Macmod, a macroeconomic model for the Tanzanian economy

Hildegunn Kyvik Nordås
with Arild Angelsen

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Summary

This report outlines the structure of a macroeconomic model for the Tanzanian economy. It consists of a core IS-LM/ Mundell-Fleming model, an SS-DD framework for estimating the consumer price inflation and other price indices, and finally a sectoral supply block. The latter is at an early stage of development, due to inadequate data. The report starts with a discussion of some key features of the Tanzanian economy, emphasizing structural weaknesses and recent gains in terms of stabilizing the economy. It continues with the presentation of the model. The workings of the model are demonstrated by a set of scenarios where various policy measures in the face of an exogenous shock are explored. Finally the report presents a study of the agricultural sector.

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Table of content

1	Introduction	1
2	The Economy	2
3	The modeling framework	5
4	The equations of the core model	17
5	Aggregate supply and demand	22
6	The sectoral supply block	25
7	Creating scenarios and forecasts	28
8	Agricultural sector modeling in Macmod: What determines agricultural output in Tanzania? By Arild Angelsen	40
Annex 1	Variables, core model, SS-DD block and sector block	54
Annex 2	Solving the IS-LM-BP model	57
Annex 3	Estimating the capital stock	58
Annex 4	Specification of parameters	60
Annex 5	Annexes to chapter 8	64
	Bibliography and references	68

1 Introduction

Macmod was first introduced in 1992/93 as an analysis tool for the development of the economic frame for the Rolling Plan and Forward Budget (RPFB). The model is therefore specially designed for analyzing the impact of fiscal and monetary policy on the economy. This document presents the third version of Macmod, but we start with a brief description of the two previous versions.

The first version focused on the supply side and was mainly an accounting framework without any behavioral equations. The development of the first version involved computerization of some of the sectors in the National Accounts and, thus, computing value added from data on quantities, prices and intermediate inputs. The model had 9 sectors corresponding to the sector composition of the National Accounts. Agriculture and manufacturing was further disaggregated into subsectors. Indirect taxes were added to GDP at factor cost estimated from the supply side. The resulting GDP at market prices was then distributed on expenditure categories. International trade was determined by applying fixed shares of GDP for intermediate imports, a fixed share of investment for investment goods and a fixed share of consumption for consumer goods. Traditional exports were estimated as fixed shares of output of the traditional export crops and mining, while the "non-traditional" exports were assumed to grow in line with world demand. Private consumption was the residual which balanced supply and demand (private consumption was also estimated residually in the National Accounts, in spite of the fact that it constituted close to 100 percent of GDP on average). Government revenue was estimated from effective tax rates and the tax base; GDP for income taxes, other taxes and non-tax revenue, sectoral output for local indirect taxes and imports for import taxes.

The second version put a stronger emphasis on the demand side. It was built on the Keynesian IS-LM/SS-DD framework. The core structure was an IS-LM model for an open economy with fixed exchange rates. The SS equation represented a marginal cost function and supply and demand were balanced by applying a mark-up rate on marginal costs.

The present, third version extends the second version by adding a balance of payment equation and thus endogenizing the exchange rate. This extension was motivated by the need to adopt the model to the new economic policy environment following recent liberalization measures. Of particular significance is liberalization of internal and external trade, a floating exchange rate regime, liberalization on the current account of the balance of payment and even some steps towards liberalization on the capital account of the balance of payments. These features are captured by extending the IS-LM model with a Mundell-Fleming type balance of payments (BP) framework.

The present version of Macmod contains a core model, the IS-LM-BP framework, which is a fixed price model of flexible exchange rates and an intermediate degree of capital mobility. In addition, the model contains an SS-DD block which determines the inflation rate and other price indices. The SS-DD block thus provides a framework for analyzing stabilization policies. Finally, the model contains a supply side block where real GDP at factor cost is determined by the sum of sectoral output. This block is provided in order to incorporate the most important structural features of the economy. Moreover, it is possible to undertake broad industrial policy analysis within this framework. However, data on interlinkages among sectors are not yet available, a fact that limits the scope for industrial policy analysis and also the possibility to analyze how changes in demand affect each sector.

This third version of Macmod incorporates new information from the revised National Accounts and the 1991/92 household budget survey. In order to improve user friendliness, the model has been extended to include a base-line scenario and an alternative scenario such that a benchmark can be maintained and the impact of shocks or changes in policy can be evaluated against this benchmark.

Macmod is developed in Excel spreadsheets. This, together with the modeling framework impose some constraints on the model. First, we are confined to linear equations. Second, the core model must be entered into the spreadsheets in a reduced form because Excel can not solve simultaneous equations directly. However, the widespread use of Excel and the ease at which it can be incorporated into the planning system by far outweighs these limitations. Besides, there is for the time being nothing in the data suggesting that non-linear equations are better at capturing economic development than linear equations, particularly when we are dealing with a relatively short time horizon. The limitations of the software have therefore not been a binding constraint so far.

The rest of this paper is organized as follows: Chapter 2 provides a brief overview of macro-economic developments over the past decade. Chapter 3 presents the modeling framework. It starts by discussing the choice of theoretical framework on which Macmod is built. The discussion concludes that the Keynesian IS-LM framework is the most appropriate. The discussion is followed by a presentation of the basic structure of the model. Chapters 4-6 present the equations of the core model, the SS-DD extension and the supply side block respectively. Chapter 7 gives an example of how Macmod can be used for policy analysis. It presents the graphs and tables of a base line "business as usual" scenario compared to a severe drought scenario. Finally, the manual contains technical annexes.

2 The economy

The economy is dominated by agriculture and the level of income per capita is among the lowest in the world. Moreover, GDP per capita has been rather stagnant over the past decade. Figure 2.1 shows development in GDP at constant 1992 prices and its sectoral composition over the past decade. Clearly, little structural change has taken place during this decade, and agriculture has actually increased its share of total GDP.

Figure 2.1

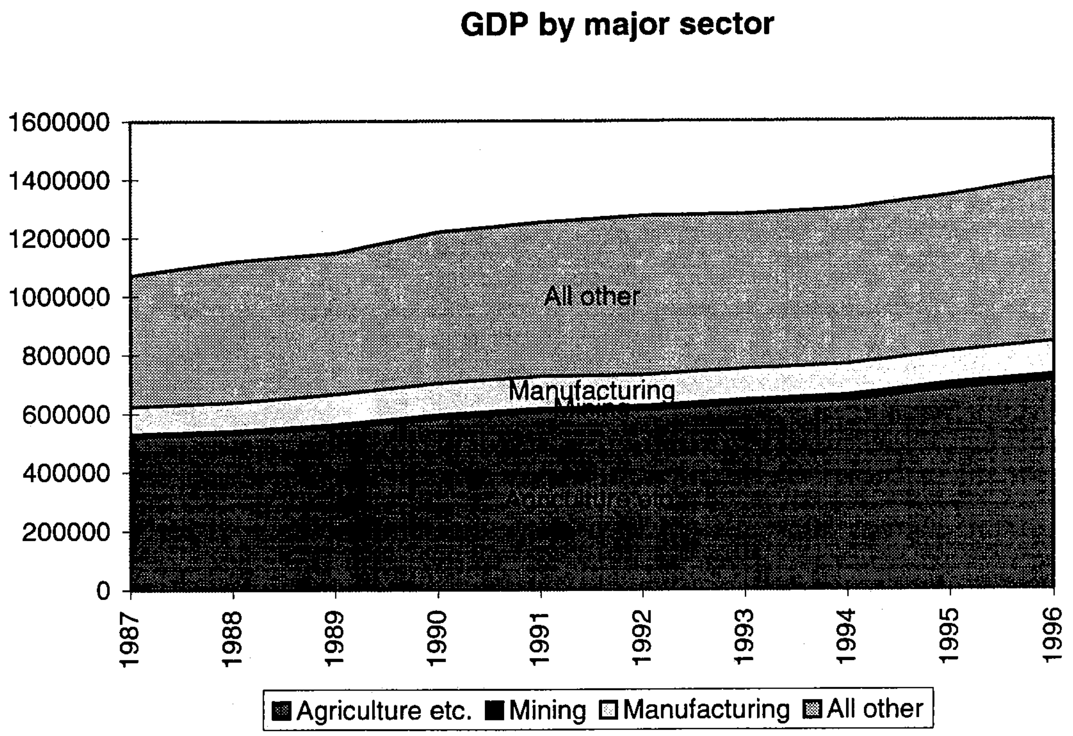


Figure 2.2

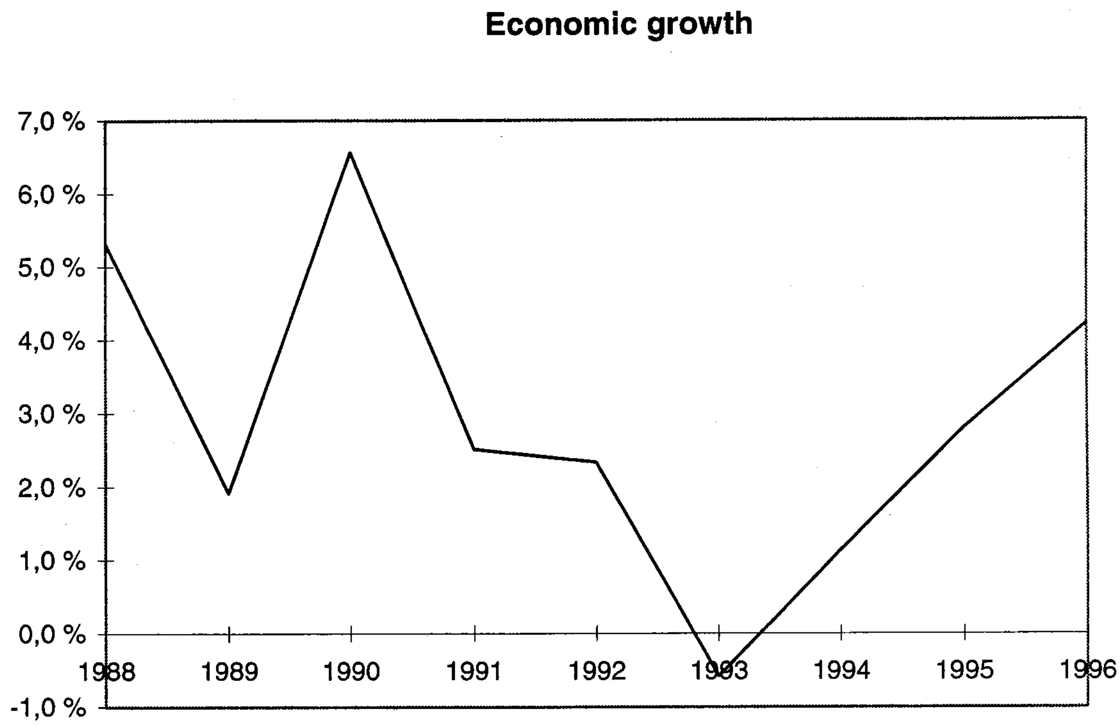


Figure 2.2 shows real GDP growth. It fluctuates widely due to the dominant position of rainfed agriculture. Thus, output can be seen more as fluctuating around a fairly flat trend, where fluctuations are induced by weather conditions, than as being on a

sustained growth path. This is particularly the case if we look at GDP per capita. There has been some discussion as to which the level of GDP per capita is underestimated in Tanzania. GDP estimates were recently revised for the period 1985-1996, where the new estimates were between 60 and 100 percent above previous estimates (Planning Commission 1996). However, although the income level has been revised, growth rates were not found to be on a rising trend as figure 2.2 suggests.

