unincorporated capital. While smallholders and urban informals invest almost exclusively in traditional agriculture and informal services, employers receive capital income from all formal sectors with the exception of utilities. Corporate capital, by contrast, is owned by private and public enterprises, who accumulate capital in all formal sectors and retain the respective factor income. Finally, the model separates public infrastructure capital, which is assumed to have a crowding-in effect on sectoral production. Public infrastructure is provided costlessly to the different sectors and no market clearing is necessary. Thus, the model includes four capital market clearing equations

[71] $\sum_i FD_{i,fc} = FS_{fc}$

with total formal capital (FCap) supply equal to the sum of private and state enterprises capital stock at the end of each period

[72] $\sum_{dg} K_{dg}$

and informal capital supply equal to investing household types' capital stock at the end of each period

[73] $FS_{dh} = K_{dh}$

3.6 The Financial Sector

In contrast to various financial CGE models that assume that existing stocks of assets cannot be traded, and only additional flows from savings can be allocated to existing assets, we assume here that domestic agents can, at least in principle, freely alter the desired composition of their stock of financial and physical assets – subject to the overall constraint that initial or beginning-of-period assets is predetermined at any given moment in time.

Accumulation balances and wealth determination

The balance sheets of the different institutions included in the model are presented in Table 4. According to the credit side the wealth constraint for each institution *d* is

[74] $ASS_d = LBT_d + WTH_d$

where ASS_d stands for total assets, LBT_d is total liabilities, and WTH_d is total wealth. Total demand for liabilities is determined by the sum of all institutions' *e* demand for individual assets $V_{d,e}$

[75] $LBT_d = \sum_e V_{d,e}$

thereby implicitly assuming a system of supply-led finance (credit rationing) and perfectly elastic liability demand. However, for each institution a specific closure rule applies which defines the effective budget constraint applicable in each case. The equations for portfolio choice and the respective closure rules are presented and discussed in the subsection on *portfolio determination* below.

Table 4 — Balance Sheets (in domestic currency terms, at current prices)

Households (including informal sector) dh			
Equity in private corporations	$V_{PC,dh}$	Loans from commercial banks	$V_{dh,PB}$
Cash holdings	$V_{CB,dh}$	Net wealth	WTH_{dh}
Deposits in commercial banks	$V_{PB,dh}$		
Foreign exchange holdings	$V_{RW,dh}$		
Nominal value of physical capital	KN_{dh}		
Private Corporations PC			
Equity in state enterprises	$V_{SE,PC}$	Households equity	$V_{PC,dh}$
Central Bank deposits	$V_{CB,PC}$	State enterprises equity	$V_{PC,SE}$
Deposits in commercial banks	$V_{PB,PC}$	Loans from commercial banks	$V_{PC,PB}$
Deposits in foreign banks	$V_{RW,PC}$	Cumulated FDI in private corporations	$V_{PC,RW}$
Nominal value of physical capital	KN_{PC}	Net wealth	WTH_{PC}
State Enterprises SE			
Equity in private corporations	$V_{PC,SE}$	Private corporations equity	$V_{SE,PC}$
Central Bank deposits	$V_{CB,SE}$	Cumulated FDI in state enterprises	$V_{SE,RW}$
Deposits in commercial banks	$V_{PB,SE}$	Net wealth	WTH_{SE}
Nominal value of physical capital	KN_{SE}		
Government (excluding SE) GV			
Central Bank deposits	$V_{CB,GV}$	Loans from Central Bank	$V_{GV,CB}$
Deposits in commercial banks	$V_{PB,GV}$	Loans from commercial banks	$V_{GV,PB}$
Nominal value of physical capital	KN_{GV}	Cumulated foreign debt	$V_{GV,RW}$
		Net wealth	WTH_{GV}
Central Bank CB			
Loans to government	$V_{GV,CB}$	Cash in circulation	$V_{CB,dh}$
Rediscount to commercial banks	$V_{PB,CB}$	Private firms deposits	$V_{CB,PC}$
Foreign reserves	$V_{RW,CB}$	State enterprises deposits	$V_{CB,SE}$
		Government deposits	$V_{CB,GV}$
		Reserve requirements	$V_{CB,PB}$
		Rest of world deposits	$V_{CB,RW}$
		Net wealth	WTH_{CB}
Commercial banks PB			
Loans to households	$V_{dh,PB}$	Household deposits	$V_{PB,dh}$
Loans to private firms	$V_{PC,PB}$	Private firms deposits	$V_{PB,PC}$
Loans to government	$V_{GV,PB}$	State enterprises deposits	$V_{PB,SE}$
Reserve requirements	$V_{CB,PB}$	Government deposits	$V_{PB,GV}$
Deposits in foreign banks	$V_{RW,PB}$	Rediscount credits	$V_{PB,CB}$
		Cumulated foreign portfolio investment	$V_{PB,RW}$
		Net wealth	WTH_{PB}
Rest of the World RW			
Cumulated FDI in private corporations	$V_{PC,RW}$	Households foreign exchange holdings	$V_{RW,dh}$
Cumulated FDI in state enterprises	$V_{SE,RW}$	Foreign exchange assets of priv. corp.	$V_{RW,PC}$
Cumulated loans to government	$V_{GV,RW}$	Foreign exchange reserves	$V_{RW,CB}$
Deposits in Central Bank	$V_{CB,RW}$	Foreign exchange assets of com. banks	$V_{RW,PB}$
Cumulated FPI in commercial banks	$V_{PB,RW}$	Net wealth position vis-a-vis the country under investigation	WTH_{RW}

From the debit side, total assets of those institutions investing in physical capital (some households, private corporations and state enterprises, government) are defined as the sum of different financial assets ($V_{d,e}$) plus the end-of-period nominal capital stock.

[76] $ASS_e = \sum_d V_{d,e} + KN_e$

For all other institutions (other households, Central Bank, commercial banks, rest of the world) total assets equal the sum of financial assets. The nominal capital stock at the end of the period consists of the pre-period physical capital stock KPP_{de}, corrected for physical depreciation and evaluated at current prices, plus nominal investment

[77] $KN_{de} = (KPP_{de} - DEP_{de}) \cdot PKI_{de} + IN_{de}$

As a result of changes in goods prices the current price of capital goods (in the base year: PKI_{de}, in the pre-period: $PKIPP_{de}$) may change as well leading to capital gains $REVK_{de}$ that result from revaluations of the remaining (not yet depreciated) pre-period capital stock

[78] $REVK_{de} = (PKI_{de} - PKIPP_{de})(KPP_{de} - DEP_{de})$

which are included in the net wealth determination of the different institutions. Thus, the nominal capital stock is always evaluated at current prices in the model. Moreover, the net wealth determination also takes into account revaluations of foreign-currency deposits held in the domestic banking system (dollarization) and abroad ($REVF_{dh}$). Thus, the net wealth of each domestic institution *da* equals net wealth in the pre-period ($WTHPP_{da}$) plus savings, plus capital gains as a result of changes in capital goods prices, plus revaluations of net foreign currency assets as a result of foreign exchange changes, minus nominal depreciation

[79] $WTH_{da} = WTHPP_{da} + SV_{da} + REVK_{da} + REVF_{da} + PKIPP_{da} \cdot DEP_{da}$

where

[80] $$REVF_{da} = \frac{ER - ERPP}{ERPP}(\sum_{ea} rca_{ea,da} \cdot VPP_{ea,da} - \sum_{ea} rca_{ea,da} \cdot VPP_{da,ea} + VPP_{RW,da} - VPP_{da,RW})$$

is the net revaluation of pre-period financial assets with the parameter *rca* reflecting the degree of dollarization of domestic accounts. Note that equations [80] and [81] (below) are general formulations. For those domestic institutions, which do not invest into physical capital total net wealth is determined solely by the pre-period wealth plus savings and financial revaluations. Moreover, for institutions, which do not hold foreign assets and liabilities, *REVF* is zero.

The net wealth position of the rest of the world equals the net wealth position vis-à-vis the domestic country only, with revaluations as a result of foreign exchange rate changes equal to the sum of revaluations of domestic institutions, with opposite sign

[81] $$WTH_{RW} = WTHPP_{RW} + SV_{RW} + REVF_{RW}$$

[82] $$REVF_{RW} = -\sum_{da} REVF_{da}$$

Portfolio determination of institutions

Central Bank: The model assumes a budget-constrained situation, in which the Central Bank determines the amount of foreign exchange reserves to be held in order to finance imports for a given number (*res*) of months

[83] $$V_{RW,CB} = res \cdot \frac{TIM}{12}$$

Moreover, the Central Bank provides loans to the government and rediscount to commercial banks. The debit side of the Central Banks' accumulation balance is assumed to be determined by other institutions. Thus, cash holdings of households, Central Bank deposits by private and state enterprises, the government, and

commercial banks all follow from these institutions' portfolio choice, whereas rediscount credits to commercial banks serve as equilibrating variable.[10]

Following Bourguignon et al. (1989), Rosenzweig and Taylor (1990) and Jemio and Wiebelt (2003), among others, institutional asset demand is modeled by CES functions with the desired asset structure being a function of relative profitability of the different types of financial assets. Thus the portfolio choice of the Central Bank is given by

$$[84] \quad V_{GV,CB} = u_{GV,CB}\left[\frac{RF_{GV,.CB}}{RW_{CB}}\right]^{\sigma^{P}_{CB}} ASS_{CB}$$

where $u_{GV,CB}$ is the share of loans to the government while σ^{p}_{CB} is the substitution elasticity for the Central Bank's portfolio. RF_{CB} is an index of the fixed Central Bank interest rate (*rcx*) and RW_{CB} is an index of the weighted average return on the Central Bank's total portfolio (as defined below in the subsection on *Rates of Return*).

The assumption that the Central Bank keeps a constant relationship between imports and foreign exchange reserves serves in this model as closure for the institutional accumulation balances and the balance of payments, implying that these accounts are always in equilibrium.

