Chapter 13

The 123PRSP Model

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Abstract. The 1-2-3 Model (the acronym stands for one country, two sectors, three commodities, e.g., exports, a domestic good and imports) is a simple, static computable general equilibrium (CGE) model that captures the effects of policies and shocks on the real exchange rate of resource allocation between the production of tradable and non-tradable goods. The model is calibrated with aggregate national accounts data. Export and import prices are exogenous making the domestic (market-clearing) price result from policy choices and consumer preferences. With very simple (but relaxable) assumptions regarding factor (labor and capital) markets (e.g., a competitive labor market at full employment, sector-specific and fixed capital), the domestic equilibrium price level is linked to the equilibrium wage rate. Profits in each sector are the residual of output after the wage bill. Thus, for a given set of macroeconomic policies, the 1-2-3 model generates a set of wages, sector-specific profits and relative prices that are mutually consistent. The link with poverty analysis is made when the model's projected changes in prices, wages and profits are plugged into household data on wages, profits and commodity demands for representative groups (or segments of the distribution, say deciles). But in principle, the model can calculate the impact on each household in the sample so as to capture the effect on the entire distribution of income. Of course, for a given poverty line, the effect on different poverty measures can also be reported. In short, the 1-2-3 framework described above allows for a forecast of welfare measures and poverty outcomes consistent with a set of macroeconomic policies in the context of a very simple general equilibrium model.

13.1. Introduction

This chapter describes a technique that links a simple static computable general equilibrium (CGE) model with household survey data. This modeling framework was designed to respond to the new demands created by the PRSP process. Existing macroeconomic models used in country economic work, such as the IMF's Financial Programming Model (FPM) or the World Bank's RMSM-X, take the two most important determinants of poverty—economic growth and

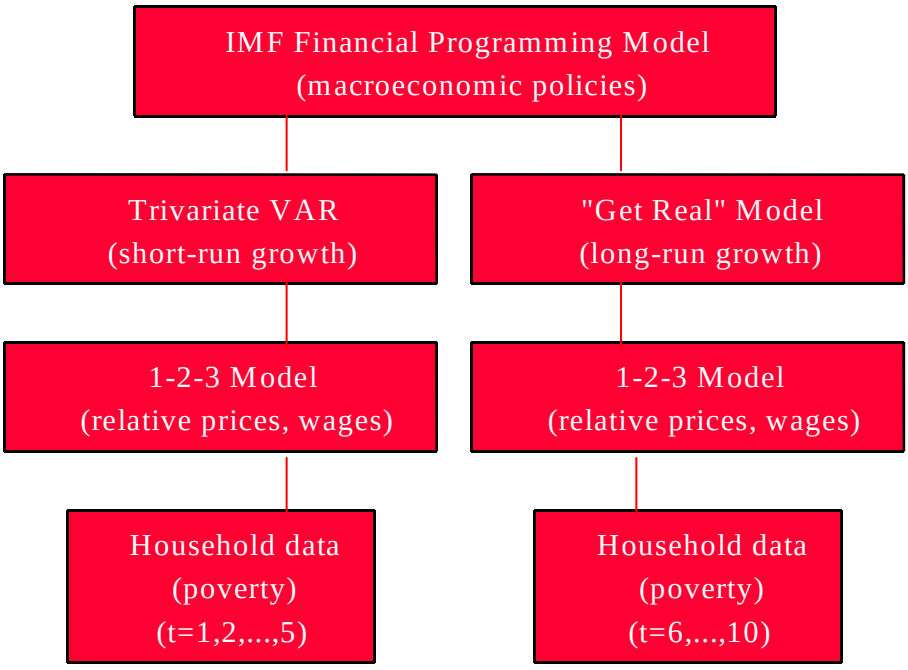
relative prices—as exogenous, so they cannot evaluate the impact of policies on poverty. More sophisticated approaches, such as disaggregated computable general equilibrium models, can capture the poverty impacts of policies, but are too data-intensive and difficult to master to be useful in the time-frame of the PRSP process. The model presented here, called the "123PRSP Model" represents the middle ground between these two approaches: it is as simple to estimate, learn and use as RMSM-X or the FPM, but it is able to capture the salient links between macroeconomic policies and shocks and poverty in a way that is both consistent with economic theory and faithful to the structural characteristics of the country[1]. Most importantly, it has been developed and used by teams from two low-income countries—Mauritania and Zambia—in their PRSP process.