Figure 2.3

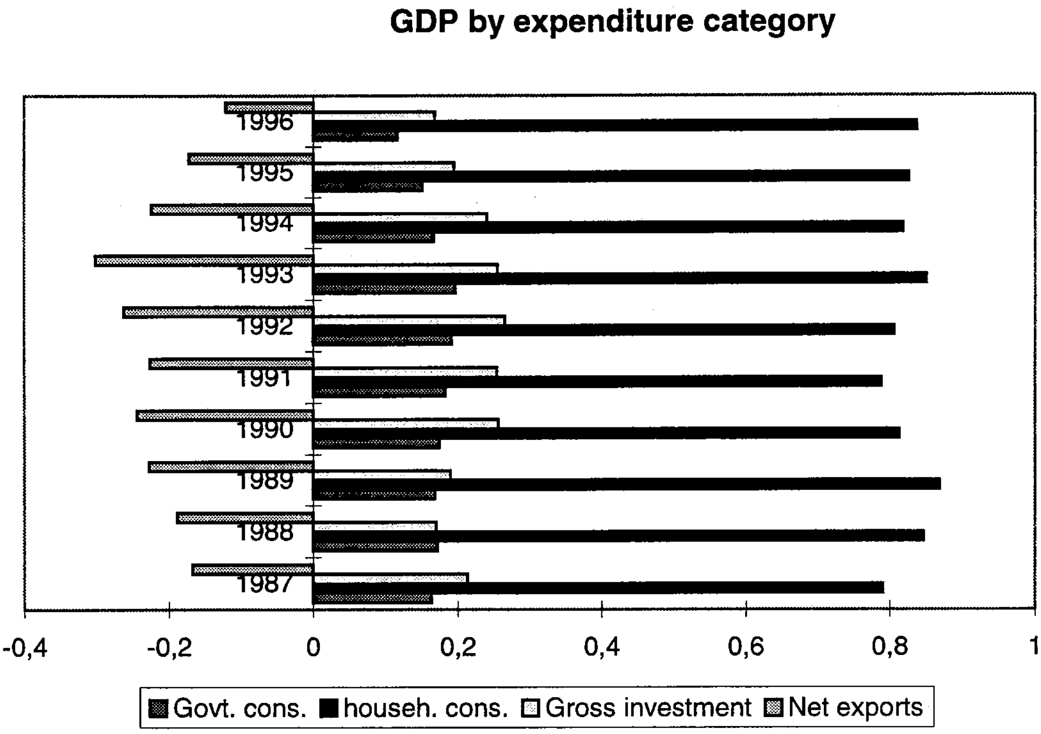
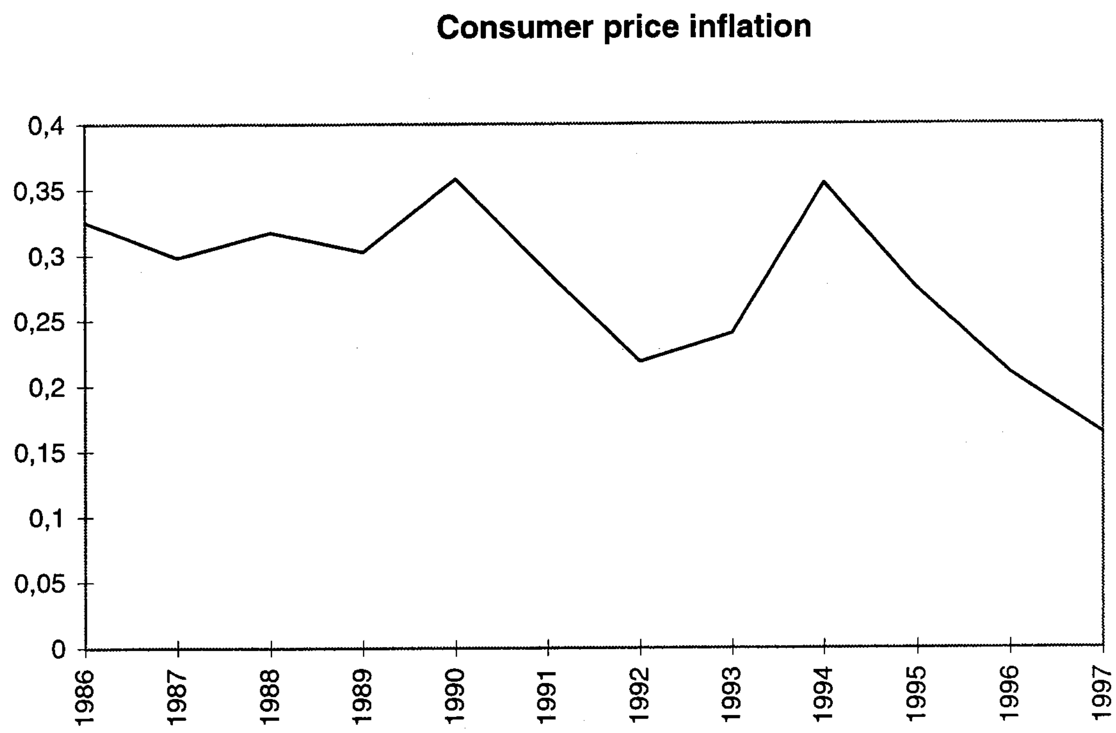


Figure 2.3 illustrates some of the structural problems of the Tanzanian economy. Private consumption is about 80 percent of GDP, and if government consumption is added to that, close to a 100 percent of GDP at market prices is spent on consumption. Thus, investment is almost entirely financed from abroad. This is reflected in a substantial deficit on the current account of the balance of payments, and even more so on the trade balance, shown in figure 2.3. Net exports of goods and services was negative to the tune of 30 percent of GDP in 1993, but have since declined to about 12 percent of GDP in 1996. This is a substantial improvement in the external balance during a relatively short period of time, and it has taken place in spite of real appreciation of the exchange rate, as is further discussed in annex 4. However, the improvement has taken place during a period of economic reforms which have improved incentives and opened some bottlenecks (see Mans 1994 for a discussion).

Curbing inflation is another area where substantial gains have been achieved during the last 5 years. As figure 2.4 shows, the rate of inflation has declined from above 30 percent in 1994 to close to 15 percent in early 1998.

Figure 2.4



From this brief presentation of the key macro-economic indicators, it is clear that there has been significant gains as far as stabilization is concerned, but the economy is not yet on a sustained growth path. Therefore, we will argue in the next chapter, it is not unreasonable to build a model which is largely demand-driven.

3 The modeling framework

3.1 The choice of theoretical framework

In spite of recent developments in macroeconomic theory comprising i) sophisticated models of economic growth, ii) models analyzing the interrelationship between the financial and the real economy and iii) models analyzing the channels through which economic reforms affect the economy, the Keynesian IS-LM framework is still the most commonly adopted framework for analyzing fiscal and monetary policy.

The Keynesian IS-LM framework is concerned with business cycle fluctuations and how fiscal and monetary policy can be used to smooth such fluctuations. The framework was developed following the world-wide depression during the 1930s and gained further ground during the stagflation period of the 1970s.[1] Thus, the framework was developed in order to analyze how the government's fiscal and monetary policy can be designed such that the economy avoids deep recessions.

[1] Stagflation is a combination of high inflation and slow growth.

In developing countries fluctuations in income and production are usually not seen as a business cycle phenomenon. Nevertheless, fluctuations in developing countries have much of the same characteristics as business cycles: They are often caused by fluctuations in commodity prices, which are indeed a business cycle phenomenon. Another cause of fluctuations, particularly in economies dominated by the agricultural sector, is weather conditions. Changes in weather conditions are often cyclical, and are therefore quite easily incorporated into a business cycle-type model.

An alternative to the Keynesian framework is the neoclassical framework. In the "purist" neoclassical model it is assumed that all markets clear at any point in time. However, there is a large body of research incorporating distortions and market imperfections into the neoclassical model in order to adopt it to developing country conditions. An applied research area in this field is the development of computable general equilibrium models (CGE). These models compute aggregate output, sector allocation of resources and income distribution. They usually apply a social accounting matrix for parameter estimations through a method of calibration (see for example Bergman et. al. (1990)).

In developing countries, the structuralist school has had great influence. The idea here is that every economy is unique, and consequently models need to take the unique features of the economy in question into consideration. Thus, models are tailor-made for the particular economy they are used in, based on empirical research identifying bottlenecks and constraints which block or narrow the channels through which fiscal, monetary, trade, and industrial policy are supposed to work. Structuralist models nevertheless are often based on a core of the IS-LM framework. Hence, they extend the IS-LM model with supply side equations in which the constraints are incorporated. The result is a framework where what is demanded is not necessarily supplied, even if high prices could be charged for the goods and services produced (for an early contribution, see Taylor (1981)).[2]

When deciding on theoretical framework and the model structure, we need to take into consideration that the Tanzanian economy is relatively open to international trade, and trade constitutes a large share of GDP. In addition, international transactions related to debt servicing and development assistance are large compared to the size of the economy. Therefore, the Tanzanian economy is influenced by the global economy to a significant extent and Macmod should consequently be a model for an open economy. In addition the following considerations were taken when the choice of a theoretical framework for Macmod was made:

1. The time horizon of the projections is 3-4 years.
2. The purpose of the model is to analyze fiscal and monetary policy in relation to the preparation of the RPFB.
3. The economy is dominated by agriculture.
4. Lack of infrastructure, both physical and economical, results in under-utilization of productive resources and inhibits economic agents from responding fully to market signals.

---

[2] Recall that the IS-LM model is demand-driven and assumes that whatever is demanded is supplied, and the supply side does not play a role in the model.

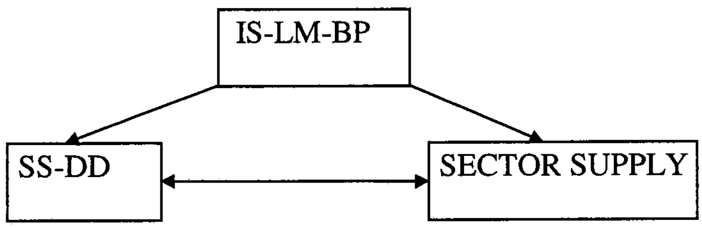
5. The financial markets are thin.
6. Only a 10 year data series of the National Accounts exists. No input-output table has been prepared since 1978 (although an input-output table is now under construction) and no social accounting matrix has ever been prepared for the economy.

Points 1, 4 and 6 rule out a CGE model. Points 1-5 point in the direction of a structuralist model. However, point 6 limits the scope for a structuralist approach and suggests that the model should be simple and built on sound economic principles rather than attempting to capture the unique features of the Tanzanian economy. On the background of these considerations, the IS-LM-BP framework has been chosen as the framework for the core model. The balance of payments part is based on the Mundell-Fleming model. Nevertheless, an attempt is made to capture points 1-5 by extending Macmod by a supply-side submodel. Here the realism of the assumption that whatever is demanded is being supplied can be explored.

3.2 Model structure

Macmod contains 3 blocks which are interlinked as follows:

Figure 3.1



The IS-LM-BP framework constitutes the core model. It is solved at constant 1992 prices for the three key macroeconomic variables: **Real income (GDP), the real interest rate, and the real exchange rate.** Aggregate demand (GDP=DD) is then linked into the SS-DD block where it is combined with aggregate supply (SS) in order to find the **rate of inflation** compatible with the equilibrium condition that supply equals demand. Aggregate demand and its components are finally linked into the sector supply block. Here it is assumed that some sectors are "followers," and output is mainly determined by demand. All the service sectors and construction belong to this category. Structural constraints and exogenous shocks are assumed to affect goods producing sectors and electricity and water the most. Electricity and water shortages in turn affect output in manufacturing. For these sectors structural features such as rainfall, world market prices and industrial policy measures are incorporated into the supply function.

Note that the linkages between the blocks run one way; from the core model to the other two blocks. This reflects the physical linkages found in the computerized model. However, if comparison of the sectoral supply model and the core model reveals that there is a significant excess supply or excess demand in the economy, this calls for rethinking the scenario for the exogenous variables in the core model. The linkage from the sector model back to the core model thus goes through the judgment of the user of the model.