Commercial banks: Commercial banks supply domestic loans on the basis of their available resources. Moreover, they hold minimum reserves at the Central Bank (at the fixed interest rate *rcx*) and are involved in financial transactions with the rest of the world (at the fixed foreign deposit and lending rate *rex*). With a fixed deposit rate *R* (which is assumed to equal the lending rate), they accept the volume of deposits forthcoming from households and the volume of liquidity reserves held by private corporations, state enterprises, and the government. Rediscount from the Central Bank

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[10] The model assumes that there is no direct financing of the government budget by Central Bank credits. However, for countries where this is the case, the model can easily be adjusted.

and foreign portfolio investments are determined in the Central Bank's portfolio choice (see above) and fixed exogenously by the rest of the world (see below), respectively.

The allocation of commercial banks' total loanable assets to the different institutions is again determined by relative profitabilities. Loans to households are used as the equilibrating variable reflecting the fact that in developing countries households are often restricted in their access to financial markets. Which household's access to the credit is restricted depends on the specific simulation.

$$[85]\quad V_{du,PB} = u_{du,PB}\left[\frac{RF_{du,PB}}{RW_{PB}}\right]^{\sigma^{P}_{PB}} ASS_{PB} \qquad du = dh, PC, GV, CB, RW$$

Government: The government has the possibility either to hold deposits (liquidity reserves) in the domestic banking system or to invest in physical (infrastructure) capital. As a default the model assumes that public infrastructure investment is the equilibrating variable adjusting to the available financial means after the financial portfolios are determined. Thus, the model is savings driven.

$$[86]\quad V_{dr,GV} = u_{dr,GV}\left[\frac{RF_{dr,GV}}{RW_{GV}}\right]^{\sigma^{P}_{GV}} ASS_{GV} \qquad dr = CB, PB$$

Formal enterprises: Private corporations and state enterprises are assumed to determine their amount of shares, their liquidity reserves in the domestic banking system, and their deposits in foreign banks based on profitability criteria. Real investment is again chosen as the equilibrating variable

$$[87]\quad V_{dk,dg} = u_{dk,dg}\left[\frac{RF_{dk,dg}}{RW_{dg}}\right]^{\sigma^{P}_{dg}} ASS_{dg} \qquad dk = PC, SE, CB, PB, RW; dg = PC, SE$$

Households: Households hold equity shares of private enterprises, deposits in commercial banks and cash, and invest into foreign assets and physical capital. It is assumed that real investment of households is the equilibrating variable, after determination of the financial portfolio

$$[88]\quad V_{dv,dh} = u_{dv,dh}\left[\frac{RF_{dv,dh}}{RW_{dh}}\right]^{\sigma^{P}_{dh}} ASS_{dh} \qquad dv = PC, CB, PB, RW$$

Rest of the world: The rest of the world holds Dollar deposits in domestic banks, which are mostly used to finance foreign trade. It is therefore assumed that foreigners hold a constant share (af_{dr}) of the export value as portfolio investment in commercial banks and in the Central Bank

$$[89]\quad V_{dr,RW} = af_{dr} \cdot TEX$$

Foreign direct investment in private and public enterprises is exogenously determined on a Dollar basis (fdi_{dg}) but implies a demand for assets of foreign investors in domestic currency. The demand for assets vis-à-vis domestic enterprises increases each period by the amount of new FDI. For simplicity, we abstract from depreciation and revaluations of foreign direct investment. FDI, which represents assets are treated as liabilities of domestic enterprises

$$[90]\quad V_{dg,RW} = VPP_{dg,RW} + fdi_{dg} \cdot ER$$

Net credits to the government are also fixed exogenously on a Dollar basis (*fgov*). Since foreign exchange changes involve changes in total foreign debt, pre-period stocks have to be adjusted

$$[91]\quad V_{GV,RW} = \frac{ER}{ERPP} \cdot VPP_{GV,RW} + fgov \cdot ER$$

Rates of return

In the following, several profitability indices are defined, which serve as a basis for the determination of the institutions' portfolios defined above. The profitability of formal enterprises is calculated for each year as the relation between net revenues (capital income plus capital gains minus nominal depreciation) and the nominal capital stock. In order to calculate indices, this profitability is related to the base year profitability. Since it is difficult to differentiate between capital and labor income in informal activities, the profitability indices for smallholders, urban informals, and employers are based on total income. Finally, for the government it is assumed that investment into physical capital is based on changes in real GDP. If the profitability in physical capital increases in relation to the base period and in relation to financial assets, this will increase the attractiveness of investments into real capital. Base year variables are assigned with a zero after the variable name:

$$[92]\quad RK_{dj} = \frac{1+\dfrac{YHF_{dj} - DEP_{dj}\cdot PKI_{dj} + REVK_{dj}}{KN_{dj}}}{1+\dfrac{YHF0_{dj} - DEP0_{dj}\cdot PKI0_{dj} + REVK0_{dj}}{KN0_{dj}}} \qquad dj = SH,\ UI,\ ER$$

$$[93]\quad RK_{dg} = \frac{1+\dfrac{YFC_{dg} - DEP_{dg}\cdot PKI_{dg} + REVK_{dg}}{KN_{dg}}}{1+\dfrac{YFC0_{dg} - DEP0_{dg}\cdot PKI0_{dg} + REVK0_{dg}}{KN0_{dg}}}$$

$$[94]\quad RK_{GV} = \frac{1+GDP}{1+GDP0}$$

The profitability indices for foreign assets and liabilities (*RE*), for domestic bank deposits and loans, and shares (*RB*), and for deposits in and credits from the Central Bank (*RC*) are calculated similarly. Changes in relative interests vis-à-vis the base year induce changes in the respective indices:

[95] $RE = \frac{1 + rex}{1 + rex0}$

[96] $RB = \frac{1 + R}{1 + R0}$

[97] $RC = \frac{1 + rex}{1 + rex0}$

In the following the profitabilities for financial assets and liabilities ($RF_{d,e}$: interest of asset *d* held by institution *e* and interest of liability *e* vis-à-vis institution *d*) are allocated to the profitability indices defined above. The profitability of bank deposits and bank credits is the same for all institutions and equal to the domestic profitability index *RB*:

[98] $RF_{PB,da} = RF_{da,PB} = RB$

Shares of private and public enterprises held by some household types as well as state and private enterprises do have profitabilities

[99] $RF_{dg,dh} = RF_{dg,dg} = RK_{dg}$

Cash holdings of households bear no interest. The respective profitability is set to one for technical reasons. Dollar cash holdings are also assumed to bear no interest. However, changes in the foreign exchange rate have to be taken into account

[100] $RF_{CB,dh} = 1$

[101] $RF_{RW,dh} = ER / ERPP$

Deposits in and credit from the Central Bank are based on the interest rate *RC*

[102] $RF_{CB,da} = RF_{da,CB} = RC$

Domestic financial institutions holding foreign assets calculate with the profitability index *RE*, which has to be corrected for exchange rate changes

[103] $RF_{RW,dr} = (ER / ERPP)RE$

Foreign investors accumulating assets of domestic private and public enterprises through foreign direct investment (FDI) base their decisions on the profitability of the respective real capital. Moreover, the exchange rate has to be taken into account. A devaluation reduces investors' interest as the investment is done by assumption in domestic currency

[104] $RF_{dg,RW} = (ERPP / ER)RK_{dg}$

Credits of foreign institutions to the government at concessional conditions imply that the grant element (*grant*) reduces the interest of creditors

[105] $RF_{GV,RW} = (ER / ERPP)RE(1 - grant)$

Finally, deposits of foreigners in domestic financial institutions are undertaken on a Dollar basis, i.e., *RE* is the relevant interest rate

[106] $RF_{dr,RW} = (ER / ERPP)RE$

In order to determine relative rates of return, weighted institutional profitabilities (RW_e) are defined where $u_{d,e}$ and uk_e stand for the shares of financial assets and physical capital in total portfolio, respectively. By using a CES aggregation function it is assumed that the different assets are not perfectly substitutable with regard to availability, security, etc.

[107] $RW_e = \left[\sum_d u_{d,e} \cdot RF_{d,e}^{\sigma_e^P} + uk_e \cdot RK_e^{\sigma_e^P} \right]^{\frac{1}{\sigma_e^P}}$

3.7 Macroeconomic Closure

The CGE model comprises all the macroeconomic balances required for a complete specification of an economy: the accumulation balances for all economic agents (companies, households and government), the supply-demand balances for all activities (formal and informal) and production factors (labor and capital), the balances for financial institutions (commercial banks and the Central Bank), and the balance for the external sector.

Macroeconomic closure within the model can be interpreted by first looking at the adjustments in the individual balances for individual institutions and socio-economic groups (the microeconomic level). This has been done in section 3.6. The way in which the overall accumulation balance for the economy adjusts thereafter, will be determined by the interaction and aggregation of individual accumulation balance adjustments. The final macro closure to be discussed requires that aggregate savings equal aggregate investment, but this condition is not an independent restriction on the system which satisfies Walras' law. Hence a residual check on the difference between saving and investment is included in the model

[108] $\sum_d SV_d = \sum_{de} IN_{de}$

The components of total savings have been discussed already: government savings is determined as the residual after government revenue is spent on fixed real government consumption, transfers, subsidies and interest payments; enterprises savings are also determined residually; household savings are determined by fixed savings rates; and foreign savings may be either fixed exogenously or determined endogenously. This model specification corresponds to a "savings driven" model, in which aggregate investment is the endogenous sum of separate savings components. This is often called "neoclassical" closure in the CGE literature. However, alternative ways of achieving savings-investment equilibrium are possible in the model.

The same holds true for balance-of-payments equilibrium. In the basic model, the exchange rate is fixed, and foreign savings (the current account balance) can adjust. Alternatively, foreign savings may be fixed. With foreign savings set exogenously, the equilibrating variable is the exchange rate (*ER*). Equilibrium will be achieved through movements in *ER* that affect export and import prices relative to domestic prices – in other words, by changing the relative price of tradables to nontradables. For example, an increase in the exchange rate leads to a real depreciation, so that tradable prices rise relative to nontradable prices. Given the export supply and import demand functions, the result will be higher exports and lower imports. Thus, from an initial equilibrium, any fall in foreign savings will lead to a new equilibrium with a higher (depreciated) exchange rate. Alternatively, the price index (PDX) can be fixed exogenously, with both *ER* and S_{RW} determined endogenously. In fact, what the model determines is a stable relationship between the real exchange rate and the balance of trade.