In developing the 123PRSP model, we make some strategic simplifications. We opt for a modular approach, linking several existing models together. One advantage of this approach is that the individual component models already exist. Another is that, if for data or other reasons a particular component model is not available, the rest of the framework can be implemented without it. The cost of adopting this approach is that the causal chain from macroeconomic policies to poverty is in one direction only: we do not capture the feedback effect of changes in the composition of demand (due to shifts in the distribution of income) on macroeconomic balances.

We turn now to a description of the individual modules of the 123PRSP Model (Figure 13.1). We begin with a static, aggregate model, such as the IMF's Financial Programming Model (FPM). This model has the advantage of having a consistent set of national accounts, linked with fiscal, balance of payments and monetary accounts. Most of the macroeconomic policies, such as the level of government spending, taxation, and the composition of deficit financing, will be contained (as exogenous variables) in this module. Since the FPM is an accounting framework, with few behavioral assumptions, there are no real alternatives to this part of the framework. However, unlike the standard practice with the FPM, the economy's growth rate and its real exchange rate are not taken as given (or as targets) but rather they are explicitly derived in the models that follow.

[1] Examples of the general-equilibrium approach include Adelman and Robinson [1979], Lysy and Taylor [1979], Dorosh and Sahn [199x], Benjamin [199x], Devarajan and van der Mensbrugghe [2000] and Agénor et al. [2001]. The approach adopted here is closer to the tradition of microsimulation models (Bourguignon, Robillard and Robinson [2001]).

Figure 13.1: The 123PRSP Model



The information in the financial programming module is then read into each of the following models: (i) the "1-2-3 Model," a static, multi-sector, general-equilibrium model; and (ii) one of two growth models, either the "Get Real" model, which is a long-run growth model, or a Trivariate VAR model that captures short-run growth effects. The 1-2-3 Model assumes aggregate output is fixed, but captures the effect of macroeconomic policies and shocks on relative prices and wages (as well as on the composition of output). Likewise, the two growth models capture the effects of policies on growth, assuming that relative prices, wages and the composition of output is unchanged. We turn now to a thumbnail sketch of each of the individual models.

13.2. The technique: starting with the 1-2-3 Model

The 1-2-3 Model takes the aggregate information from the FPM but then divides the economy into two sectors: exports (E) and all other final goods produced, called domestic goods (D).[2] The economy's production possibilities between these two goods is described by a constant elasticity of transformation function, with elasticity Ω. There is one other good in the economy, which is imports (M)—hence the name, "one country, two sectors, three commodities." Consumers have

[2]. Since the 1-2-3 model is well-documented elsewhere (Devarajan, Lewis, and Robinson [1990,1993], Devarajan, Go, et al. [1997]), we provide only a thumbnail sketch here.

a constant elasticity of substitution utility function in *D* and *M*, with σ the elasticity of substitution. The prices of E and D are given by their world prices (and trade taxes). The price of *D* is determined by that price which equilibrates supply and demand for *D*. Inasmuch as *D* is a domestic good that is neither exported nor imported, the relative price of *D* to *E* or *M* is a real exchange rate. The salient aspect of the 1-2-3 model, therefore, is that it captures the effects of macroeconomic policies on a critical relative price, namely, the real exchange rate. The model is in the tradition of the Salter-Swan model that distinguishes between tradable and nontradable goods. However, unlike that model, the 1-2-3 model divides the economy into goods that are actually traded (E and M) and not traded (D), making the calibration of the model from national accounts data much easier.