3.3 The core model

The IS-LM-BP model consists of three markets:

1. The market for goods and services
2. The money market
3. The market for foreign exchange

Solving the model is defined as the process of finding the combination of real GDP (representing the value of goods and services produced in the economy), the real interest rate and the real exchange rate which ensure balance in all three markets at the same time.

A market is defined as a meeting-place where people, or agents, engage in economic transactions. Macmod classifies these agents into four categories:

1. Households
2. Government
3. The financial sector
4. The rest of the world.

These agents engage in trade and transfer financial resources among themselves on all three markets listed above. The government, for example, collects taxes from households, it borrows from the financial sector and from the rest of the world and pays interest and principal on these loans.

The IS-LM-BP framework does not make the flow of funds between economic agents explicitly. Therefore, and in order to be sure that there are no loose ends in the model, a flow of funds accounting framework is incorporated into the model. This framework does not have any bearings on the solution to the model, but is put there as a consistency check. It shows that demand from each agent adds up to total demand and that sources of funds equal uses of funds (including savings) for each agent. Finally it shows the changes in stocks owned by each agent as a result of the flow of funds. The flow of funds consistency framework is similar to the one applied in the World Bank's RSM-X model.

Households are assumed to own the productive resources of the economy. Thus, households own the stock of physical capital and land in the economy. They also supply the labor which is needed to produce final output.

It is, however, the case that the government owns both land and capital and participates in the production of goods and services through its parastatals. In the model the government's productive activities are treated in the same way as private productive activities. Hence, the parastatals are classified under the private sector (e.g. households). This accords well with accounting practices in the country. Thus, the parastatals' income is not recorded as government revenue, and parastatals pay taxes in the same way as private enterprises. Flow of funds between the four agents is shown in table 3.1.

Table 3.1 Flow of funds

	Households	Government	Financial sector	Rest of world	Production Account	Total sources
Households		Transfers	Interest on deposits	Exports of factor services, transfers	GDPfc	
Government	Income taxes and other taxes		Interest on deposits	Transfers	Indirect taxes less subsidies	
Financial sector	Interest on loans	Interest on loans		Interest on foreign assets		
Rest of the world	Interest on loans, Tanzanian import of factor services	Interest on loans	Interest on loans		Imports less exports (to/from Tanzania)	
Consumption and savings	Government consumption government savings	private consumption private savings	Change in net worth	foreign savings		
Total uses						

The rows show each agent's sources of funds while the columns show each agent's uses of funds. For example the first column shows that households spend their income on consumer goods and services, they pay taxes to the government and interest on loans from the financial sector. Finally they save. The first row shows that GDP in the first instance accrues on households as earnings on the labor they supply and as return on their capital and land assets. Other sources of income are transfers from government and abroad, payment for factor services sold abroad, and interest on deposits in banks.

Changes in stocks are shown in table 3.2 below. Again rows represent sources of funds while columns show uses of funds. All entries are *changes* in stocks.

Table 3.2 Changes in stocks

	Households	Government	Banks	Rest of world	Savings account	Total sources
Households		Capital transfers	borrowing	borrowing	private savings	
Government	Borrowing (bonds and bills)		borrowing	borrowing	government savings	
Banks	Deposits	Deposits		borrowing, reserves		
Rest of the world	amortization	amortization	amortization		foreign savings	
Investment account	Private investment	Government investment				
Total uses						

In the absence of capital controls financial assets are usually much more internationally mobile than goods and services. Thus, capital flows respond to market signals such as differences in interest rates and productivity levels much more quickly and vigorously than trade flows. Moreover, even if strict capital controls are in place, they are increasingly difficult to enforce due to improvements in communication technology and lower transaction costs.

Tanzania does regulate international capital flows on the capital account of the balance of payment. However, capital controls are not synonymous with prohibition of capital flows. Moreover it is an objective to gradually liberalize capital flows, particularly those related to foreign direct investment. On this background the core model assumes an intermediate degree of capital mobility. However, the parameter which represents the degree of capital mobility may be re-estimated as further liberalization takes place.

These assumptions, reflecting the policy stance in the country, have crucial bearings on the way the economy responds to changes in the exogenous variables, or the policy variables. The implications are the following:

1. Monetary authorities control money supply. Monetary policy is therefore a powerful tool in controlling aggregate demand.[3] The transmission mechanism is as follows: An increase in the money supply leads to a decline in the rate of interest, an increase in investment and consequently an increase in aggregate demand.
2. The IS-curve moves endogenously as a response to movements in the exchange rate. Fiscal policy through expenditure is therefore a less effective tool in controlling aggregate demand, although it does affect the composition of demand.
3. The BP curve moves endogenously as a response to changes in government expenditure. Again the effect is to make fiscal policy less effective in controlling aggregate demand, but more effective in influencing the composition of demand.

[3] This as opposed to the case of fixed exchange rates where the money supply required to maintain the exchange rate fixed would take precedence over all other considerations.

Figure 3.2

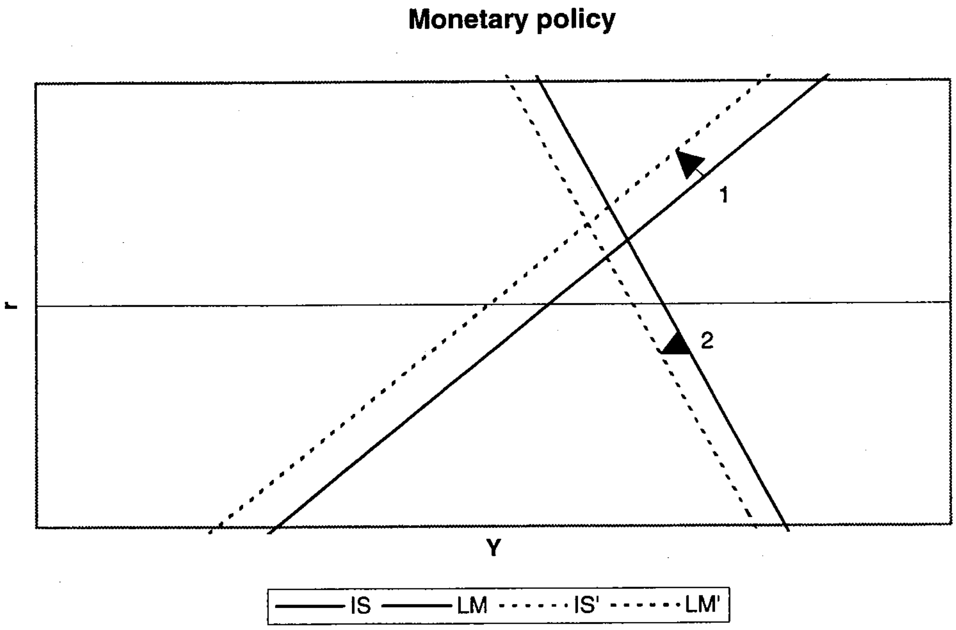


Figure 3.2 illustrates the impact of a contractive monetary policy on the economy. A reduction in the money supply shifts the LM curve to the left (arrow 1). In the first instance this leads to a higher interest rate. This is, however, not compatible with equilibrium in the market for foreign exchange, and the shilling appreciates in real terms. During this adjustment, we are on the excess supply side of the IS curve (the goods and services market), and the IS curve will endogenously shift to the left as a response to the appreciation of the exchange rate (arrow 2). How far it shifts depends on the degree of capital mobility. The new equilibrium is on the BP curve (omitted for convenience of presentation) to the left of the initial equilibrium. A tightening of monetary policy has consequently lead to a lower level of aggregate demand.

Figure 3.3

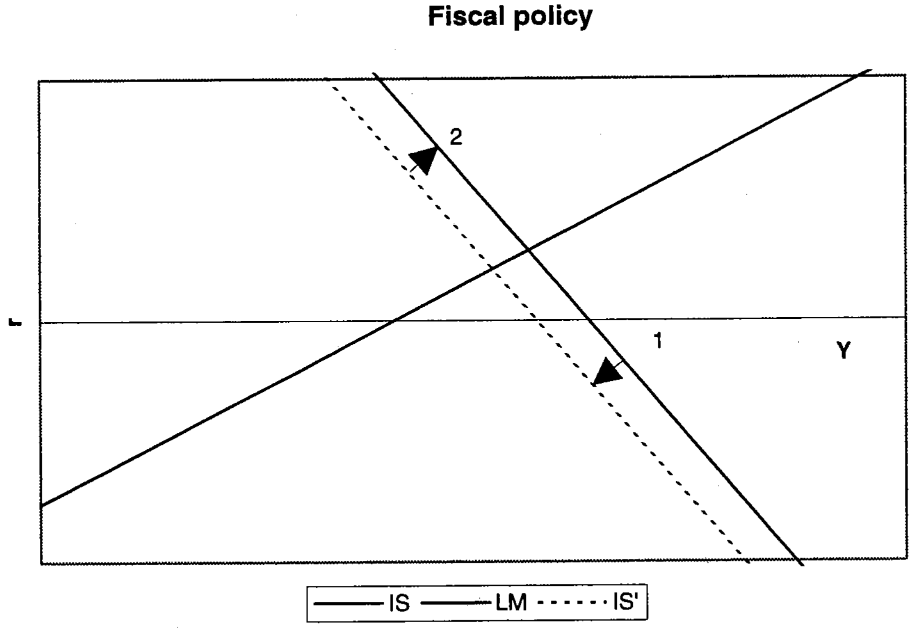


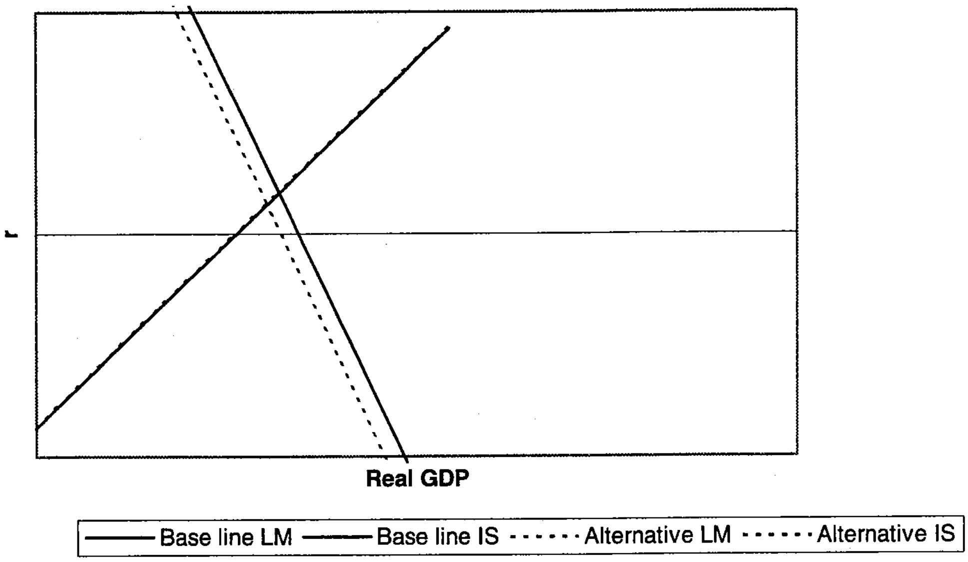
Figure 3.3 illustrates the impact of tightening fiscal policy from the expenditure side. The IS-curve will first move to the left as a result of reduced government expenditure (arrow 1). Since some government expenditure is spent on imports, the BP curve (omitted) will also move to the left, but the shift is much smaller than for the IS curve. This first step in the adjustment process leads to a situation with lower interest rates which are incompatible with balance in the market for foreign exchange, causing an outflow of capital and a depreciation of the exchange rate. As a result, both the IS and the BP-curves will start moving back to their initial position (arrow 2). Depending on the real exchange rate elasticity of the two curves, and the degree of capital mobility. Both may move all the way back to the initial position or somewhere between the initial and the first round adjustment position. Thus, fiscal policy will have little effect on aggregate demand. However, in the extreme case presented in figure 3.3, demand is shifted, shilling for shilling, from government expenditure to reduced net imports. Hence, in the open economy with flexible exchange rates government expenditure is more likely to crowd out net exports than local investment.