3.8 Dynamics

GEM-PIA is recursive-dynamic, meaning that it solves for a sequence of static one-period equilibria for future time periods connected through capital accumulation and changes in labor supply. The dynamics of the model are defined by equations which describe how the endowments of the primary factors capital and labor evolve over time. The major driving factors of the labor dynamics are exogenous population change and endogenous migration. The driving forces for capital accumulation are the savings rate and the rate of return on physical capital, and thus the endogenous rate of capital accumulation. GEM-PIA is recursive in the sense that it is solved stepwise in time without any ability to anticipate possible future changes, relative prices or constraints.

The savings behavior of households is characterized by constant savings rates over time. For all other domestic institutions, their savings are determined residually either

as gross income minus corporate taxes (for private and public enterprises) or gross income minus current expenditures (for the government).

The following subsection describes the evolution of labor and capital supply in more detail.

To capture the reality of developing countries' employment and to keep track in a detailed manner of the poors' main income flows, the model assumes a high degree of labor market segmentation. Beside the self-employed labor of smallholders and urban informals, two types of unskilled labor (agricultural and non-agricultural) as well as skilled labor are distinguished. Labor markets are linked via rural-rural and rural-urban migration. While the former involves smallholders becoming hired workers in modern agriculture, the latter involves the absorption of smallholders by the urban informal sector. Along the lines of the Harris-Todaro model, the decision to migrate is assumed to depend on wage differentials. Hence, labor supply for the different labor categories at the end of each time period FS_{fl} is given by:

[109] $$FS_{Slab} = FSPP_{Slab}(1 + nl_{SLab})$$

[110] $$FS_{UULab} = FSPP_{UULab}(1 + nl_{UULab})$$

[111] $$FS_{SHLab} = FSPP_{SHLab}(1 + nl_{SHLab}) - RRMIG - RUMIG$$

[112] $$FS_{UIlab} = FSPP_{UIlab}(1 + nl_{UILab}) + RUMIG$$

[113] $$FS_{RUlab} = FSPP_{RUlab}(1 + nl_{RULab}) + RRMIG$$

[114] $$RRMIG = FSPP_{SHLab} \cdot migrr\left(\frac{WF_{RULab}}{WF_{SHLab}}\right)$$

[115] $$RUMIG = FSPP_{SHLab} \cdot migru\left(\frac{WF_{UILab}}{WF_{SHLab}}\right)$$

where $FSPP_{fl}$ denotes exogenous labor supply at the end of the pre-period, nl_{fl} stand for the exogenous natural rates of growth of labor categories, and *RRMIG* and *RUMIG* denote the number of smallholders migrating either into modern agriculture or the urban informal sector with the extent of migration driven by endogenous wage differentials and the exogenous parameters *migrr* and *migru*, which reflect the costs of migration.

The model also assumes segmented capital markets, with a distinction made between unincorporated, corporated, and public infrastructure capital. Three household groups (smallholders, urban informals, and employers) own unincorporated acpital. While smallholders and urban informals invest almost exclusively in traditional agriculture and informal services, employers invest in all formal sectors with the exception of utilities and public services. Corporate capital, by contrast, is owned by private and public enterprises, who accumulate capital in all formal sectors and retain the respective factor income. Finally, the model separates public infrastructure capital, for which it is assumed that it can be used in all production sectors. Thus, the model includes a crowding-in effect of public infrastructure investment.

Current period's investment augments the capital stock at the end of the period which is assumed to enter production. The institutional capital stock is updated by an accumulation function equating the end-of-period capital stock K_{de} to the sum of the depreciated capital stock at the end of the pre-period KPP_{de} and the current period's physical quantity of investment IR_{de}.

[116] $$K_{de} = (1 - ab_{de})KPP_{de} + IR_{de}$$

where ab_{de} denotes the exogenously given constant depreciation rate. The allocation of private institutions' capital among sectors follows from the intra-period optimization of firms and households.

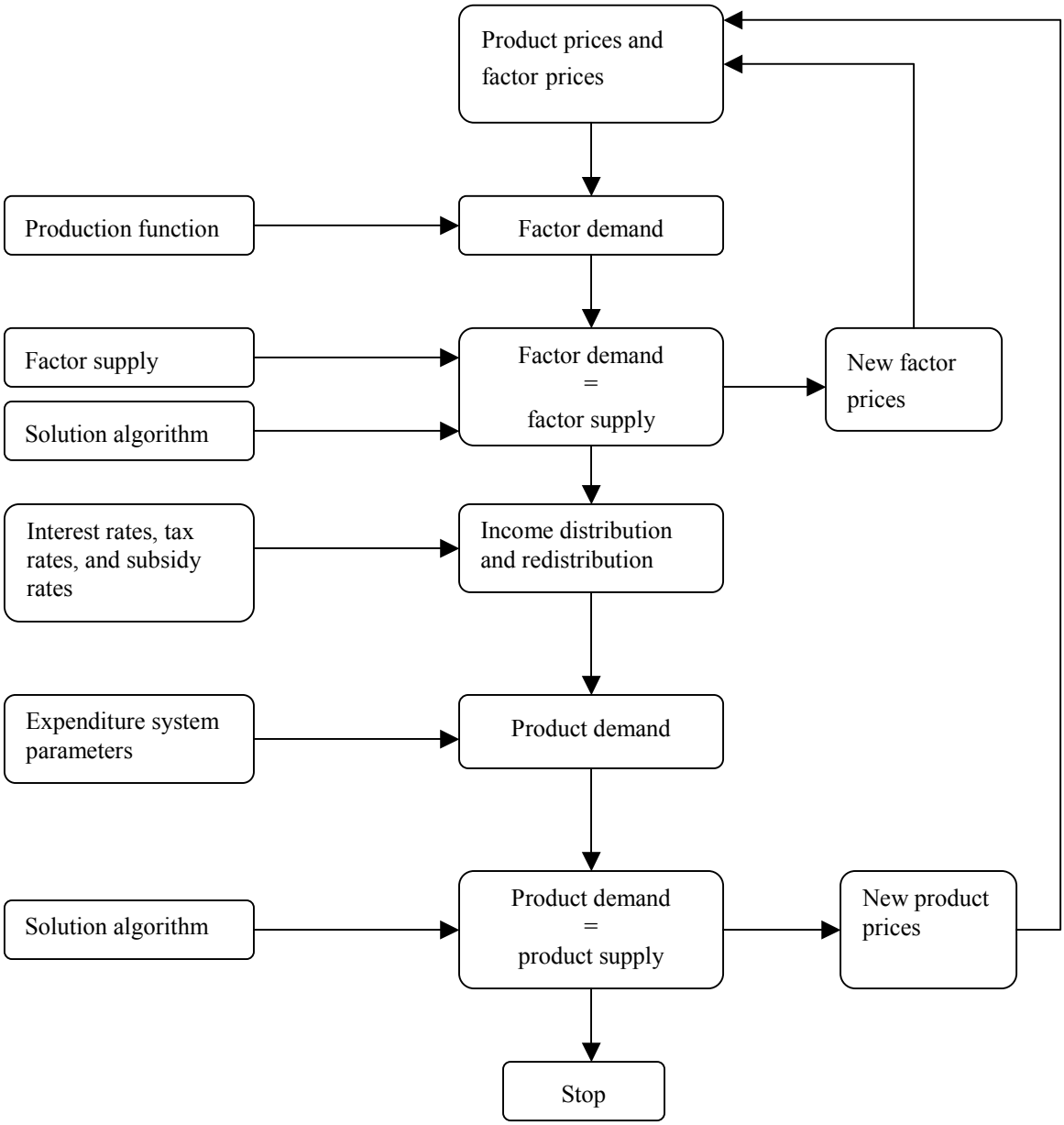
3.9 Solution Strategy

The equations of the within-period general equilibrium model can be reduced by substitution to a set of nonlinear excess demand equations. In our model, there are five sets of markets that must be cleared: factor markets, product markets, the foreign exchange market, the credit market, and the money market. Although GAMS attacks all five sets of markets simultaneously, it is useful to consider the various steps of the solution strategy. The particular strategy presented in Figure 3 assumes flexible product and factor prices, whereas the exchange rate and all interest rates (*R, rcx, rex*) are fixed. Foreign factor income, remittances, and capital inflows are also assumed to be fixed implying that the trade balance adjusts to clear the balance of payments. Moreover, the model assumes a budget-constrained situation with money supply to households and credit supply to commercial banks determined by the Central Bank's reserve position. Households' credit demand is assumed to clear the loan market. Finally, we assume that the accumulation balance adjustment for all investing households, for both types of formal enterprises, and for the government follows the 'prior-saving' approach. This means that the level of investment and the accumulation of other financial assets adjust to the availability of funds that is determined exogenously. These institutions, however, can choose their portfolio structure following profitability criteria.

Under these assumptions the markets for foreign exchange, money, rediscount, and domestic credit clear by quantity adjustments. There are two types of markets left where price adjustments are assumed to reach an equilibrium between supply and demand – the product markets and the factor markets.

Essentially, the solution strategy follows the order in which the equations of the CGE model are presented. Assume an initial guess at product prices. The strategy then works on the factor markets. Given sectoral production functions, the assumption of cost-minimizing behavior on the part of producers, and an initial guess at factor prices

Figure 3 — Solution Strategy



of the different labor and capital quantities, one solves for the demand for factors in each sector. Given factor supplies (or factor supply functions), one computes excess demands for factors. If these demands are zero, the factor markets are solved. If not, the solution algorithm generates a new guess at factor prices and starts a new iteration.