The transformation frontier between *E* and *D* is based on the allocation of factors between the two sectors. Thus behind this function is a market for labor and capital. For simplicity, we assume there is only one labor market in the economy and that it is a competitive one. We further assume there is full employment. Finally, we assume that capital is fixed and sector-specific in this static model. All these assumptions can be relaxed if there are data on different labor categories, and information on how the factor markets operate. In this simple model, the assumptions imply that associated with the equilibrium price of *D* is also an equilibrium wage rate. Profits in each sector are then the residual of output after the wage bill. To summarize, starting with a set of national accounts, for a given set of macroeconomic policies, the 1-2-3 model generates a set of wages, sector-specific profits and relative prices (of *D*, *M* and *E*) that are mutually consistent.

a) The "Get Real" Model

The 1-2-3 model is a static model. For a given growth rate of the economy, it calculates the wages, profits and relative prices that are consistent with that rate. This "given growth rate" is normally a forecast or a target in most macroeconomic models used by country economists. Yet, the macroeconomic policies in question may have an impact on the economy's long-run growth rate. The "Get Real" Model (Easterly [1999]) presents a parsimonious set of cross-country growth regressions that capture the long-run growth impact of these policies. The coefficients of an extended version that includes long-term trade and debt factors are given in Table 13.1. Note, for example, that the long-run growth effects of increases in secondary-school enrollment and in infrastructure stocks (telephone lines) are captured by this model.

The "Get Real" Model is one alternative of capturing the long-run growth effects of macroeconomic policies. It is a reduced-form model, and since it is based on cross-country

regressions, the coefficients are the same for all countries.[3] An alternative would be to estimate a country-specific model. The problem here is that there is not enough intertemporal variation in policies to obtain significant coefficients. Nevertheless, if the analyst has an alternative model of long-run growth determination, there is nothing stopping him or her from inserting it in place of the Get Real Model at this stage in the framework.

Table 13.1: Growth Coefficients of the Get Real Model

Policy determinants		
Black market premium	**–0.0153**	**(-4.02)**
M2/GDP	0.0004	(3.31)
Inflation	-0.0014	(-0.21)
Real exchange rate	–0.0087	(-2.36)
Secondary enrollment	0.0003	(2.40)
Telephone lines/1000	0.0054	(2.13)
Shocks		
Terms of trade as % of GDP	0.2125	(2.45)
Interest on external debt as % of GDP	-0.0029	(-3.28)
OECD trading partner growth	0.0210	(3.56)
Initial conditions		
Initial income	-0.0105	(-2.33)
Intercept	0.0236	(0.71)
Shifts 80s	-0.0021	(-0.41)
Shifts 90s	0.0046	(0.60)
Zambia's economic growth		
Actual, 90s	-1.5 %	
Estimated	-2.1%	

Source: Easterly (2000). Figures in parenthesis are t-statistics

b) Trivariate VAR Model

The Get Real model captures the long-run effects of macroeconomic policies—approximately five years after the policies have been enacted. What about the first five years? One option is to use the consensus forecast for growth in those five years. However, this forecast would not tell us what the short-run growth impact of, say, a terms of trade shock or an increase in government expenditure would be. To capture these impacts, we estimate a trivariate vector autoregression (VAR), where the three variables are: the exogenous shock or policy (terms of trade or government expenditure), the real exchange rate and growth. The short-run growth elasticities of the trivariate VAR model for Zambia are given in Table 13.2.

[3]. Although the coefficients are the same for all countries, the long-run growth rates will be different since the levels of the explanatory variables will be different.