The adjustment process just described takes place in a world of fixed prices. An alternative adjustment process is, however, one of stagflation. That happens when excess supply of money instead of leading to lower interest rates and an outflow of capital, leads to increases in prices such that the real money supply declines and the LM curve shifts to the left. The end result in that case will be lower aggregate demand and higher prices. This does, however only happen when the exchange rate is floating and there is strict control of the capital account on the balance of payment, which is an unlikely policy combination.

Tightening fiscal policy from the revenue side is more powerful in affecting aggregate demand than government expenditure as illustrated in figure 3.4. It shows an increase in the effective tax rate on income.

Figure 3.4

The impact of increased income taxes



Increased taxes will reduce disposable household income, and thereby reduce private consumption and also aggregate demand if it is not followed by an offsetting expansion in expenditure. Since the tax rate affects the fiscal multiplier, the slope of the IS curve becomes steeper as a result of an increase in taxes. This also implies that the higher the tax level, the steeper the IS curve and by implication the less effective is monetary policy in affecting demand.

Before closing this section, it is useful to look at how monetary and fiscal policy have influenced aggregate demand in the past. To get a very rough idea, we have computed the correlation coefficients between the various components of total expenditure and money supply and government final consumption respectively for the period 1987-1996. The results are presented in table 3.3.

Table 3.3 Correlation between money supply and GDP and its expenditure categories.

	M2
GDPmp	0.92
Private consumption	0.93
Investment	-0.1

As can be seen from this table, the correlation coefficients between money supply and GDP and consumption are exceptionally high.[4] The correlation between money

[4] For comparison, the correlation between GDP and M2 and between private consumption and M2 are found to be negligible in South Africa, while the correlation between the same expenditure categories and narrow money (M0) was found to be about 0.8 (Sharp 1997).

supply and investment is, however, negligible and, if anything, slightly negative. This suggests that the transmission mechanism for monetary policy in the past has not been the Keynesian transmission via interest rates and investment. It appears that money supply has rather had a direct effect on private consumption and GDP through net wealth effects. This is probably because a large share of the money demand has been for working capital in parastatals and cooperatives and for credit to government, which in turn has increased the purchasing power in the economy. In future, however, the Keynesian transmission mechanism should be expected to be more prominent as capital markets are deregulated, and government monetize the budget deficit to a much lesser extent.

Turning to the correlation between government final consumption and other expenditure categories, the correlation coefficients are presented in table 3.4. The first column shows the correlation of government expenditure and other expenditure categories in the same year, the second column shows the correlation between government consumption and other expenditure categories with one year lag.

Table 3.4 Correlation between government final consumption and other expenditure categories

	Government consumption	Govt. cons -1
Private consumption	-0.48	-0.46
GDPmp	-0.46	-0.45
Investment	0.58	0.45

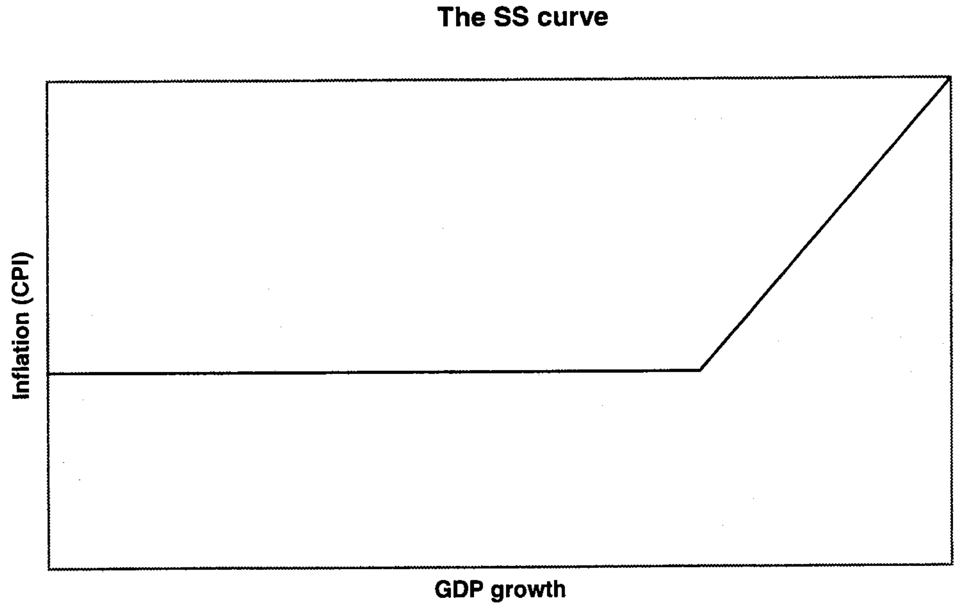
Although correlations say nothing about causation, it appears from these correlation coefficients that fiscal policy has the opposite effect as what the Keynesian framework predicts; government consumption appears to crowd out private consumption and crowd in investment. It is difficult to explain these correlations, but they do justify the feature that fiscal policy has little effect on aggregate demand in Macmod.

3.4 The SS-DD block

This sub-model balances total supply and demand. As opposed to the core model, it is written in log-linear form. In an open economy, there are two sources of consumer price inflation, i) local inflation and ii) imported inflation. The latter has a direct and an indirect impact on consumer prices. The direct impact is obviously changes in the price of imported consumer goods. The indirect impact works through increased costs of locally produced goods due to increased costs of intermediate imports.

There are three major factors driving the market price for locally produced goods. The first is the marginal cost of production. A constant returns to scale production technology is assumed such that marginal costs are constant for given input prices. The second source of inflation is excess demand. Thus, inflation grows faster than the increase in marginal costs if aggregate demand grows faster than capacity output. It is, however, assumed that prices are flexible upwards, but less so downwards. Consequently, excess demand has an inflationary effect, while excess supply does not have a deflationary effect.[5] The third factor which determines the CPI is changes in indirect taxes. The SS curve is illustrated in figure 3.5.

Figure 3.5



If the growth rate of aggregate demand (determined in the core model) in a particular year is lower than the growth rate of capacity output, the solution is on the horizontal part of the SS-curve. If aggregate demand grows faster than capacity output on the other hand, the solution is on the upward sloping part of the SS-curve.

3.5 The sector supply block

The sector supply block is at this stage a rough estimation of sectoral output. It entails the 9 sectors represented in the National Accounts. The most important sector, agriculture, is further subdivided into three subsectors; cash crops, food crops and other agriculture.

Sectoral output is not estimated from sectoral production functions as would have been the case in a CGE model. Instead the idea is to capture some of the structural features which may jeopardize the assumption that whatever is demanded is supplied, and that prices play the role of balancing supply and demand as demonstrated by the SS-DD framework. The sectoral supply block is thus added to the model in order to assess the realism of the results from the demand-driven model, and serves as another consistency check.

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[5] Capacity utilization in Tanzania is generally believed to be low. It therefore takes substantial growth over several years to reach the capacity limit. Nevertheless, there may be adjustment costs related to increasing the rate of capacity utilization, for example costs of hiring new workers and start-up costs for previously idle machinery. Thus, it is assumed that if actual output *grows* faster than capacity output, it has an inflationary effect.

Disruptions on the supply side is first and foremost a problem in agriculture, which is mainly rainfed and therefore vulnerable to weather conditions. On the basis of the study reported in annex 5, the impact of weather conditions on agricultural output is estimated and incorporated into the supply function for each subsector.

Manufacturing and mining are at this stage represented by a trend factor. In addition manufacturing is adversely affected by power and water shortages. More research is needed for a better understanding of supply from these two sectors. This is particularly the case for mining, which is potentially the most important exporting sector of the economy, and which is believed to be largely under-reported in the National Accounts and balance of payment statistics.

Supply of the non-traded sectors (construction and all the service sectors) is determined by demand.

A key factor to watch in the sector supply block is the discrepancy between aggregate supply from the sectors and aggregate supply derived by the SS-curve and in the core model (and its intersection with the DD curve). This discrepancy is presented in the model as the adjustment factor needed in order to bring total sectoral supply in line with aggregate supply from the core model solution. If this factor is significantly different from unity, the assumptions made on the exogenous variables in the core model should be reconsidered.

3.6 Concluding remarks

This chapter has clearly demonstrated that a macroeconomic model is a helpful tool in analyzing fiscal and monetary policy and the impact of exogenous shocks such as unfavorable weather conditions or changes in donor policy. However, the discussion has also shown that a significant amount of judgment has been involved both in constructing the model and in designing scenarios for future developments in the economy. Therefore, the projections should also be interpreted with caution.

Macmod is used for the projection of the framework of the RPFB. This fact should cater for even greater cautiousness:

1. The base line scenario should always be as realistic as possible. It is better to err on the downside than the upside. This is because unrealistic growth rates lead to unrealistic government revenue projections. Revenues are in turn distributed among sectors and votes, and once they are in the budget, activity levels are planned accordingly, and it may be difficult to cut back when the lack of realism of the revenue projections eventually becomes apparent.
2. Effective tax rates should be maintained flat for base line projection purposes even if increases in tax rates or broadening the tax base are planned. Until the merits of the new measures have been proven, they should only appear in the alternative scenario.
3. Transfers from donors should be no more than what is realistically expected for the first year of projection, and it should be on a declining trend further into the future.
4. The base line scenario should never assume "good" weather conditions (e.g. above average). The only exception to this rule is when the model is used for estimating

historical data not yet released from the relevant institution producing them, and the weather conditions are known.
5. The alternative scenario can be used for exploring the upside (or the unrealistically severe downside).

4 The equations of the core model

This chapter presents the equations of the model. The independent equations are numbered, while the derived equations are named by their designation in macro-economic terminology. Annex 1 lists the variables and parameters together with their base year values. Annex 2 explains how the reduced form IS-LM-BP model is solved for the three key endogenous variables (real income, real interest rate and real exchange rate), annex 3 explains how the capital stock was estimated while annex 4 explains how the parameters are estimated.

The model is solved at constant 1992 prices for all variables. The time unit is the calendar year. Since the fiscal year deviates from the calendar year and runs from July to June, the government budget figures are derived by taking the average of two calendar years.

4.1 The IS-LM-BP framework with fixed prices and flexible real exchange rate

The fixed price framework deals with a situation of under-employment where real output is determined from the demand side. Equilibrium in the goods, money and foreign exchange market is determined simultaneously. The manual takes the general budget identity as a point of departure and goes on to identify each component of aggregate demand and finally reduces the model to three equations in three endogenous variables, the familiar IS, LM and BP equations.

The computerized model, however, starts at the other end. As explained in annex 2, the model is first solved for the three key endogenous variables, real income, real interest rate and real exchange rate. The solution is then entered into the equations identifying each component of demand.[1]

4.1.1 The goods market (the IS equation)

The national income identity:

$$Y \equiv PC + GC + PI + GI + X - M \qquad (4.1)$$

Private consumption

$$PC = (1-s)(1-t_y)Y \qquad (4.2)$$

Private investment

[1] Another alternative is to enter the reduced form model in matrix form.

$PI = pi_y Y + pi_{ftrp} eFTRP - pi_r r$ (4.3)

Exports of goods and non-factor services
$X = TX + NTX + NFSX$ (4.4)

Traditional exports
$TX = TRTX + tx_p ePtx/Pw$ (4.5)

Non-traditional exports
$NTX = TRNTX + ntx_p e$ (4.6)

Exports of non-factor services
$NFSX = TRNFSX + nfsx_p e$ (4.7)

where $TR_j = TR_{j,t-1}(1+tr_j)$, j = TX, NTX, NFSX e.g. the fixed term at each point in time consists of the fixed term in the previous year and an exogenous trend. Thus, changes in the fixed factor shift the export function and reflect changes in trade policy, changes in the sectoral composition of output, particularly new mining projects, and the narrowing of bottlenecks facing exporters.