When the factor markets are solved, the model generates wages, capital rentals, employment, production, and exports (the latter based on some specification of the export market). One then has enough information to generate the functional, institutional, and household income distribution, including inter-institutional income redistribution via public transfer and financial transfers (the latter based on fixed interest rates applied to end of pre-period asset and liability stocks) – the entire flow of funds in the SAM. Then, given the parameters of the household and government expenditure functions, one can generate the consumption demand for products and imports.

The expenditures on investment goods (as well as the credit demand and the money supply) of the various institutions investing into physical capital are determined residually in the accumulation balances.[11] Then, given the parameters of the different institutions' investment functions, one can generate the investment demand for products and imports. Finally, given the product supplies solved earlier, one generates the excess demands for products. If they are zero, the model is solved. If not, the solution algorithm generates a new guess at prices and starts a new iteration.

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[11] As mentioned earlier, the model assumes a budget-constrained situation with monetary control (money and credit supply) determined by the Central Bank's reserve position. E.g., with passive monetary policies, the monetary base will expand with a devaluation (through the domestic currency value of Central Bank reserves) and thereby domestic credit supplies which will alleviate budget constraints on domestic investment.

4. Assessing the Properties of the Model: The Example of Bolivia

Assessing the properties of GEM-PIA requires calibration and numerical simulations. Given that the primary objective of the model is to analyze the poverty-impact of external shocks and policy reforms in highly-indebted poor countries (HIPC), it has been calibrated for illustrative purposes to data on Bolivia, which qualified for debt-service relief under the enhanced HIPC-initiative in June 2001.

4.1 Calibration and Solution

For dynamic models, the base run should ideally be calibrated against the observed trajectories for the endogenous variables of the model. This base run would include not only the observed changes in the exogenous variables (population, international prices, etc.) but also in the policy instruments (including those that are not the object of any planned policy simulations) and in the exogenous shocks (weather, etc.). Successful calibration would then allow one to engage in counterfactual historical policy analysis, leading to statements such as "had the country under investigation followed this alternative policy course, it would have grown by this much more in year t and the welfare of each particular social group in that year have been different by so much".

GEM-PIA is fundamentally an equilibrium model where all markets are expected to clear during the period through either price or quantity adjustments or both. It only marginally captures dynamic and disequilibrium phenomena such as lags, partial adjustments, and quantity constraints. It does not incorporate endogenous government behavior, attitudes towards risk, and strategies regarding variations of inventories. Attempting to calibrate it on the observed time path in a period of disequilibria is clearly inconsistent with the model specification since the model itself is not constructed to capture these effects. In addition, many of the policies observed during the reference years were introduced in complement to or in compensation for the very policies that will subsequently be modified counterfactually. To do policy analysis, then, when introducing a policy change, all the subsequent endogenous policy changes

that appeared in the base run should also be modified, a clearly impossible task. Finally, in calibrating the base run on an observed time path, all the policy instruments used during the base years would need to be calibrated, even those that will subsequently not be used counterfactually since they affect the observed outcomes, an equally impossible task due to the lack of degrees of freedom.

The correct strategy is consequently to anchor the model on typical conditions that abstract from unplanned or irrelevant occurrences. For the Bolivian GEM-PIA, a slightly modified version of a Social Accounting Matrix (SAM) for the year 1997 (Thiele, Piazolo 2003) has been chosen as the "base year" (Appendix Table A1 and A2). Average spending propensities were directly derived from this SAM, while the elasticities reflect a combination of borrowed estimates and guesstimates (Appendix Table A3). The base year calibration procedure follows that common to CGE application: initial prices and quantities are combined with parameters and elasticities to calculate share parameters and exogenous constants that validate the base year values of the SAM. The presence of assets in the model complicates calibration since income flows (and hence savings decisions) depend on incomes earned from assets. The structure of the SAM, showing beginning and end year stocks of asset and liability holdings, already recognized this complication. The model has been calibrated for the end-of-year portfolio holdings of all institutions as reported in the accumulation balances (Appendix Table A2).

For the dynamic time path on which the base run is calibrated, a smoothed trend of the levels of endogenous and exogenous variables in the 1990s was used (Klasen et al. 2004). Because of this, the model is subsequently used as a policy laboratory to dissect the impact of specific shocks and policies in the structural and behavioral context of Bolivia. The results can be used to provide guidelines for the choice of alternative policy approaches in terms of their efficiency and welfare effects. They cannot be used to tell where Bolivia would be in 2010 would it follow another policy course. This is the best use that can be made of the CGE approach at this stage of the state of the art.

In the baseline scenario, the economy exhibits smooth economic growth of about 4.7 percent on average over a ten-year period (Table 5), where economic growth is driven by capital accumulation, (exogenous) growth of the labor force, and (exogenous) technical progress. This not only describes an optimistic forward-looking scenario, but is also a good description of the record of Bolivia in the 1990s. The growth process is associated with roughly constant domestic savings and investment ratios, which implies that the large savings gap is not closed over time. The continuing savings gap corresponds to a persistent current account deficit, and both are reflected in a fairly stable real exchange rate.

Table 5 — Baseline Scenario

Indicator \ Period	0	1	2	3	4	5	6	7	8	9	10
Real GDP growth		4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Real factor income											
Smallholders	100	101	102	104	105	107	109	110	112	114	116
Agr. workers	100	101	102	104	106	107	109	111	113	115	118
Non-agr. workers	100	104	107	111	114	117	121	124	128	131	135
Urban informals	100	102	103	105	106	108	109	111	112	114	116
Employers	100	103	105	108	110	112	114	116	117	119	120
Employees	100	104	108	112	116	120	124	128	133	138	142
Poverty headcount											
National	63.6	62.6	61.6	61.0	60.2	59.2	58.1	57.2	56.6	56.1	55.3
Urban	49.7	48.1	47.0	46.1	45.1	43.6	42.1	41.0	40.3	39.7	38.9
Rural	86.9	86.8	86.1	85.9	85.7	85.3	84.9	84.4	83.9	83.4	82.8
Poverty gap											
National	37.5	36.9	36.3	35.8	35.2	34.6	34.1	33.6	33.1	32.6	32.1
Urban	21.9	21.2	20.5	19.8	19.2	18.6	18.0	17.5	17.0	16.4	15.9
Rural	63.7	63.3	62.9	62.5	62.0	61.6	61.1	60.6	60.2	59.7	59.2
Gini coefficient											
National	62.7	62.8	62.9	63.0	63.0	63.1	63.2	63.2	63.3	63.4	63.4
Urban	54.4	54.4	54.5	54.5	54.6	54.6	54.7	54.7	54.8	54.8	54.9
Rural	64.5	64.6	64.7	64.8	64.9	65.0	65.0	65.1	65.2	65.2	65.3

Source: Own calculations based on GEM-PIA.

In line with past experience, the structural change projected in the baseline scenario is rather moderate. The shares of the broad aggregates “Agriculture”, “Industry” and “Services” in total value added barely change over time. More pronounced shifts of resources are taking place within these three sectors. Within agriculture, for example, the more productive export-oriented segment gains at the expense of the traditional, subsistence-like segment. The same pattern prevails in the services sector, where higher productivity growth and a higher income elasticity of demand raise the provision of formal relative to informal services.

From a distributional point of view, the baseline scenario suggests that without further policy reforms and without external shocks the rise in urban inequality observed over the 1990s will continue, and that the rural-urban gap in income levels will widen. In addition, inequality within rural areas will also increase. In both urban and rural areas inequality is already at very high levels, which is why aggregate growth in Bolivia barely translates into poverty reduction. As the following figures indicate, this holds in particular for rural areas. In the course of the simulated 10-year period, the national headcount merely declines from 63.6 percent to 55.3 percent. This moderate reduction results from a decrease in the urban headcount from 49.7 percent to 38.9 percent, and a reduction of only 4 percentage points from 86.9 percent to 82.8 percent in rural areas. Even under this optimistic scenario, Bolivia would just manage to reach the revised national poverty reduction target (UDAPE 2002). According to our model, poverty reduction in rural areas falls short of the reduction predicted in the revised PRSP, while urban poverty declines faster.

4.2 Illustrative Experiments

This section presents and discusses the numerical results associated with two types of shocks: an exogenous increase in export volumes of the oil&gas sector and a devaluation of the Boliviano. Both the short- and longer-run effects of these shocks are analyzed, with a particular focus on poverty.

Gas sector development

We first simulate the impact of increases in gas exports. Perhaps more than any macroeconomic and structural reform policy, the development of the natural gas sector promises to change the medium-run growth path of the Bolivian economy. Two large export-oriented hydrocarbon projects with Brazil and Argentina are already under way (IMF 2004), another project involving the export of liquefied natural gas (LNG) to North America has entered the planning stage but is currently on hold. Although the LNG-project has been granted to Indonesia (EIU 2004) North America remains a potential lucrative market especially amid the problems regarding regional target markets (Kuester 2004). Taken together, these projects could roughly double the share of oil and gas in total domestic production from 5 to 10 percent within a decade, and oil and gas could eventually account for as much as 50 percent of total exports.

Higher export demand for oil and gas yields higher income and higher savings and investment thereby leading to an expansion of domestic absorption and real GDP. In 2008 and 2009, when the LNG-project is assumed to reach full capacity, the growth rates of absorption and GDP are likely to approach 6 and 5.5 percent, respectively, (Table 6) [12] compared to 4.7 respective 4.4 percent in the reference simulation. These impacts are mainly the result of higher export revenues in the combined oil&gas sector which increase total export revenues despite reduced export revenues in other sectors. Although the export boom induces additional import expenditures (at given import prices), the trade balance and the current account improve. Since part of the trade balance surplus is used for the consumption of domestically produced goods, the domestic price level increases (at constant world prices for exports and imports) thereby inducing a real appreciation and a restructuring of domestic production towards nontraded goods and of final demand towards imports. These are the familiar Dutch Disease effects of resource booms.

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[12] The growth result obtained here comes quite close to the projections reported in IMF (2004).