Table 13.2: Growth Elasticities in the First Two Years*

	Year 1	Year 2
Terms of trade shock (price of copper)	0.053	0.024
Government spending	0.038	-0.033

*Note: Impulse response from the VAR for the first two periods.

c) Household Data

So far, we have not mentioned poverty, and yet this framework is supposed to capture the effects of macroeconomic policies on poverty. We turn therefore to the final—and most important—module, which is labeled "household data" in Figure 13.1. Consider each of the households in the household survey. If each household maximizes its utility (over labor supply and consumption), the indirect utility function, v, is a function of wages (w), profits (π) and prices (p):

$$v = v(w, \pi, p)$$

To look at the impact of small changes in prices on this utility, we differentiate v and apply Shephard's Lemma:

$$dv / \lambda = wL(dw / w) + d\pi - pC(dp / p).$$

where $\lambda = \partial v/\partial \pi$, the marginal utility of income, L is net labor supply and C is net commodity demand.

Each of the variables on the right-hand side is portrayed by the results of the combined 1-2-3 and Get Real/Trivariate VAR models. Thus, with the information on changes in wages, profits and the prices of the three goods given by the models, and with the initial levels of labor income and commodity consumption given by the household surveys, we can calculate the impact of macroeconomic policies on household welfare.

Table 13.3 shows the information on wages, profits and commodity demands for the ten deciles in Zambia. An examination of Table 3 reveals several interesting features of the distribution of income and expenditures in Zambia. First, note that the poor spend more of their income on domestic goods, whereas the rich spend more on imported goods. A policy that leads to an appreciation of the real exchange rate (increased government spending on non tradables, for

instance) would favor the rich vis-à-vis the poor. On the income side, the poor get more of their non wage income from the domestic sector, so a real depreciation would hurt the poor

Table 13.3: Distribution of Income and Expenditure, Zambia

Share of Income				Share of Expenditure	
Deciles	W	Π_D	Π_E	Exp M	Exp D
1	0.00	0.98	0.02	0.23	0.77
2	0.01	0.92	0.07	0.24	0.76
3	0.06	0.82	0.13	0.26	0.74
4	0.33	0.52	0.15	0.28	0.72
5	0.55	0.34	0.11	0.28	0.72
6	0.83	0.14	0.04	0.29	0.71
7	0.88	0.09	0.02	0.30	0.70
8	0.89	0.09	0.02	0.30	0.70
9	0.90	0.09	0.02	0.31	0.69
10	0.64	0.13	0.23	0.30	0.70
Average	0.71	0.14	0.16	0.30	0.70

Source: Zambia Household Survey

In principle, we can calculate the impact on each household in the sample so as to capture the effect on the entire distribution of income. Of course, for a given poverty line, the effect on different poverty measures can also be reported. In short, the framework described so far allows for a forecast of welfare measures and poverty outcomes consistent with a set of macroeconomic policies. Since the model is quite flexible, it will eventually permit the analysis of poverty across different regions in a country, when the data allow for such a level of disaggregation.

13.3. Illustrations Using Zambia Data

We turn now to an illustration of the 123PRSP model as applied to Zambia. One of the poorest countries in Africa, Zambia represents an economy that is ideally suited to the 123PRSP model. Its economy is chronically dependent on mineral exports (minaly copper) whose prices fluctuate wildly. At the same time, with elections looming in late 2001, there was some concern that the

government might increase public spending. Both copper price shocks and increased public expenditure will have growth and distributional effects on the economy—precisely those effects the 123PRSP is designed to capture. Table 13.4 represents the starting point for the analysis—the consensus forecast of the medium-term macroeconomic framework for Zambia.

Table 13.4: Consensus Forecast: Medium-term Macroeconomic Framework, Zambia[4]
(IMF Financial Programming/Bank RSMS-X; in percent change, unless otherwise specified)