Imports are disaggregated into four categories. Merchandise imports are classified according to their use. In addition there are imports of non-factor services. All categories of imports, except capital goods, are assumed to have local substitutes such that relative expenditure on local and imported goods and services depends on the real exchange rate.

Total imports
$M = CM + INTM + INVM + NFSM$ (4.8)

Imports of consumer goods
$CM = cm_y(PC+GC) - cm_p e(1+t_{cm})$ (4.9)

or inserting 4.2:
$CM = cm_y((1-s)(1-t_y)Y + GC) - cm_p e(1+t_{cm})$

Imports of intermediate goods

$INTM = intm_y Y - intm_p (1+t_{intm})e$ (4.10)

Imports of capital goods
$INVM = a_4(PI+GI)$ (4.11)

or inserting 4.3
$INVM = a_4(pi_y Y + pi_{ftrp} eFTRP - pi_r r + GI)$

Imports of non-factor services
$NFSM = nfsm_y Y - nfsm_p e$ (4.12)

The real exchange rate:

$e = EPw/P$ (4.13)

where the nominal exchange rate E is given in terms of local currency per US dollar.

Combining equations (4.1)-(4.13) yields the IS-curve:

$$r = -\frac{k}{f}Y + \frac{b}{f}e + \frac{EXOGIS}{f} \quad \text{(IS)}$$

where k is the inverse of the simple Keynesian expenditure multiplier given by

$$k \equiv 1-(1-s)(1-cm_y)(1-t_y) - pi_y(1-a_4) + \text{int}\, m_y + nfsm_y$$

b is a parameter determining the impact of a change in the real exchange rate and is given by:

$$b \equiv tx_p Ptx / Pw + ntx_p + nfsx_p + cm_p(1+t_{cm}) + \text{int}\, m_p(1+t_{\text{int}\, m}) + nfsm_p + (1-a_4)pi_{ftrp}FTRP$$

Lower case letters represent derivatives of the corresponding variables represented by capital letters in equations (4.1)-(4.13) with respect to the variable given by the subscript. E.g. cm_y is the partial derivative of imports of consumer goods with respect to income. The same convention is applied throughout the paper. t_y is the sum of non-tax revenue, income taxes and other taxes. f represents the channels through which the real interest rate affects output, and is given by

$$f \equiv pi_r(1-a_4)$$

The variables lumped together in the EXOGIS term are:

$$EXOGIS = (1-cm_y)GC + (1-a_4)GI + TRTX + TRNTX + TRNFSX$$

4.1.2 The money market (the LM equation)

Money demand:
$M_d = (m_y Y - m_r r)\, P$ (4.14)

It is implicitly assumed that wealth is held in both money and bonds. The demand for bonds is the mirror image of the demand for money. Thus, when the interest rate rises, it encourages substitution into bonds and out of money.

Money supply:
$M_s = M_{sd} + NFA$ (4.15)

Hence, money supply has a domestic and a foreign component. The total supply and the domestic component are assumed to be controlled by the Government and the

Central Bank, through the general monetary policy and decisions about the extent to sterilize changes in net foreign assets.

Combining equations (4.14) and (4.15) yields the LM equation:

$$r = \frac{m_y}{m_r} Y - \frac{1}{m_r} \frac{M_s}{P} \qquad \text{(LM)}$$

4.1.3 The balance of payment (the BP equation)

The current account:

$$CA = X - M + e(FTRP + FTRG) - \alpha_2 r_f eGFB_{t-1} \qquad (4.16)$$

The capital account

$$KA = \alpha_1 (r + \dot{P} - r_f) \qquad (4.17)$$

where $\alpha_1 > 0$, but less than infinity, assuming less than perfect capital mobility. Net capital inflows are thus a function of the nominal interest differential between local and foreign assets. The inflation rate here is the *expected* rate of inflation, which in turn is assumed to be equal to last year's inflation.

The overall balance on the balance of payments is financed by changes in reserves, arrears on foreign debt servicing and exceptional financing. While a text-book IS-LM-BP model would have a balance in the foreign exchange market given by changes in reserves equal to zero, this is not realistic in the foreseeable future here. The stock of reserves is lower than the desired level from time to time, calling for a non-zero change in reserves. Moreover, exceptional financing achieved through negotiations with donors and creditors may lead to increases in reserves even when there is an increase in the overall deficit on the balance of payments. The model allows the possibility to set an exogenous target for the balance of payments in order to attain the desired level of reserves under these circumstances.[2] In that case the BP curve shows the locus of real output and interest rate compatible with this target change in stocks.

$$BOP = CA + KA \qquad (4.18)$$

The BP equation is derived by combining equations (4.4) - (4.12) and (4.16) - (4.18) and reads:

$$r = \frac{1}{\beta}[\gamma Y - \lambda e - EXOGBP] \qquad \text{(BP)}$$

Where $\beta \equiv a_4 pi_r + \alpha_1$,

$\gamma \equiv cm_y(1-s)(1-t_y) + \text{int}\, m_y + a_4 pi_y + nfsm_y$

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[2] The model can of course run the text-book case by setting BOP = 0.

$$\lambda \equiv cm_p(1+t_{cm}) + \operatorname{int} m_p(1+t_{\operatorname{int} m}) + nfsm_p + tx_p \frac{Ptx}{Pw} + ntx_p + nfsx_p + (1-a_4 pi_{ftrp})FTRP$$
$$+FTRG - \alpha_2 r_f GFB - BOP$$

$$EXOGBP \equiv TRTX + TRNTX + TRNFSX - cm_y GC - a_4 GI + \alpha_1(\dot{P} - r_f)$$

The aggregate of exogenous terms, EXOGBP, may take a positive or negative value depending on the relative importance of the fixed terms in the export functions, capital mobility and the government's propensity to import. Note that the BP curve, which represents the combination of r and Y which yields equilibrium in the foreign exchange market for a given exchange rate, has the normal upward slope. It shifts down for an increase in the real exchange rate (e.g. a depreciation of the shilling), given that $\lambda > 0$. By inspecting the expression for λ we see that this condition is fulfilled if the stock of external debt, or the allowed deficit on the overall balance (which are two sides of the same coin) are not too high. This means that a lower interest rate and a higher level of income are compatible with equilibrium in the foreign exchange market when the foreign exchange is more expensive.

Note also that the BP curve shifts up for exogenous increases in government expenditure. This implies that fiscal policy is not very effective in affecting aggregate demand as discussed in chapter 3 of this paper.

The IS-LM-BP framework has now been reduced to 3 equations in three endogenous variables, Y, r and *e*.

4.2 The Government

This section extracts the relations involving the Government from the IS-LM-BP framework. These are not assumed to affect real GDP and its components (e.g. there are no wealth effects in the model). They are shown in the flow of funds consistency check part of the model. The results are finally collected and presented in a budgetary framework format.

Government expenditure consists of the following items:

$$G = GC + GI + r(GNBB_{t-1} + GBB_{t-1}) + \alpha_2 r_f eGFB_{t-1} \qquad (4.19)$$

The first two items are entirely exogenous policy variables, while interest payments on domestic and foreign debt depend on the stock accumulated and local and world market interest rates. Finally foreign debt servicing depends on the real exchange rate.

Government tax revenue:

$$DREV = (t_{inc} + t_{oth} + t_I)Y + t_{\operatorname{int} m} INTM + t_{cm} CM + t_{invm} INVM \qquad (4.20)$$

Government financing requirement:

$$GFR = DREV + eFTRG - G \qquad (4.21)$$

Government has three sources of financing the budget deficit: domestic non-bank borrowing (bills and bonds sold to the general public), foreign loans and domestic bank borrowing:

$$\Delta GBB = GFR - \Delta GNBB - \Delta EGFB \qquad (4.22)$$

The outstanding stock of government non-bank borrowing:

$$GNBB_t = GNBB_{t-1} + \Delta GNBB \qquad (4.23)$$

These equations are included for accounting purposes. It is assumed that the way the government budget deficit is financed does not have an impact on real output. It does, however influence credit supply to the private sector, given that total money supply is unaffected by government financing requirements.

4.3 The monetary sector

Flows of financial assets are included for accounting purposes. Credit to the household sector is determined as a residual assuming that government has priority as far as credit allocation is concerned, and given the overall balance in the money market as represented by the LM curve.

$$PBB = M_d - GBB - NFA \qquad (4.24)$$

The other items on the monetary survey is extracted from the core model. Thus, money supply is exogenous, credit to government is determined from the government budget and net foreign assets are determined from the balance of payment. This completes the core model given at constant 1992 prices. In addition to this solution, the model includes tables which convert GDP by expenditure categories and GDP by sector to current prices, a monetary survey at current prices, balance of payment tables at constant 1992 US dollars and current US dollars, and finally the government budget frame given at current prices in fiscal years, constant and current prices and each item as a share of GDP.

5. Aggregate supply and demand

This chapter presents an extension of the IS-LM-BP model which determines the rate of inflation. The variables are given as rates of change. Lower case letters in the equations represent the logarithm of the corresponding upper case letter. The SS-DD model builds on the following assumptions:

1. The macro production function is a Cobb-Douglas function subject to constant returns to scale.
2. The aggregate supply function in the economy is equivalent to the marginal cost curve derived from the macro production function when growth in capacity output exceeds or is equal to growth in aggregate demand.
3. When aggregate demand grows faster than capacity output, wages are bid up and marginal costs increases accordingly.

In a similar way as the core model, the manual starts by presenting each component of the consumer price index (CPI) and then solves the model for the CPI, while the computerized model starts at the opposite end.

The macro production function reads:

$$\hat{Y} = AK^{\hat{a}1} L^{\hat{a}2} INTM^{\hat{a}3} \tag{5.1}$$

where Y hat represents gross output, e.g. the contribution from labor, capital and imported intermediates. The functional form ensures that the cost share of each input equals the exponent on each input.

Starting with labor input, wage increases are assumed to be determined by productivity growth, the inflation rate and the extent of excess demand as follows:

$$\dot{w} = \dot{A} + \sigma_1 \dot{P} + \sigma_2 (y - \bar{y}) \tag{5.2}$$

where the last term is the difference between demanded output and capacity output, both given in logarithms. A dot over a variable indicates its time derivative. Producer price inflation is then determined by the weighted average of unit wage costs and imported intermediate goods:

$$P\dot{p} = \hat{a}_2 (\dot{w} - \dot{A}) + \hat{a}_3 (P\dot{w} + \dot{E} + \dot{T}_{\text{int}\,m}) \tag{5.3}$$

Capital T represent 1+ the tax rate indicated by the subscript. The market price for local goods are:

$$P_m = Pp(1 + t_l) \tag{5.4}$$

Consumer price inflation is a weighted average of local inflation as represented by changes in the market price for local goods and import price inflation:

$$\dot{P} = (1 - cm_y)\dot{P}_m + cm_y\left(\dot{T}_{cm} + \dot{E} + \dot{P}_w\right) \tag{5.5}$$

The GDP deflator is confined to local determinants of inflation only. It is therefore a function of labor costs. Changes in the GDP deflator are given by:

$$\Delta GDPD = \dot{w} - \dot{A} \tag{5.6}$$

Combining equations (4.2) - (4.5) yields the consumer price inflation:

$$\dot{P} = \frac{1}{1 - (1 - cm_y)\hat{a}_2 \sigma_1} x$$

$$\left\{\left[(1 - cm_y)\hat{a}_3 + cm_y\right](\dot{P}w + \dot{E}) + (1 - cm_y)\left[\hat{a}_2 \sigma_2 (y - \bar{y}) + \hat{a}_3 \dot{T}_{\text{int}\,m} + \dot{T}_l\right] + cm_y \dot{T}_{mc}\right\}$$

This equation contains two unknown variables, the inflation rate and the nominal exchange rate. We can, however, derive the change in the real exchange rate from the IS-LM-BP framework. By taking logarithms and time derivatives on both sides of equation 2.13 we get:

$$\dot{P} = \dot{P}w + \dot{E} - \dot{e}$$

Hence, we can substitute $\dot{P} + \dot{e} = \dot{P}w + \dot{E}$ in the price equation and solve for the consumer price inflation. This yields:

$$\dot{P} = \frac{1}{(1-cm_y)(1-\hat{a}_2\sigma_1 - \hat{a}_3)} x \qquad \text{SS}$$

$$\left\{\left[(1-cm_y)\hat{a}_3 + cm_y\right]\dot{e} + (1-cm_y)\left[\hat{a}_2\sigma_2(y-\bar{y}) + \hat{a}_3\dot{T}_{\text{int}\,m} + \dot{T}_l\right] + cm_y\dot{T}_{mc}\right\}$$

However, we need to estimate capacity output in order to determine the inflation rate. That is done as follows:

The macro production function which represents full capacity output:

$$\bar{Y} = (1-a_3)(1+y_{rain}rain)AK^{\hat{a}1}L^{\hat{a}2}INTM^{\hat{a}3} \qquad (5.7)$$

where the production function returns gross output, e.g. it includes imported intermediate goods. It is assumed to take a Cobb Douglas form while the *rain* variable is assumed to be a shift parameter. Hence, each factor of production receives a fixed share of total output. Therefore, value added, or GDP, equals gross output less the share of imported intermediate goods.