Table 6 — Gas Projects

Indicator \ Period	1	2	3	4	5	6	7	8	9	10
Real GDP growth	5.1	5.1	5.3	5.1	6.1	5.8	5.0	5.0	5.1	5.1
Real factor income[a]										
Smallholders	-1	-2	-5	-5	-13	-20	-19	-18	-17	-15
Agr. workers	-1	-2	-6	-8	-15	-24	-26	-26	-26	-27
Non-agr. workers	1	2	3	5	11	15	18	19	21	22
Urban informals	0	1	1	2	3	4	5	7	8	9
Employers	0	1	1	2	2	2	4	6	7	8
Employees	0	0	0	1	2	3	4	3	3	4
Poverty headcount[a]										
National	-0.2	0.1	-0.1	-0.4	-0.8	-0.8	-0.7	-1.1	-1.2	-1.5
Urban	-0.2	0.0	-0.2	-0.8	-1.5	-1.4	-1.5	-2.0	-2.4	-2.8
Rural	0.0	0.3	0.3	0.1	0.6	0.5	0.7	0.5	0.9	0.9
Poverty gap[a]										
National	0.0	0.0	-0.1	-0.1	0.2	0.4	0.3	0.1	0.0	-0.2
Urban	-0.1	-0.2	-0.3	-0.4	-0.7	-0.8	-0.9	-1.1	-1.1	-1.3
Rural	0.2	0.2	0.5	0.6	1.4	2.4	2.3	2.1	1.9	1.7
Gini coefficient[a]										
National	0.1	0.1	0.1	0.2	0.3	0.5	0.5	0.5	0.4	0.4
Urban	0.0	-0.1	-0.1	-0.1	-0.2	-0.3	-0.2	-0.3	-0.3	-0.4
Rural	0.1	0.2	0.3	0.4	0.9	1.6	1.6	1.5	1.5	1.4

[a] Percentage points deviation from base run.

Source: Own calculations based on GEM-PIA.

The growth in gas exports and the accompanying rise in foreign exchange earnings have a positive impact on overall growth, but export growth and higher domestic savings are not the only elements to explain the economic expansion. Two other interactions are important in explaining the output expansion. One is the indirect effect of commodity exports on domestic credit supply through foreign portfolio investment. As described in Section 3.6, the rest of the world is assumed to hold a constant share of the export value as Dollar deposits in domestic commercial banks and the Central Bank. Thus, with passive monetary policies, the monetary base will expand and thereby domestic credit supplies, which will alleviate budget constraints on domestic investment. The other interaction reinforces the overall budget constraint. As explained in Section 3.6, the amount of foreign exchange reserves to be held by the

Central Bank is tied to the import bill. Thus, with increasing import expenditures more foreign exchange reserves will be held thereby reducing the amount of rediscount credit available for commercial banks. In the simulation of the gas boom, the former interaction dominates the latter thereby alleviating budget constraints on domestic investment. Since relative rentabilities of financial assets do not change and since it is assumed that investment into physical capital is determined residually by all institutions part of total assets is invested in physical capital accumulation thereby fostering growth.

The distribution of income between the public and the private sector is determined by the tax and subsidy system and by adjustments in the private sector. Which final demand components (private and public consumption and investment) benefit most from the export boom depends on their dependency on (now more expensive) domestically produced goods, on the one hand, and domestic policies, on the other. Since the growth of real government consumption is, by assumption, exogenously given changes in total government consumption expenditures are fully determined by changes in domestic prices for nontradable public goods, which increase as a result of demand expansion. Remaining public revenues are channeled into public savings, which are used to finance additional public infrastructure investment. Moreover, since we assume identical substitution possibilities between imports and domestically produced goods for all final demand components, the distribution of benefits is determined by the composition of domestic production. For example, the higher the share of capital goods imports (which prices remain constant) in total imports, the less will be the rise in capital goods prices in relation to the overall price level.

The sectoral employment and accumulation of capital and the resulting sectoral production are determined by the relationship between changes in production costs and changes in demand. Moreover, cumulative public investment is assumed to improve the productivity of activities. Since production tax rates are kept constant, cost changes result only from changes in wages and price changes for intermediates. These cost

changes have to be contrasted to changes in demand for private and public consumption and investment. Variations in these final demand components induce changes in prices for domestically produced goods. Increases in private consumption affect primarily those sectors for which income elasticities of demand are high. In Bolivia, this holds true for all types of formal services and for manufacturing goods except consumption goods. The oil & gas sector, mining, and construction are the least affected by the expansion of private consumption since their outputs are not directly consumed. However, the expansion of private and public investment demand affects the construction sector, which is isolated from the world market and to a less extent the capital goods sector, which faces competition from imports. Finally, public services are unaffected since the growth rate of public consumption demand is held constant.

This distribution of domestic demand implies that total domestic production increases on average compared to the base run. Only modern agriculture and to a less extent the consumer goods sector reduce their production. These two sectors produce quite homogenous products and therefore face strong foreign competition, both on the supply and the demand side. Moreover, there are strong backward linkages from the consumer goods industry to modern agriculture, which mostly produces intermediates to be processed by the former industry. On the supply side, the real appreciation induces a restructuring of supply from foreign to the domestic market with a tendency to reduce domestic prices. Additionally, the real appreciation provides an incentive for domestic consumers to restructure their demand from domestic to import supply, which also tends to lower domestic prices. Finally, with income elasticities of private demand being less than one increases in income are translated into less than proportional changes in demand. Moreover, for modern agriculture there is a negative demand effect via reduced intermediate demand of the consumer goods industry.

The changes of real imports are much more pronounced. These are determined, on the one hand, by changes in domestic demand without differentiating between domestic and foreign supply and by changes in relative prices between imported and

domestically produced goods together with their respective substitution elasticities, on the other. These elasticities are quite high for primary commodities, consumer goods, and services (2.0) and low for intermediate and capital goods (0.5). Since the prices for domestically produced tradables increase relative to the respective import prices in all sectors except traditional agriculture there are more imports in all sectors – except traditional agriculture.

With the exception of the oil & gas sector (which is affected by the export boom) and mining (the export demand of which is exogenous) changes in exports reflect increases in domestic prices as a result of higher production costs. Thus, all those sectors loose international competitiveness on which domestic demand is concentrated. Yet, the price push is somewhat weaker if domestic goods can be substituted more easily by imports.

The distributional results (Gini coefficient) and poverty results (poverty headcount and poverty gap) listed in Table 6 reflect changes in labor and capital income (factor incomes) as well as changes in transfers from the Bolivian government and remittances from family members living abroad but neglect interest payments and direct tax payments, which are not identifiable in the Bolivian household survey. They also take account of changes in cost of living of the different households. Neglecting direct tax payments does not affect the poverty results since poor households are assumed to pay no income taxes; it slightly affects the distributional results because net income of rich households (employers and employees) is somewhat overestimated. However, the poverty results are somewhat distorted by neglecting higher net interest payments of poor smallholder and urban informal households.

Overall, rural areas, i.e., smallholders as well as agricultural workers, suffer significant losses in real factor income, in particular in the peak years of the natural gas boom, while all households living in urban areas benefit from the boom (Table 6). The main beneficiaries are non-agricultural workers whose real per-capita factor income

increases by up to 20 percent, on average, during the last 4 years of the simulation period. Non-agricultural workers are intensively used in both the oil & gas sector and in construction. Hence, their wages increase not only as a result of the export demand expansion but also as a result of the expansion of construction, which is induced by additional investment demand. Moreover, like all other urban households, they benefit from additional demand for manufactured goods, except consumption goods, and services following the overall increase in income. By contrast, smallholders in traditional agriculture and urban informals in the urban informal services sector are considered as self-employed and are remunerated on the basis of their per capita output, which depends on demand; there is no minimum level of income. Over one year, supply is almost constant[13] for a given number of self-employed, and if demand slackens and/or if input intermediate costs increase, the adjustment will be through a fall in prices, which lowers nominal income. Moreover, real factor incomes are affected by changes in the household-specific consumer price level, which increases for all households. Thus, the dramatic decline of smallholders' real factor income can be traced back to a combination of demand factors, cost increases for intermediates, which cannot be shifted on to consumers and an increase in costs of living. By contrast, urban informals benefit from the expansion of domestic consumption and gains in nominal income are only partially eroded by increasing costs of living. Finally, agricultural workers suffer the most drastic declines in real factor income. Agricultural workers are assumed to be employed exclusively in the modern agricultural sector within each year, but can migrate over time to join urban informals. Hence, within each year their factor income is determined residually after subtracting from revenues all other production costs. Since modern agriculture production

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[13] Beside their labor force, both household types also own small amounts of capital, which smallholders invest in traditional and modern agriculture whereas urban informals invest in the informal services sector as well as in some manufacturing sectors and in construction. Since the model assumes that capital is mobile within each year some output adjustment in traditional agriculture and in informal services is possible through reallocations of capital.

contracts (see above) and since other production costs, particularly for skilled labor, increase drastically quasi rents for agricultural workers go down significantly.

These changes in factor incomes induce only minor distributional and poverty changes (Table 6). Even when the per capita factor incomes of smallholders and agricultural workers fall by 21 and 28 percent relative to employers (in period 7), the national Gini coefficient changes by only 0.5 percentage points; and the incidence of poverty and the poverty gap in rural areas increase by only 0.7 and 2.3 percentage points, respectively. The reason is that households as identified in the Bolivian household survey receive factor income from different sources and the factor income of the household head may not be the most important of these. Thus, factor income losses of rural households whose head is either self-employed in traditional agriculture or is working as an agricultural worker in modern agriculture are to a large part compensated by factor income gains of family members who are working in urban manufacturing and services sectors. Nevertheless, the results show that the distributional and poverty impact of a gas boom is disappointing. Despite considerably higher economic growth, the decrease in nation-wide poverty is only moderate compared to the base run. More remarkably, rural poverty even increases. The rural poverty gap ratio, which during the second half of the simulation period is about 2 points higher than in the baseline scenario, illustrates that many of those who were already poor incur additional income losses.