	1999	2000	2001	2002	2003
Real GDP	2.4	3.6	5.0	5.0	5.5
Inflation – end year CPI	20.6	30.1	17.5	12.0	10.0
Inflation – average annual CPI	26.8	26.1	22.5	13.7	10.8
GDP deflator	21.7	27.9	24.9	17.2	13.2
Investment (percent of GDP)					
Term of trade	- 5.7	1.9	3.1	3.5	2.4
Copper price (US$/lb)	0.70	0.83	0.87	0.91	0.92
End-period Exchange rate (kwacha/US$)	2630	4160			
Average Exchange rate (kwacha/US11$)	2380	3110			
Current account balance (percent of GDP)	-15.2	-18.5	-19.9	-21.1	-19.3
Broad money	29.2	67.5	17.1		
Net foreign assets	-14.7	63.9	16.3		
Net domestic assets	43.9	1.6	0.8		
Net claims on government	10.2	12.4	-4.2		
Claims on public enterprises	12.0	3.6	-4.4		
Revenue and grants (percent of GDP)	25.5	25.4	26.7	23.5	23.4
Revenue (percent of GDP)	17.6	19.6	17.3	17.7	18.1
Expenditure (percent of GDP)	29.2	31.2	31.3	29.7	28.2
Overall balance (cash basis – percent of GDP)	-4.0	-7.1	-5.0	-6.6	-5.2
O. balance w/o grants(cash basis–percent of GDP)	-11.9	-12.9	-14.5	-12.4	-10.5
Domestic balance (cash basis- percent of GDP)	0.4	-3.4	-3.3	-2.2	-1.2

The two main risks factors to the consensus forecast in the short and medium-term are: weakening of copper price because of a possible slowdown in world demand; and expenditure pressures from the presidential election in late 2001.

a) Deviations to the Medium-term Projections

The short-run growth elasticities of the two key risk factors, expenditure pressures and copper price shock, are given Table 13.2.

[4] The figures and ratios to GDP may differ from PRGF/FSC numbers for a number of reasons – the assumptions of the consensus forecast are run through to the 123PRSP model to derive the reference run numbers; the tax rates are smoothed out if the implied taxes from the revenue to GDP ratios suggest wide variations in the tax rates.

Shocks in public expenditure: The growth elasticities indicate that increases in government consumption do not have much short-term beneficial impact on growth—the slight positive effect in the first year is offset by the second year.

Shocks in copper prices: Changes in Zambia's GDP can be tracked almost completely by changes in world price of copper (except for a brief period between 1970-74). The response of GDP to changes in copper prices persists for 2 to 3 years, but the response has been tighter since the balance-of-payments situation deteriorated in the late eighties.

The results of two simulations are shown in Table 13.5.

The first simulation is *the expenditure shock*. Using the consensus forecast as a reference run, election pressures raise expenditure (government consumption) by 15 percent in the first year and 10 percent in the next year. The findings confirm the arguments about expenditure policy in Zambia—the benefits are few but the risks of fiscal deficit and the crowding of investment are high. In the next and last section, we return to the issues about the links between public expenditure, growth and poverty.

In the second simulation, *a terms-of-trade shock* is added to the above: Over the first simulation, copper price also deviates from the medium term framework by –20 percent in the first year; -15 percent in the second year and –10 percent in the third year. For comparison, the average volatility of the spot price of copper is about 23 percent; during the period 1997-99, copper price fell by more than 45 percent from peak to trough. The adverse effects of such a copper price shock will be devastating in Zambia. GDP growth will fall by –0.5 percentage point immediately, -1.4 percentage point in the second year, and a further –1.3 percentage point in the third year. Triggered by the need for the economy to adjust to this sharp drop in terms of trade, the depreciation of the real exchange rate or relative price of foreign goods will be high, particularly for imports. As a consequence, household welfare generally declines. Relative to the reference run, household incomes in general will fall by 2 percent immediately, accumulating to about 6 percent in the third year. The impact on each income decile is shown in Table 13.5. The results generally confirm that such a terms-of trade shock will be hard on all household groups, particularly the poorest. They also show how a "macro shock", even though it is accommodated by a real exchange rate depreciation, can have severe distributional consequences.