Data on the capital stock is not available. Therefore, an attempt is made to estimate it as shown in annex 3. Real growth of capacity output is then calculated as follows:

$$\frac{\dot{Y}}{Y} = a_1\frac{PI + GI}{K} + a_2\frac{\dot{L}}{L}$$

where the first term on the right hand side represents capital accumulation and the second term the growth rate of the labor force, which is exogenous. It is assumed that the capital-output ratio is constant over time, (one of Kaldor's stylized facts). The benchmark year capital stock is found by solving this equation for K, and inserting the benchmark year values for all the other variables. Having estimated the capital stock for the base year of the model, projections for subsequent years reads:

$$K_t = (1-\delta)K_{t-1} + PI_{t-1} + GI_{t-1} \qquad (5.8)$$

We have now defined capacity output growth while actual output growth is determined from the demand side. Inserting this into the SS equation unanimously determines the consumer price inflation.[1]

6. The sectoral supply block

The core model is entirely driven by the demand side of the economy. This is justified by the observation that actual production appears to be well below capacity output (ref). This may be due to inadequate demand, but it may also at least partly stem from constraints and bottlenecks in the economy. This block provides a framework for analyzing how such constraints affect the productive sectors of the economy. It also offers a framework for analyzing how industrial and trade policy may affect the sectoral composition of output.

If significant changes in the sectoral composition of output take place, this will have a bearing on the parameters at the macro level. In particular, if sectors producing mainly for exports, for example mining, increase their share in total output, the fixed factor as well as the price elasticity of the non-traditional exports function will be affected (see chapter 3, equation 3.6). Thus, the sectoral supply block provides a guide to when parameters of the core model need to be re-estimated.

Demand-driven output at the aggregate level is of course also reflected in demand-driven output at the sectoral level. Thus, GDP at market prices is imported into the sectoral model from the core IS-LM-BP framework and constitute an important determinant of sectoral growth. From there GDP at factor cost is calculated by subtracting net indirect taxes and making necessary adjustments.[2]

The sectors included are the following (symbols used in the equations in parenthesis):

1. Agriculture (AGR)
2. Mining (MI)
3. Manufacturing (MA)
4. Electricity and water (E&W)
5 Construction (CON)
6. Wholesale and retail trade, hotels and restaurants (TRA)
7. Transport, storage and communication (COM)
8. Finance, insurance, real estate and business services (FI)
9. Public administration and other services (PA)

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[1] Slack in the economy, e.g. when potential output grows faster than actual output seems to have had little effect on reducing inflation in the past. Therefore, the excess demand element in the price equation has only an upside effect in the model. Hence the IF-function in the spreadsheet.

[2] Such adjustments are due to discrepancies in data on net indirect taxes as given in the National Accounts and net indirect taxes reported in government budgets. The core model makes projections of indirect taxes as received by government, while the flow of funds consistency check ensures that the amount paid in indirect taxes is the same as the amount received by the government. Since this is not the case in the historical data, some adjustments are made.

Sectors are subdivided into two groups: Those which are mainly responding to domestic demand, and those who are driven by other forces such as world market prices, rainfall, technology and other factors which are incorporated into a trend factor. Among the former sectors are sectors 5-9, while the latter sectors are sectors 1-4.

Agriculture has three subsectors:
1.1 Export crops (EC)
1.2 Food crops (FC)
1.3 Other agriculture (OTH)

A supply function is estimated for each sub-sector in agriculture.

Lower case *tr* followed by the sector symbol means trend growth while a delta means rate of change in all the equations.

The supply functions for agriculture is based on the sector study found as annex 5 in this manual.

Output from all sectors is estimated in terms of growth rates as follows:

Export crops:

$$\Delta EC = ec_p \Delta(e\frac{Ptx}{Pw}) + rain_{ec} + trec \qquad (6.1)$$

Food crops

$$\Delta FC = ef_p \Delta(Pfc / P) + rain_{fc} + trfc \qquad (6.2)$$

Food crops have a large weight in the consumer price inflation. For projections we do not estimate the price for food crops separately. That would have required a partial equilibrium model for the food crop market, which would include demand, local supply and import supply. Since such a model is beyond the scope of this macro model, the relative price of food crops compared to other consumer goods will be one, and the first term in equation (5.2) will be zero. Nevertheless, it is useful to have the term in place if new information becomes available.

Other agriculture

$$\Delta OTH = troth + rain_{oth} \qquad (6.3)$$

Other agriculture is estimated, mainly on the basis of population growth rates in the National Accounts, and the same method is used here, adjusted for rainfall. The impact of rainfall on this subsector is, however, smaller than for the crops sectors.

Mining and manufacturing are projected by a trend-factor only, but adjusted to total demand as explained above:

Mining

$$\Delta MI = trmi \qquad (6.4)$$

Manufacturing output is determined by a trend factor and the impact of water and power shortages. Thus, α_4 is zero if rainfall is normal or above normal, but has a negative value if rainfall is below normal.

$$\Delta MA = trma + \alpha_4 \Delta E\&W \qquad (6.5)$$

Electricity and water is estimated by a trend factor, and is also affected by rainfall on the down-side. Thus, drought will affect electricity and water negatively, but good rains will have no impact on the sector.

$$\Delta E\&W = trew + rain_{e\&w} \qquad (6.6)$$

Construction is assumed to grow at the same pace as investment:

$$\Delta CON = \Delta(PI + GI) \qquad (6.7)$$

Wholesale and retail trade, hotels and restaurants are assumed to grow in pace with the average of GDP growth and growth of imports:

$$\Delta TR = 0.5\Delta Y + 0.5\Delta M \qquad (6.8)$$

Transport, storage and communication are assumed to grow in pace with the average of GDP, exports and imports

$$\Delta COM = 1/3\Delta Y + 1/3\Delta X + 1/3\Delta M \qquad (6.9)$$

Finance, insurance, real estate and business services are assumed to grow in pace with GDP:

$$\Delta FI = \Delta Y \qquad (6.10)$$

Public administration and other services are assumed to grow in pace with the growth of government expenditure:

$$\Delta PA = \Delta GC \qquad (6.11)$$

Since some of the sectors are estimated independently from total demand, the aggregate output from the supply side can not be expected to equal aggregate demand net of indirect taxes. In order to balance total sectoral output and aggregate demand, therefore, an adjustment parameter is applied as follows:

GDPfc = (EC+FC+OTH+MI+MA+E&W+CON+TRA+COM+FI+PA)*adj

where the left hand side equals GDP at factor cost determined in the core model. Excel solver is used for the balancing purpose. The resulting adjustment factor is an important variable to watch:

It should not differ very much from unity. When the adjustment factor exceeds unity, there is excess demand in the economy (before adjustments). This may indicate that the fiscal or monetary policy is too expansionary, or that the household savings rate is set too low. One condition which typically yields a situation of excess demand is if there is a drought, while fiscal and monetary policy are not adjusted to this. If the adjustment parameter is below unity on the other hand, there is excess supply in the economy. If such a result appears, the monetary policy is probably too tight and/or the assumptions on private savings are unrealistically high.

7 Creating scenarios and forecasts

This chapter presents an example of how Macmod can be used for policy analysis. We have chosen a realistic example of how to adjust to an exogenous shock such as adverse weather conditions. The point in time when the model is run is March 1998. The policy objectives before the shock is to bring down inflation, reduce the budget deficit before grants to 1.5 percent of GDP and increase overall income growth. However, the economy has been adversely affected by the so-called El Nino effect. The impact has already been felt through untimely and heavy rainfall, but little is known about exactly how this phenomenon will affect the key macro variables and how fiscal and monetary policy may affect the outcome. During such adverse exogenous shocks a Keynesian response would be to increase or at least maintain government expenditure at the pre-shock level in order to dampen the impact on the economy. However, in a situation with cash-budgeting (e.g. only actual revenue collected can be spent) this response is out of the question.

The rainfall variable in the model is a dummy which can take 4 values, ranging from "very bad," via "bad," and "normal" to "good" (see annex 3 how these weather conditions translate into exogenous shocks). We explore the case with "very bad" rainfall. Note that the dummy is not a linear function of millimeters of rainfall. Both too much and too little lead to "bad" or "very bad."

Our base line scenario is the tight fiscal and monetary policy regime aiming at stabilizing the economy by curbing inflation and reduce internal and external imbalances. It is run for normal weather conditions during the entire period.

The first alternative scenario shows the impact on the adverse weather conditions assuming unchanged policy. This is a scenario where aggregate demand is maintained while the supply side is negatively affected by the El Nino effect. This creates excess demand, and higher inflation in the first year. For subsequent years it affects aggregate demand through inflation expectations.

Given the objective of reducing the budget deficit, government may decide to reduce government expenditure, anticipating that El Nino will reduce government revenue collection. This is presented in the second alternative scenario where government consumption is reduced compared to the base line scenario in 1998/99, but growth in government consumption is back to the base line scenario for subsequent years. This tightening of fiscal policy does improve the internal and external balance (see chapter 3), but has little impact on inflation which increased due to the El Nino effect.

A third alternative scenario presents the case where curbing inflation remains objective number one in spite of the El Nino effect. In order to obtain this objective, monetary policy is tightened in addition to the fiscal policy measure introduced in alternative scenario II.

Finally, we present a fourth alternative scenario where the objective of dampening the negative impact of El Nino on income takes precedence over the inflation objective. Here the tightening of fiscal policy from alternative II and III is maintained, while monetary policy is loosened in order to stimulate demand.

The scenarios are analyzed in more detail in sections 7.1 - 7.4. Each scenario is analyzed against the background of the base line scenario with a relatively tight fiscal and monetary policy and no shocks.

7.1 The El Nino shock, but no policy changes

Table 7.1 presents the assumptions on the key exogenous variables. The only difference between the two scenarios is the rainfall dummy which is normal (0) in the base line scenario and "very bad" (-2) in the alternative. Real increase in government consumption is given for fiscal years (1998 = 1998/99). The entries in the table are percentage changes, except for rainfall which is a dummy.

Table 7.1 Key exogenous variables

	1998	1999	2000	2001
Base line				
Real increase in GC	2	2.5	3	
Increase in real money supply	1	0	0	0
Rain	0	0	0	0
Alternative I				
Real increase in GC	2	2.5	3	
Increase in real money supply	1	0	0	0
Rain	-2	0	0	0

Figure 7.1 shows the impact of El Nino on inflation, and figure 7.2 shows the impact on the nominal exchange rate. Due to excess demand stemming from a decline in supply while demand is unaffected in the first year, inflation increases. The second year this has an impact on aggregate demand through inflation expectations. Recall that the capital account on the balance of payment is determined by the nominal interest rate differential where the price element is *expected* inflation (equation 4.17). An increase in the expected inflation rate leads to a higher interest rate differential and a net inflow of foreign capital. Note that this need not involve an increased inflow of foreign capital. It may just as well involve less outflow of capital. As a result, the exchange rate appreciates and the IS-curve moves slightly to the left, reducing aggregate demand the second year after the shock. The growth rates of real GDP is compared to the base line scenario in figure 7.3.