An even worse outcome could be expected if additional public revenues resulting from the export boom are spent for consumptive purposes rather than on investment. In this case, the reduction of poverty would be significantly lower in urban areas, and both the headcount and the poverty gap in rural areas would be much higher. In addition, the rise in inequality would be somewhat more severe due to a stronger Dutch Disease effect (Klasen et al. 2004).

Devaluation

One of Bolivia's biggest achievements since the beginning of reforms in 1985 has been the containment of inflation by means of prudent monetary, fiscal and exchange rate policies. There would appear to be little reason for devaluation. The current account deficit in the base year, although large (6.5 percent of GDP), is to a considerable extent determined by the high level of autonomous capital inflows such as direct and portfolio investment in the privatization process. However, it might be argued that now, with an internal equilibrium that is firmly established, the exchange rate could be used to improve the external competitiveness of the Bolivian economy and affect its income distribution, given that the Boliviano has always been quite strong (Schweickert et al. 2003). Macroeconomic policy instruments are also still needed to bring about the real devaluations required in the face of negative external shocks. In this technical paper, the main reason for the simulation of an exchange rate policy, however, is to get more insight into the working of the model.

The exchange rate policy is implemented in the model by a temporary 10 percent rise of the nominal exchange rate (Boliviano/US-Dollar) in the first year, whereas the devaluation is held at the levels of the base run in subsequent years. The effects are very much in line with theoretical expectations. As shown in Table 7, the devaluation has almost no impact on GDP growth; the policy is slightly expansionary in the very short run but the positive impact fades over the medium run and the economy returns to the base run trend.

The devaluation affects the trade balance and thereby import capacity, but also affects domestic prices and the accumulation balances of domestic institutions. The response of exports and import demand to devaluation depends on their respective price elasticities. Since foreign goods are assumed to be imperfect substitutes for domestically produced goods, trade balance effects are not the most important adjustment effects following devaluation. The volume of exports rises in the first

Table 7 — Devaluation

Indicator \ Period	1	2	3	4	5	6	7	8	9	10
Real GDP growth	4.8	4.6	4.7	4.7	4.7	4.7	4.7	4.6	4.6	4.6
Real per-capita factor income[a]										
Smallholders	1	0	-1	0	0	-1	0	0	-1	-1
Agr. workers	2	0	0	0	0	0	0	0	-1	-2
Non-agr. workers	-2	0	-1	-1	-1	-2	-1	-2	-2	-2
Urban informals	-2	0	-1	-1	-2	-1	-2	-2	-2	-3
Employers	0	1	1	1	2	2	1	2	2	2
Employees	0	0	-1	-1	0	0	0	0	-1	0
Poverty headcount[a]										
National	0.3	0.1	0.1	0.2	0.3	0.2	0.4	0.2	0.1	0.5
Urban	0.8	0.1	0.2	0.2	0.4	0.3	0.4	0.1	0.3	0.5
Rural	-0.3	0.1	0.0	0.1	0.3	0.0	0.2	0.4	0.1	0.6
Poverty gap[a]										
National	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3
Urban	0.2	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3
Rural	-0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3
Gini coefficient[a]										
National	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.1
Urban	0.1	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Rural	-0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0

[a] Percentage points deviation from base run.

Source: Own calculations based on GEM-PIA.

period, but falls below the base run level afterwards. The reason is that the devaluation has an inflationary effect due to rising cost of imported final demand and intermediate inputs. Moreover, with full employment of labor and wages determined by their marginal value product, the increase in prices leads to rising wages. The increases in intermediate input cost and wages reduce the positive effect that the devaluation has on export supply. Overall, the inflationary impact tends to equal the rate of devaluation, meaning that the policy appears to be ineffective in achieving a significant depreciation of the real exchange rate, which would be necessary to stimulate lasting export growth. The volume of imports rises, but after the third year

falls below the base run level. The outcome of these processes is reflected in the trade and current account deficits, which both worsen slightly compared to the base run.

The devaluation also has an impact on the domestic currency value of current transfers from abroad such as factor incomes, remittances and development aid, which all increase as a result of the devaluation. Moreover, it has an impact on the portfolios of the various institutions. The change in the exchange rate affects the domestic currency value of foreign assets and liabilities, the domestic currency cost of foreign liabilities and returns on foreign assets and, therefore, leads to wealth revaluations and to portfolio adjustments, which, in turn, affect the level of investment and growth. With passive monetary policies, the monetary base expands with a devaluation (through the domestic currency value of Central Bank reserves) and thereby domestic credit supply, which alleviates the budget constraints on domestic investment. A similar effect on individual institutions' budget constraints results as long as net capital transfers from abroad (net lending less interest payments) is positive. However, the devaluation may also lead to a widening of the domestic-currency fiscal balance due to the high public external debt burden.

The effect of rising domestic-currency value of external debt servicing is clearly present, but it appears that this effect is outweighed by the general equilibrium effects on domestic incomes and thus tax revenue, such that the government can sustain and even slightly increase its level of savings. Income effects are discussed further below, but the main impact is that the devaluation raises rural factor incomes relative to urban ones. However, given the generally low incidence of income taxation in Bolivia, this redistribution does little to weaken the Treasury. The increase in tax revenues is mainly derived from more indirect taxes and corporate taxes. Overall the portfolio effects of the devaluation are generally expansionary leading to increasing investment expenditures of all those institutions, which invest in physical capital. However, these increases in nominal investment expenditures are almost completely compensated by rising prices for imported capital goods (as a result of the devaluation) and rising

prices in the construction sector (as a result of internal adjustments) leaving overall real investment almost unaffected in the medium to long term. Thus, growth tends to stagnate at the base run level.

The impact of the devaluation is not the same for all segments of the Bolivian society. Rather, the incidence among households is determined by various mechanisms whereby the devaluation affects the distribution of earned income. First, on the supply side the change in relative net prices affects the distribution of value added between sectors and, within sectors, the distribution of value added between different factors of production. These shifts determine, after taxes, the distribution of earned nominal income among households. Second, the distribution of income is affected by differential changes in the cost of living across household groups. The relevant prices are those of composite goods, which include imports. Third, transfers, which here arises from public transfers, transfers from abroad and net interest income or payments, affect the distribution of income.

With income tax rates and household subsidy rates held constant at the base run levels, the distribution of net income is unaffected by public redistribution. Moreover, the devaluation increases households' domestic currency value of remittances from abroad by the same factor. Thus changes in income distribution can only result from changes in real factor income and net interest income. As a result of the devaluation, real per-capita factor incomes rise slightly in the short run in rural areas and fall in urban areas (Table 7). This can be traced back to an improvement in agricultural net price terms of trade and changes in household-specific cost of living. In the medium to long run all households except employer households realize small real factor income losses. The latter supply capital, which has become relatively scarce compared to the base run. Finally, real net household income is affected by changes in interest income and payments. As argued above, the devaluation will increase both the deposits in domestic and foreign banks as well as credits of the domestic banking system at given interest rates. Thus net lenders, such as smallholders and urban self-employed realize

an increase in interest payments in the medium to long term, while net creditors' interest surplus (employees and employers) will improve.

Small changes in real net factor income and interest income translate into small changes of the distributional and poverty indicators (Table 7). Moreover, households receive different forms of factor income depending on their endowments, which generally leads to a leveling-off of income differentials. This is reflected in the Gini coefficients, which hardly change as a result of the devaluation. Poor rural households benefit from the devaluation in the short run; both the rural headcount and the rural poverty gap fall. However, increasing poverty in the medium and long run compensates these marginal improvements. Urban poor households are most hit by the devaluation in the short run as a result of the contraction of the construction sector.

Overall, it appears that income inequalities and poverty tend to become larger with the devaluation. The short run reduction of rural poverty by means of a devaluation in the CGE model do not suggest a sustainable 'virtuous circle' between income redistribution and growth. Even though further analysis of this hypothesis is required, it seems that – given the supply and financial constraints on the Bolivian economy – mere income and demand composition effects are unlikely to be sufficient to produce such a 'benign cycle'.

5. Conclusions

This paper provides a technical description of GEM-PIA, a recursive-dynamic real-financial computable general equilibrium model for a single economy, which is linked to household survey information. The model can be used to project economic activities, trade flows, and distributional and poverty outcomes according to exogenous assumptions about the dynamics of the model. It can also be used to simulate changes in external conditions, such as terms-of-trade or interest-rate shocks, or policy scenarios in various economic fields, like for example, trade policy, fiscal

policy, exchange rate policy or monetary policy, and to analyze their allocation and distributional impacts. Because of its integrated treatment of the real and financial sides of an economy, the model is better suited (than pure real models) to analyze Worldbank/IMF stabilization and structural adjustment programs. Moreover, linking the extended functional distribution and the redistribution of income to socioeconomic characteristics of individual households as observed in household surveys allows for a detailed assessment of the poverty impacts of external shocks and domestic policies.

In order to demonstrate the workings of GEM-PIA, the model has been calibrated to a Social Accounting Matrix for Bolivia for the year 1997 and an optimistic forward-looking scenario with regard to foreign capital inflows. This base run captures quite well the long-term dynamics of the Bolivian economy in the 1990s both in terms of growth rates and directions of structural change. The distributional results suggest that under these optimistic external conditions, Bolivia would manage to reach its national poverty reduction target, but would fail to reduce rural poverty as envisaged in the revised PRSP.

No firm conclusions should be attached to the two simulations: a permanent rise of gas export demand and a temporary devaluation; they were very simple and more designed to test the model than to answer policy questions. But all runs agree on one important aspect: The Bolivian economy is strongly integrated with the world economy through both commodity and financial markets. The analysis further suggests that the outcomes of external and policy shocks are strongly influenced by portfolio effects. Changes in the relative returns or cost of the various financial assets or liabilities do have wealth effects and do lead to substitution processes which influence the direction and intensity of the impacts of the scenarios. It also suggests that the distributional results are strongly determined by the constraints, which poor households are facing on markets for commodities, factors, and financial assets.