Table 13. 5: Impact of Shocks in Government Expenditures and Copper price
(Percent Deviation from the Reference Run; unless otherwise stated)

	2001	2002	2003
Real GDP (percentage point +/-)			
Expenditure shock	0.6	-0.1	0.1
Expenditure + TOT shock	-0.5	-1.4	-1.3
Overall fiscal balance (cash basis–% of GDP)			
Reference run	-5.0	-6.6	-5.2
Expenditure shock	-6.0	-7.8	-6.3
Expenditure + TOT shock	-7.3	-9.8	-8.6
Real exchange rate of imports (depreciation >0)			
Expenditure shock	0.0	0.0	0.0
Expenditure + TOT shock	21.8	35.9	35.8
Real exchange rate of exports (depreciation>0)			
Expenditure shock	0.0	0.0	0.0
Expenditure + TOT shock	7.9	12.7	13.6
Imports (real)			
Expenditure shock	0.5	0.4	0.6
Expenditure + TOT shock	-12.8	-20.1	-21.2
Exports (real)			
Expenditure shock	0.6	0.4	0.6
Expenditure + TOT shock	2.7	3.2	2.2
Investment (real)			
Expenditure shock	-4.3	-4.9	-4.5
Expenditure + TOT shock	-14.6	-25.3	-25.1
Consumption (real)			
Expenditure shock	0.6	0.4	0.6
Expenditure + TOT shock	-7.6	-11.6	-13.0
Household income in real terms			
Expenditure shock			
Decile 1 (poorest)	0.5	0.4	0.6
Decile 2	0.6	0.6	0.7
Decile 3	0.6	0.6	0.7
Decile 4	0.6	0.5	0.7
Decile 5	0.6	0.5	0.7
Decile 6	0.6	0.5	0.7
Decile 7	0.6	0.5	0.7
Decile 8	0.6	0.5	0.7
Decile 9	0.6	0.5	0.7
Decile 10	0.6	0.5	0.7
Total	0.6	0.5	0.7

Expenditure + TOT shock			
Decile 1 (poorest)	-4.6	-8.0	-9.8
Decile 2	-4.2	-7.4	-9.2
Decile 3	-4.0	-7.0	-8.8
Decile 4	-3.6	-6.4	-8.2
Decile 5	-3.4	-6.1	-7.8
Decile 6	-2.6	-5.0	-6.6
Decile 7	-2.4	-4.7	-6.3
Decile 8	-2.7	-5.1	-6.7
Decile 9	-2.5	-4.8	-6.4
Decile 10	-1.7	-3.7	-5.3
Total	-2.1	-4.4	-5.8

13.4. Concluding Remarks

The PRSP process emphasizes country ownership, consultation and a poverty-focus of all policies. In particular, a poverty-focus of macroeconomic policies calls for a new framework that can capture some of the tradeoffs and distributional implications of traditional macroeconomic policies and shocks. The framework presented here, the 123PRSP model, attempts to portray some of these effects. In an application to Zambia, the model showed that a terms of trade shock (a fall in the price of copper) could have adverse distributional consequences, harming the poor more than the rich, even if the shock were fully accommodated by macroeconomic policies. This outcome was due to differences in the sectoral composition of income sources in Zambia between the poor and the rich. Similarly, the model showed that, in the case of Zambia at least, greater fiscal flexibility may not be so desirable. The first-round Keynesian multiplier effects of an increase in government spending (financed domestically) are offset by the crowding-out effects of higher fiscal deficits in the near term. That this model could be put together in a relatively short time, in a country with limited data, and that policy-relevant results could be generated and used by policymakers in their PRSP, is evidence that the first objective of the PRSP, country ownership, could also be reinforced with the present exercise. In addition, the model fulfills many of the criteria for a macroeconomic framework for PRSPs: it is capable of identifying some of the salient tradeoffs; it is based on solid economic foundations; it can be estimated with data from low-income countries; and—perhaps more important—it is simple enough that model results are easy to interpret. Alternative frameworks will have to ensure they do not sacrifice these desirable characteristics.

13.5 References

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