Figure 7.1

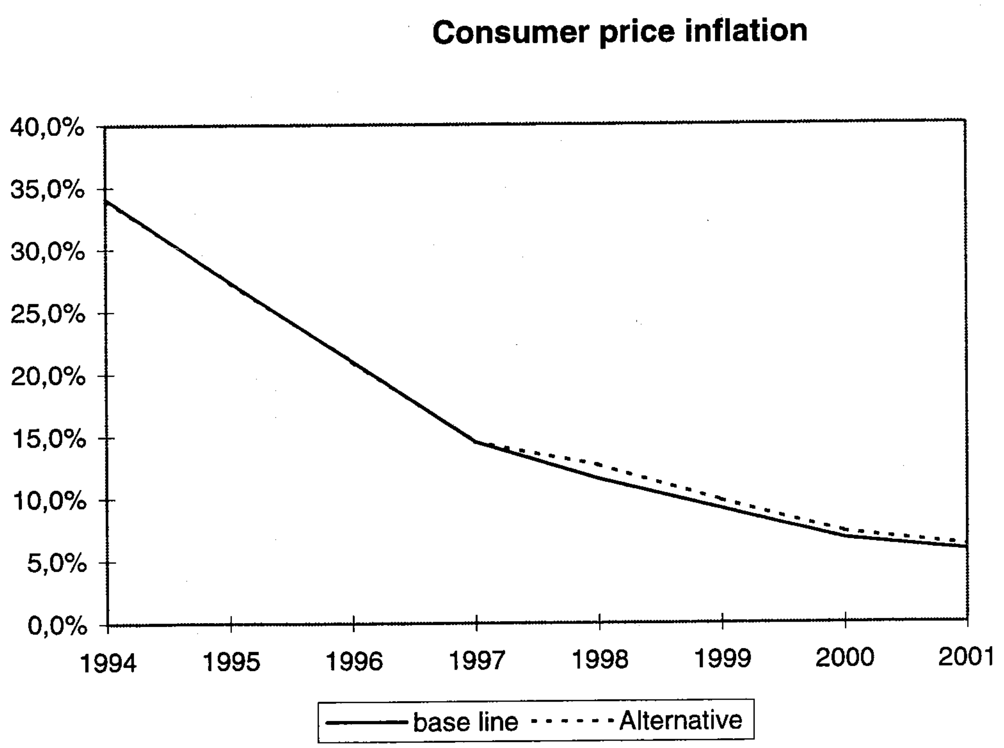


Figure 7.2

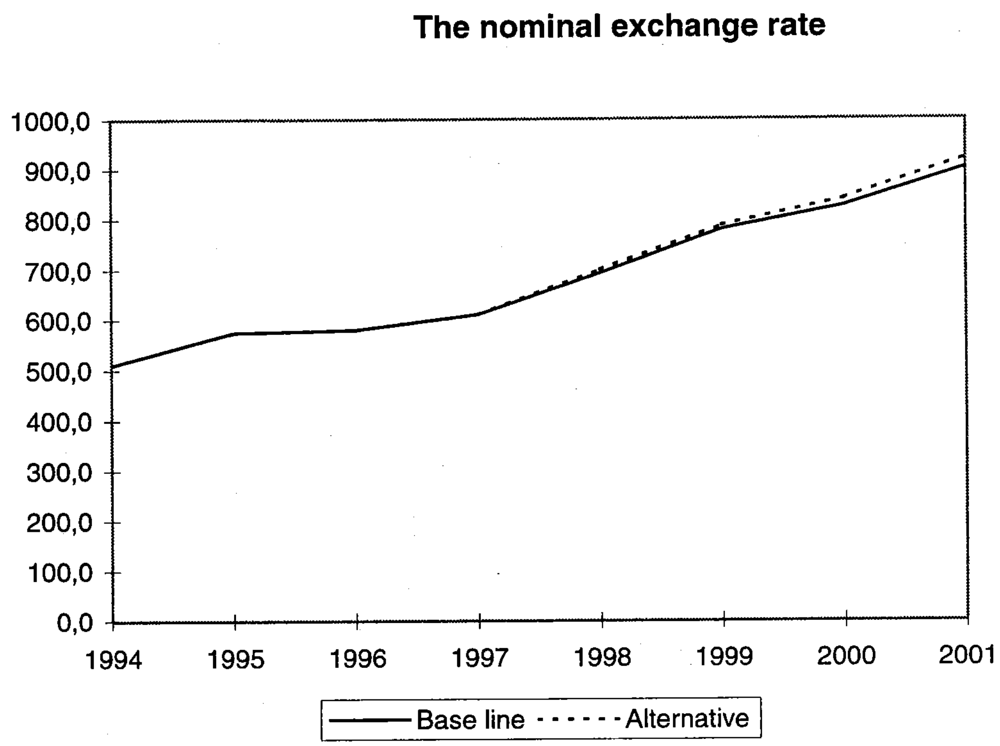


Figure 7.3

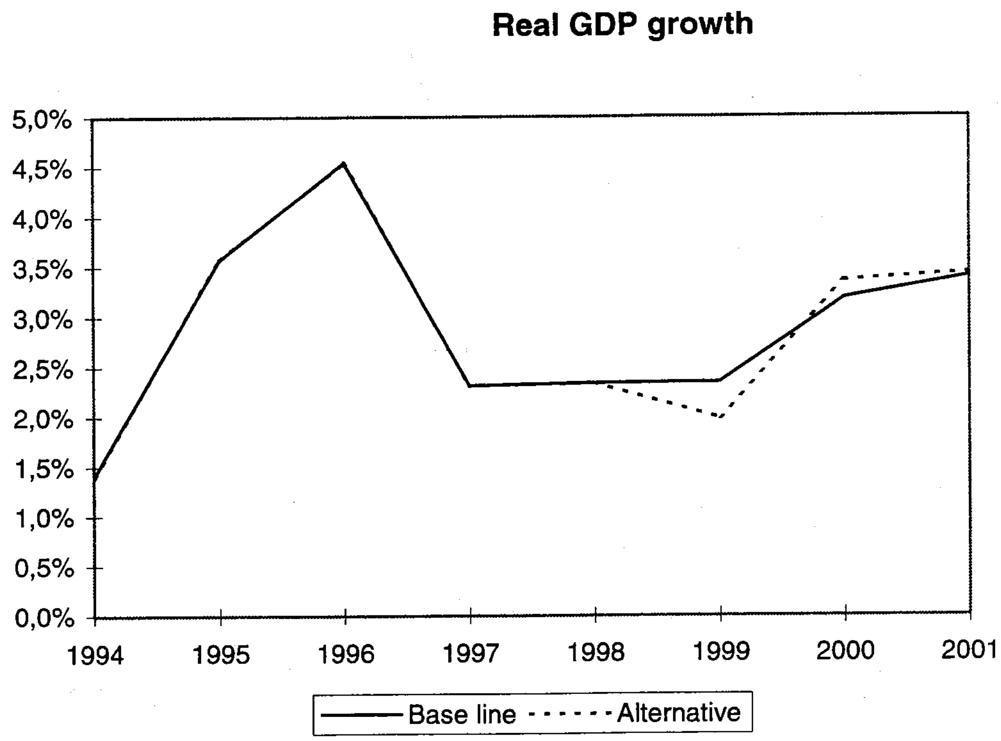


Table 7.2 Key results

	1998	1999	2000	2001
Base line				
real exchange rate	241.1	255.6	260.1	275.1
real interest rate	16	19	24	28
inflation rate	11.1	8.9	6.5	5.7
current account	-155781	-154876	-154659	-158485
Alternative I				
real exchange rate	241.1	253.7	258.6	274.1
real interest rate	16	19	23	28
inflation rate	12.7	9.8	7.2	6.2
current account	-155781	-156155	-155424	159067

Table 7.2 presents the real exchange rate forecasts, the current account deficits given at constant 1992 Tshillings, the inflation rate and the real interest rate. Except for the inflation rate, the two scenarios are similar in the first year. The second year we see the real appreciation stemming from the net capital inflows discussed above. This leads to a widening of the current account deficit compared to the base line scenario.

7.2 El Nino and reduced government consumption

This scenario explores the total effect of El Nino combined with a reduction in government consumption due to anticipated reduced revenue. The key assumptions are shown in table 7.3 Government final consumption does not increase at all in real terms in 1998/99, but expansion of government consumption is resumed from 1999/2000. It is, however, not assumed that government compensates for the lower expenditure by increasing it over and above the base line scenario assumptions in subsequent years. Thus, the *level* of government expenditure is lower throughout the forecasting period in the alternative II scenario compared to the base line.

Table 7.3 Key exogenous variables

	1998	1999	2000	2001
Base line				
Real increase in GC	2	2.5	3	
Increase in real money supply	1	0	0	0
Rain	0	0	0	0
Alternative I				
Real increase in GC	0	2.5	3	
Increase in real money supply	1	0	0	0
Rain	-2	0	0	0

Figures 7.4 and figure 7.5 depict consumer price inflation and the nominal exchange rate compared to the base line scenario. Clearly, the tighter fiscal policy did not improve the inflation performance much. It does, however, have an impact on aggregate demand as shown in figure 7.6. The results on the other key variables are shown in table 7.4