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Appendix — Table A1: Social Accounting Matrix for Bolivia, 1997 (mill. of Bolivianos)

		TA	MA	OG	M	CG	IG	CAG	EGW	C	IS	FS	PS	Total	SHLab	UILab	Slab	RULab	UULab	FCap	SHCap	UICap	ERCap	Total
		1	2	3	4	5	6	7	8	9	10	11	12	1-12	13	14	15	16	17	18	19	20	21	13-21
Traditional agriculture (TA)	1	413	135	0	3	2301	5	0	0	9	43	97	67	3073										
Modern agricutlure (MA)	2	92	83	0	16	1422	15	0	0	42	8	19	19	1716										
Crude oil & natural gas (OG)	3	0	0	32	0	33	1190	0	83	0	1	2	1	1342										
Mining (M)	4	1	1	0	1	2	742	0	0	188	1	3	1	940										
Consumer goods (CG)	5	162	90	10	50	2520	79	11	24	115	588	1370	286	5305										
Intermediate goods (IG)	6	197	155	251	157	699	608	154	175	1196	714	1722	251	6279										
Capital goods (CAG)	7	21	24	20	91	160	65	56	62	81	171	384	171	1306										
Electr., gas & water (EGW)	8	2	3	29	50	156	118	6	13	8	106	219	85	795										
Construction (C)	9	0	0	0	0	0	2	0	8	0	4	137	2	153										
Informal services (IS)	10	156	126	87	50	944	144	29	51	147	531	895	207	3367										
Formal services (FS)	11	286	320	231	173	1365	363	57	219	218	1521	3133	600	8486										
Public sector (PS)	12	1	2	2	1	10	2	0	1	1	10	14	3	47										
Total	1-12	1331	939	662	592	9612	3333	313	636	2005	3698	7995	1693	32809										
Smallholder labor (SHLab)	13	4000	0	0	0	0	0	0	0	0	0	0	0	4000										
Urban internal labor (UILab)	14	0	0	0	0	0	0	0	0	0	2500	0	0	2500										
Skilled labor (Slab)	15	23	122	279	82	440	206	16	226	222	0	3408	4237	9261										
Agr. unsk. labor (RULab)	16	94	486	0	0	0	0	0	0	0	0	0	0	580										
Non-agr. unsk. labor (UULab)	17	0	0	142	271	623	278	23	27	311	0	213	427	2315										
Formal capital (FCap)	18	0	490	404	319	801	401	0	780	94	0	2550	0	5839										
Smallholder cap. (SHCap)	19	125	0	0	0	0	0	0	0	0	0	0	0	125										
Urban informal cap. (UICap)	20	0	0	0	0	823	147	44	0	377	481	0	0	1872										
Employers cap. (ERCap)	21	11	744	0	1011	1232	599	17	0	145	0	5666	0	9425										
Total	13-21	4253	1842	825	1683	3919	1631	100	1033	1149	2981	11837	4664	35917										

Appendix — Table A1 continued

		TA	MA	OG	M	CG	IG	CAG	EGW	C	IS	FS	PS	Total	SHLab	UILab	Slab	RULab	UULab	FCap	SHCap	UICap	ERCap	Total
		1	2	3	4	5	6	7	8	9	10	11	12	1-12	13	14	15	16	17	18	19	20	21	13-21
Smallholder (SH)	22														4000	0	0	0	0	0	125	0	0	4125
Agricult. workers (AW)	23														0	0	0	580	0	0	0	0	0	580
Employees (EE)	24														0	0	9321	0	0	0	0	0	0	9321
Non-agric. workers (NAW)	25														0	0	0	0	2315	0	0	0	0	2315
Urban informals (UI)	26														0	2500	0	0	0	0	0	1872	0	4372
Employers (ER)	27														0	0	0	0	0	0	0	0	9425	9425
Private corp. (PC)	28														0	0	0	0	0	4373	0	0	0	4373
State ent. (SE)	29														0	0	0	0	0	1466	0	0	0	1466
Government (GV)	30	16	37	648	150	1021	1617	905	118	329	0	881	5	5727										0
Ind. tax		0	24	560	68	425	1084	109	44	46	0	320	5	2685										
VA tax		0	10	88	82	535	392	430	74	283	0	561	0	2455										
Tariffs		16	3	0	0	61	141	366	0	0	0	0	0	587										
Total	22-30	16	37	648	150	1021	1617	905	118	329	0	881	5	5727			9321		2315	5839	125	1872	9425	35977
Rest of world (RW)	31	398	104	0	89	2079	3254	5230	0	0	220	852	0	12226										
Changes of stocks (STK)	32																							
Smallholder (SH)	33																							
Agricult. workers (AW)	34																							
Employees (EE)	35																							
Non-agric. workers (NAW)	36																							
Urban informal (UI)	37																							
Employers (ER)	38																							
Priv. corp. (PC)	39																							
State ent. (SE)	40																							
Government (GV)	41																							
Central Bank (CB)	42																							
Commercial banks (PB)	43																							
Rest of world (RW)	44																							
Total	31-44																							
Total Exp.	1-44	5998	2922	2135	2514	16631	9835	6548	1787	3483	6899	21565	6362	86679	4000	2500	9321	580	2315	5839	125	1872	9425	35977

Appendix — Table A1 continued

		SH	AW	EE	NAW	UI	ER	PC	SE	GV	Total	RW	STK	SH	AW	EE	NAW	UI	ER	PC	SE	GV	CB	PB	RW	Total	Total
		22	23	24	25	26	27	28	29	30	22-30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	31-44	1-44
Traditional agriculture (TA)	1	552	67	549	205	358	493			0	2224	780	-79	0	0	0	0	0	0	0	0	0				0	5998
Modern agricutlure (MA)	2	49	7	95	32	55	84			0	322	713	40	16	0	0	0	0	0	115	0	0				131	2922
Crude oil & natural gas (OG)	3	0	0	0	0	0	0			0	0	525	-55	0	0	0	0	0	0	185	138	0				323	2135
Mining (M)	4	0	0	0	0	0	0			0	0	1587	-13	0	0	0	0	0	0	0	0	0				0	2514
Consumer goods (CG)	5	1561	235	2668	818	1426	2336			0	9044	2222	60	0	0	0	0	0	0	0	0	0				0	16631
Intermediate goods (IG)	6	290	44	839	141	289	729			0	2332	1009	79	0	0	0	0	0	0	136	0	0				136	9835
Capital goods (CAG)	7	167	25	482	81	166	422			0	1343	58	244	21	0	0	0	23	72	1879	1195	407				3597	6548
Electr., gas & water (EGW)	8	84	14	380	56	126	332			0	992	0	0	0	0	0	0	0	0	0	0	0				0	1787
Construction (C)	9	0	0	0	0	0	0			0	0	0	0	104	0	0	0	139	508	382	622	1575				3330	3483
Informal services (IS)	10	121	18	1175	371	694	1153			0	3532	0	0	0	0	0	0	0	0	0	0	0				0	6899
Formal services (FS)	11	1144	165	3988	642	1201	3659			0	10799	1897	0	8	0	0	0	9	15	143	104	104				383	21565
Public sector (PS)	12	39	6	209	31	58	182			5790	6315	0	0	0	0	0	0	0	0	0	0	0				0	6362
Total	1-12	4007	581	10385	2377	4373	9390			5790	36903	8791	276	149	0	0	0	171	595	2840	2059	2086				7900	86679
Smallholder labor (SHLab)	13																										4000
Urban internal labor (UILab)	14																										2500
Skilled labor (Slab)	15											60															9321
Agr. unsk. labor (RULab)	16																										580
Non-agr. unsk. labor (UULab)	17																										2315
Formal capital (FCap)	18																										5839
Smallholder cap. (SHCap)	19																										125
Urban informal cap. (UICap)	20																										1872
Employers cap. (ERCap)	21																										9425
Total	13-21											60															35977

Appendix — Table A1 continued

		SH	AW	EE	NAW	UI	ER	PC	SE	GV	Total	RW	STK	SH	AW	EE	NAW	UI	ER	PC	SE	GV	CB	PB	RW	Total	Total
		22	23	24	25	26	27	28	29	30	22-30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	31-44	1-44
Smallholder (SH)	22									74	74	24															4223
Agricult. workers (AW)	23									11	11	4															595
Employees (EE)	24							1476		2249	3725	54															13100
Non-agric. workers (NAW)	25									42	42	13															2370
Urban informals (UI)	26									79	79	25															4476
Employers (ER)	27							1500			1500	54															10979
Private corp. (PC)	28	179		448		60	455		172	123	1437	477															6287
State ent. (SE)	29							703		387	1090	283															2839
Government (GV)	30		4	1834	14		127	1314	566		3859	925															10511
Ind. Tax																											2685
VA tax																											2455
Tariffs																											587
Total	22-30	179	4	2282	14	60	582	4993	738	2965	11817	1859															55380
Rest of world (RW)	31							654	89	675	1418																13644
Changes of stocks (STK)	32										0			-189				-199	-103	578	189					276	276
Smallholder (SH)	33	37									37			0	0	0	0	0	0	0	0	0	0	25	0	25	62
Agricult. workers (AW)	34		10								10			0	0	0	0	0	0	0	0	0	0	5	0	5	15
Employees (EE)	35			433							433			0	0	0	0	0	0	0	0	0	0	575	0	575	1008
Non-agric. workers (NAW)	36				-21						-21			0	0	0	0	0	0	0	0	0	0	10	0	10	-11
Urban informal (UI)	37					43					43			0	0	0	0	0	0	0	0	0	0	9	0	9	52
Employers (ER)	38						1007				1007			0	0	0	0	0	0	0	0	0	0	885	0	885	1892
Priv. corp. (PC)	39							640			640			0	0	25	0	0	147	0	-1	0	0	999	4293	5463	6103
State ent. (SE)	40								2012		2012			0	0	0	0	0	0	105	0	0	0	0	10	115	2127
Government (GV)	41									1081	1081			0	0	0	0	0	0	0	0	0	-4	246	808	1050	2131
Central Bank (CB)	42													102	10	264	-21	80	-167	171	-122	62	0	476	-427	428	428
Commercial banks (PB)	43													0	5	719	10	0	589	1792	2	-17	420	0	701	4221	4221
Rest of world (RW)	44											2934		0	0	0	0	0	831	617	0	0	12	991	0	2451	5385
Total	31-44	37	10	433	-21	43	1007	640	2012	1081	5242	2934	0	102	15	1008	-11	80	1400	2685	-121	45	428	4221	5385	15237	
Total Exp.	1-44	4223	595	13100	2370	4476	10979	6287	2839	10511	55380	13644	276	62	15	1008	-11	52	1892	6103	2127	2131	428	4221	5385		

Appendix — Table A2: Accumulation Balance for Bolivia, 1997 (mill. of Bolivianos)

	SH	AW	EE	NAW	UI	ER	PC	SE	GV	CB	PB	RW	TotalLiab.	Net Wealth
Smallholder (SH)	0	0	0	0	0	0	0	0	0	0	1823	0	1823	5106
Agricult. workers (AW)	0	0	0	0	0	0	0	0	0	0	5	0	5	15
Employees (EE)	0	0	0	0	0	0	0	0	0	0	3609	0	3609	2451
Non-agric. workers (NAW)	0	0	0	0	0	0	0	0	0	0	40	0	40	119
Urban in formals (UI)	0	0	0	0	0	0	0	0	0	0	607	0	607	7303
Employers (ER)	0	0	0	0	0	0	0	0	0	0	3346	0	3346	29562
Priv. corp. (PC)	0	0	695	0	0	585	0	280	0	0	13243	5485	20288	32712
State ent. (SE)	0	0	0	0	0	0	1991	0	0	0	0	1784	3775	10829
Government (GV)	0	0	0	0	0	0	0	0	0	3326	1834	14809	19969	28459
Central Bank (CB)	81	15	140	119	113	570	608	515	3303	0	525	3680	9669	2341
Commercial banks (PB)	0	5	5225	40	0	4828	5777	29	141	2404	0	3101	21550	3938
Rest of world (RW)	0	0	0	0	0	217	370	0	0	6280	456	0	7323	21536
Phys cap	6848	0	0	0	7797	26708	44254	13780	44984	0	0	0	144371	
Total ass	6929	20	6060	159	7910	32908	53000	14604	48428	12010	25488	28859		
Traditional agriculture (TA)	0	0	0	0	0	0	0	0	0					
Modern agricutlure (MA)	16	0	0	0	0	0	115	0	0					
Crude oil & natural Gas (OG)	0	0	0	0	0	0	185	138	0					
Mining (M)	0	0	0	0	0	0	0	0	0					
Consumer goods (CG)	0	0	0	0	0	0	0	0	0					
Intermediate goods (IG)	0	0	0	0	0	0	136	0	0					
Capital goods (CAG)	21	0	0	0	23	72	1879	1195	407					
Electr., gas & water (EGW)	0	0	0	0	0	0	0	0	0					
Construction (C)	104	0	0	0	139	508	382	622	1575					
Informal services (IS)	0	0	0	0	0	0	0	0	0					
Formal services (FS)	8	0	0	0	9	15	143	104	104					
Public sector (PS)	0	0	0	0	0	0	0	0	0					
Fxd invest	149	0	0	0	171	595	2840	2059	2086					
STK	-189	0	0	0	-199	-103	578	189	0					
Smallholder (SH)	0	0	0	0	0	0	0	0	0	0	25	0	25	
Agricult. workers (AW)	0	0	0	0	0	0	0	0	0	0	5	0	5	
Employees (EE)	0	0	0	0	0	0	0	0	0	0	575	0	575	
Non-agric. workers (NAW)	0	0	0	0	0	0	0	0	0	0	10	0	10	
Urban in formals (UI)	0	0	0	0	0	0	0	0	0	0	9	0	9	
Employers (ER)	0	0	0	0	0	0	0	0	0	0	885	0	885	

Appendix — Table A2 continued

	SH	AW	EE	NAW	UI	ER	PC	SE	GV	CB	PB	RW	Tot Liab.	Net Wealth
Priv. corp. (PC)	0	0	25	0	0	147	0	-1	0	0	999	4293	5463	
State ent. (SE)	0	0	0	0	0	0	105	0	0	0	0	10	115	
Government (GV)	0	0	0	0	0	0	0	0	0	-4	246	808	1050	
Central Bank (CB)	102	10	264	-21	80	-167	171	-122	62	0	476	-427	428	
Commercial banks (PB)	0	5	719	10	0	589	1792	2	-17	420	0	701	4221	
Rest of world (RW)	0	0	0	0	0	831	617	0	0	12	991	0	2451	
Ass change	102	15	1008	-11	80	1400	2685	-121	45	428	4221	5385	15237	
Depr	137	0	0	0	156	534	920	241	900				2888	
Smallholder (SH)	0	0	0	0	0	0	0	0	0	0	67	0	67	
Agricult. workers (AW)	0	0	0	0	0	0	0	0	0	0	0	0	0	
Employees (EE)	0	0	0	0	0	0	0	0	0	0	134	0	134	
Non-agric. workers (NAW)	0	0	0	0	0	0	0	0	0	0	0	0	0	
Urban in formals (UI)	0	0	0	0	0	0	0	0	0	0	22	0	22	
Employers (ER)	0	0	0	0	0	0	0	0	0	0	135	0	135	
Priv. corp. (PC)	0	0	26	0	0	22	0	10	0	0	458	203	719	
State ent. (SE)	0	0	0	0	0	0	64	0	0	0	0	62	126	
Government (GV)	0	0	0	0	0	0	0	0	0	123	68	544	735	
Central Bank (CB)	3	1	15	6	4	21	22	19	123	0	55	136	405	
Commercial banks (PB)	0	0	216	0	0	201	220	1	5	101	0	114	858	
Rest of world (RW)	0	0	0	0	0	22	15	0	0	234	17	0	288	
Capital	238	0	0	0	271	927	1596	418	1561	0	0	0	5011	
Total reval.	241	1	257	6	275	1193	1917	448	1689	458	956	1059		
Smallholder (SH)	0	0	0	0	0	0	0	0	0	0	1915	0	1915	5180
Agricult. workers (AW)	0	0	0	0	0	0	0	0	0	0	10	0	10	26
Employees (EE)	0	0	0	0	0	0	0	0	0	0	4318	0	4318	3007
Non-agric. workers (NAW)	0	0	0	0	0	0	0	0	0	0	50	0	50	104
Urban in formals (UI)	0	0	0	0	0	0	0	0	0	0	638	0	638	7443
Employers (ER)	0	0	0	0	0	0	0	0	0	0	4366	0	4366	31093
Priv. corp. (PC)	0	0	746	0	0	754	0	289	0	0	14700	9981	26470	33630
State ent. (SE)	0	0	0	0	0	0	2160	0	0	0	0	1856	4016	12922
Government (GV)	0	0	0	0	0	0	0	0	0	3445	2148	16161	21754	29594
Central Bank (CB)	186	26	419	104	197	424	801	412	3488	0	1056	3389	10502	2394
Commercial banks (PB)	0	10	6160	50	0	5618	7789	32	129	2925	0	3916	26629	4036
Rest of world (RW)	0	0	0	0	0	1070	1002	0	0	6526	1464	0	10062	25241
Capital	6909	0	0	0	7884	27593	48348	16205	47731	0	0	0	154670	
Total ass	7095	36	7325	154	8081	35459	60100	16938	51348	12896	30665	35303		

Appendix — Table A3 Parameter and Elasticity Specification

Production and technology		TA	MA	OG	M	CG	IG	CAG	EGW	C	IS	FS	PS
Indirect tax rates	txx_i		0.007	0.26	0.03	0.03	0.17	0.11	0.02	0.01		0.02	
Value-added tax rates	tvx_i tvx		0.004	0.10	0.05	0.12	0.19	0.81	0.07	0.20		0.05	
Factor substitution elasticities:													
Private factors/public capital	σ_i^x	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Private factors	σ_i^{va}	1.0	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	1.0	0.8	0.8
Foreign trade		TA	MA	OG	M	CG	IG	CAG	EGW	C	IS	FS	PS
Export transformation elasticity	σ_i^t	2.0	2.0	2.0	2.0	2.0	0.5	0.5				0.5	
Export demand elasticity	η_i												
Import substitution elasticity	σ_i^q	2.0	2.0	2.0	2.0	2.0	0.5	0.5			2.0	2.0	
Tariff rates	tmx_i tmx	0.04	0.03			0.03	0.04	0.07					
Labor market		SHLab	RULab	Slab	UULab	UILab							
Labor force growth	nl_{fl}	0.03	0.02	0.02	0.02	0.02							
Migration:													
Rural/rural	*migrr*	0.0002											
Rural/urban	*migru*	0.002											
Institutions		SH	AW	NAW	EE	UI	ER	PC	SE	GV	PB	CB	RW
Marginal budget shares:	μ_i, dh												
Traditional agriculture (TA)		0.11	0.09	0.07	0.03	0.06	0.02						
Modern agricutlure (MA)		0.02	0.02	0.01	0.01	0.01	0.01						
Crude oil & natural Gas (OG)		0.34	0.35	0.29	0.17	0.26	0.11						
Mining (M)		0.08	0.09	0.07	0.09	0.08	0.10						
Consumer goods (CG)		0.05	0.05	0.04	0.05	0.05	0.06						
Intermediate goods (IG)		0.02	0.03	0.03	0.04	0.04	0.04						
Capital goods (CAG)		0.03	0.03	0.13	0.07	0.13	0.05						
Electr., gas & water (EGW)		0.33	0.33	0.34	0.50	0.36	0.59						
Construction (C)		0.01	0.01	0.02	0.03	0.02	0.03						
Marginal savings rates	ms_{dh}	0.05	0.05	0.05	0.20	0.05	0.20	end.	end.	end.			
Direct tax rates	tdx_d		0.007	0.006	0.14		0.01	0.30	0.23				
Portfolio demand	τ_d^p	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	ex.

Note: end. = endogenous; ex. = exogenous