Figure 7.4

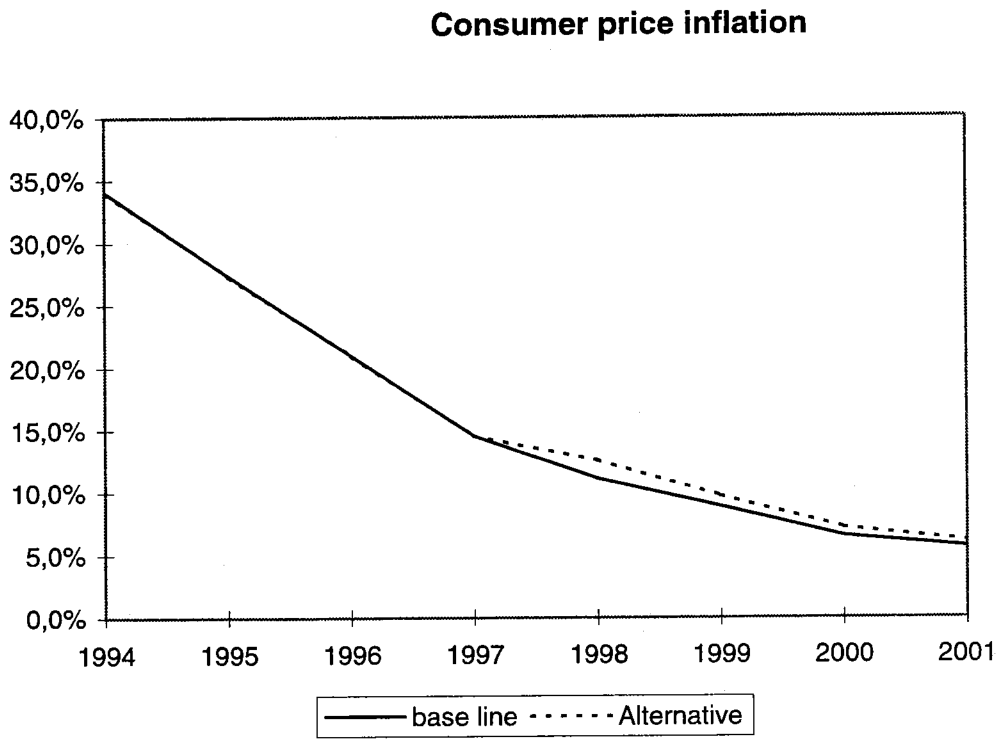


Figure 7.5

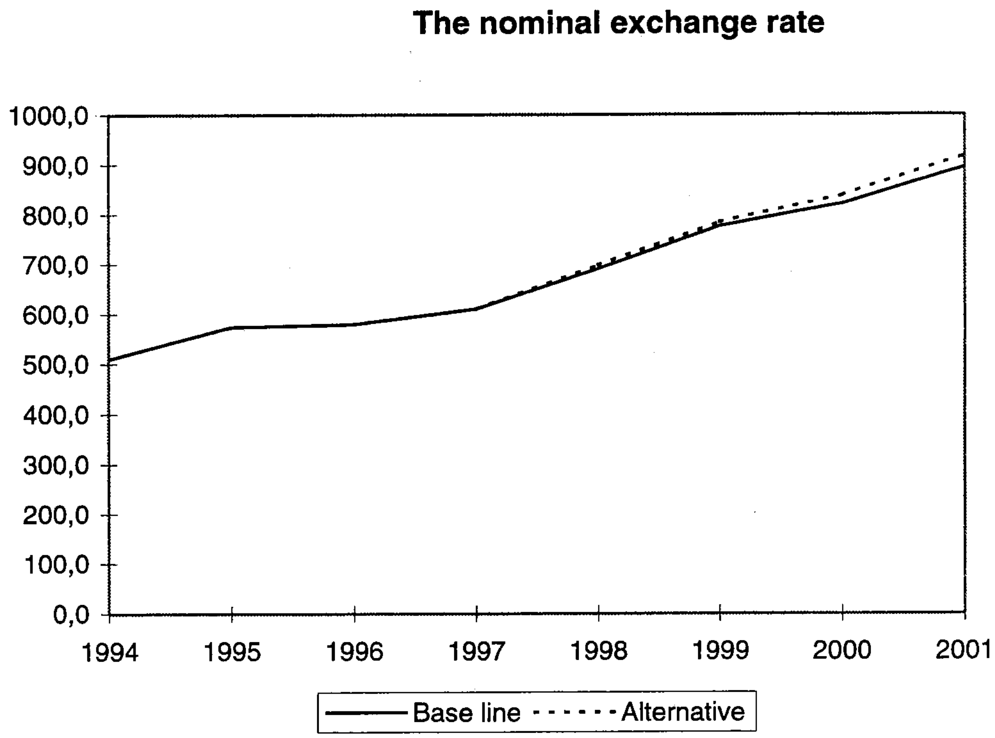


Figure 7.6

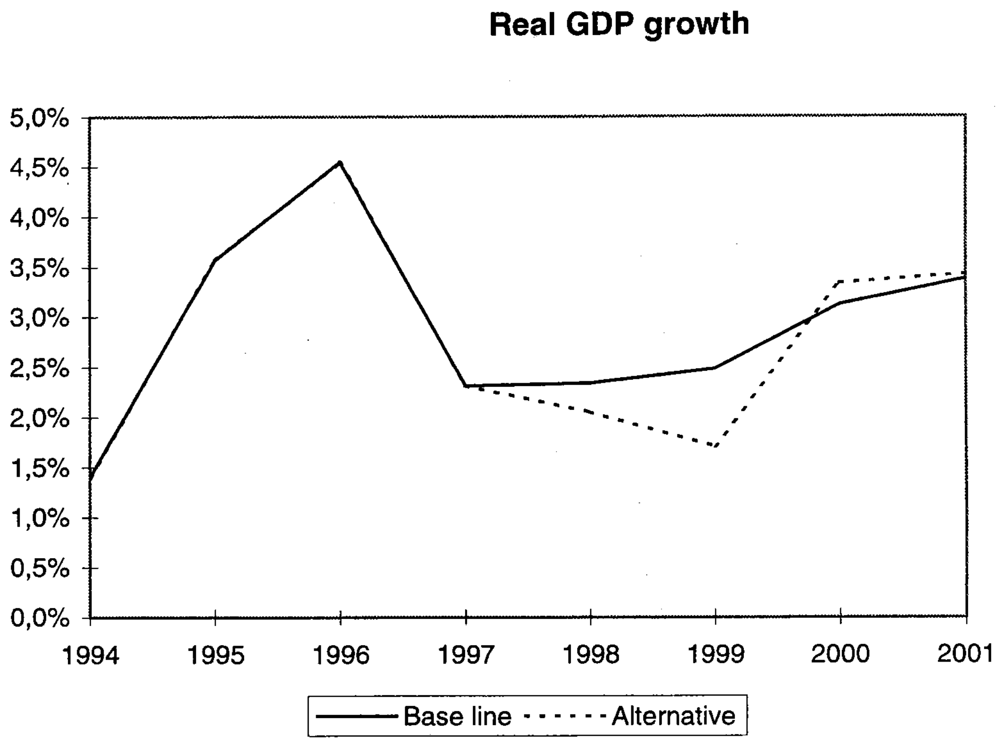


Table 7.4 Key results alternative II

	1998	1999	2000	2001
Base line				
real exchange rate	241.1	255.6	260.1	275.1
real interest rate	16	19	24	28
inflation rate	11.1	8.9	6.5	5.7
current account	-155781	-154876	-154659	-158485
Alternative II				
real exchange rate	240.8	253.1	258.2	273.5
real interest rate	16	18	22	27
inflation rate	12.7	9.8	7.2	6.2
current account	-154761	-154021	-153263	-156859

The tighter fiscal policy leads to a shift to the left on the IS curve. As explained in chapter 3, this first induces a higher interest rate and capital inflows, and second an appreciation of the exchange rate such that the IS curve shifts to the right again, but not necessarily to its initial position. Also as explained in chapter 3, this leads to a shift in expenditure from government consumption to net exports, such that the current account improves.

7.3 El Nino, reduced government expenditure and tighter monetary policy

Suppose that the authorities are not satisfied with the inflation performance under alternative scenario II, and tightens monetary policy in addition to the fiscal tightening under alternative scenario II. The key assumptions are shown in table 7.5

Table 7.5 Key exogenous variables alternative III

	1998	1999	2000	2001
Base line				
Real increase in GC	2	2.5	3	
Increase in real money supply	1	0	0	0
Rain	0	0	0	0
Alternative I				
Real increase in GC	0	2.5	3	
Increase in real money supply	-2	0	0	0
Rain	-2	0	0	0

This policy mix leads to a shift both in the LM and the IS curves as explained in chapter 3. Thus, the IS-curve moves to the left first as a consequence of the fiscal tightening and then one further step as a response to the monetary tightening which affects the IS curve through the exchange rate. The policy mix takes the rate of inflation almost back to the baseline path as shown in figure 7.7. The real appreciation of the exchange rate as a consequence of the policy mix is sufficient to obtain a lower nominal exchange rate compared to the base line as well (see figure 7.8). The tightening of both fiscal and monetary policy do, however induce a recession in 1998, and slower growth also in 1999 compared to the base line. The details of the scenario are presented in table 7.6.

Figure 7.7

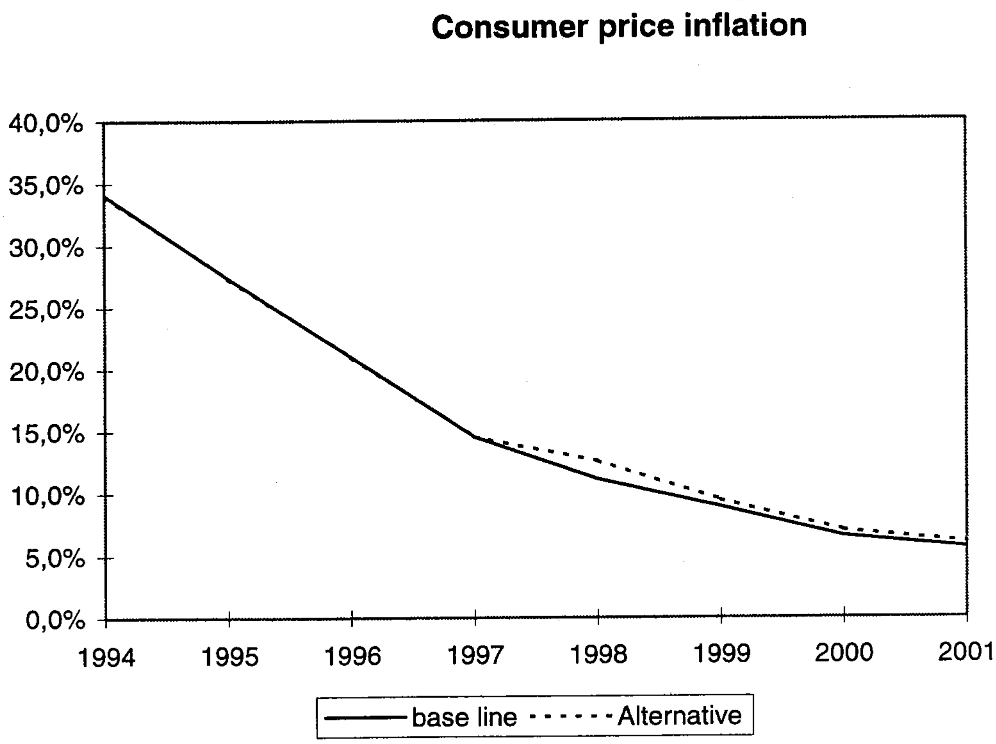


Figure 7.8

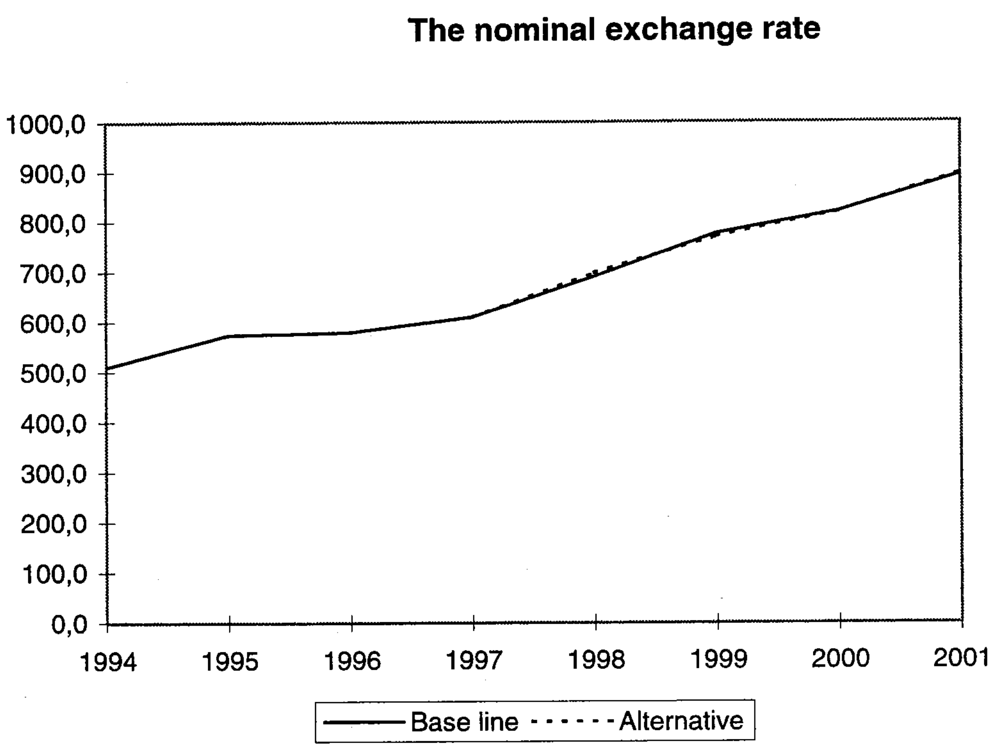


Figure 7.9

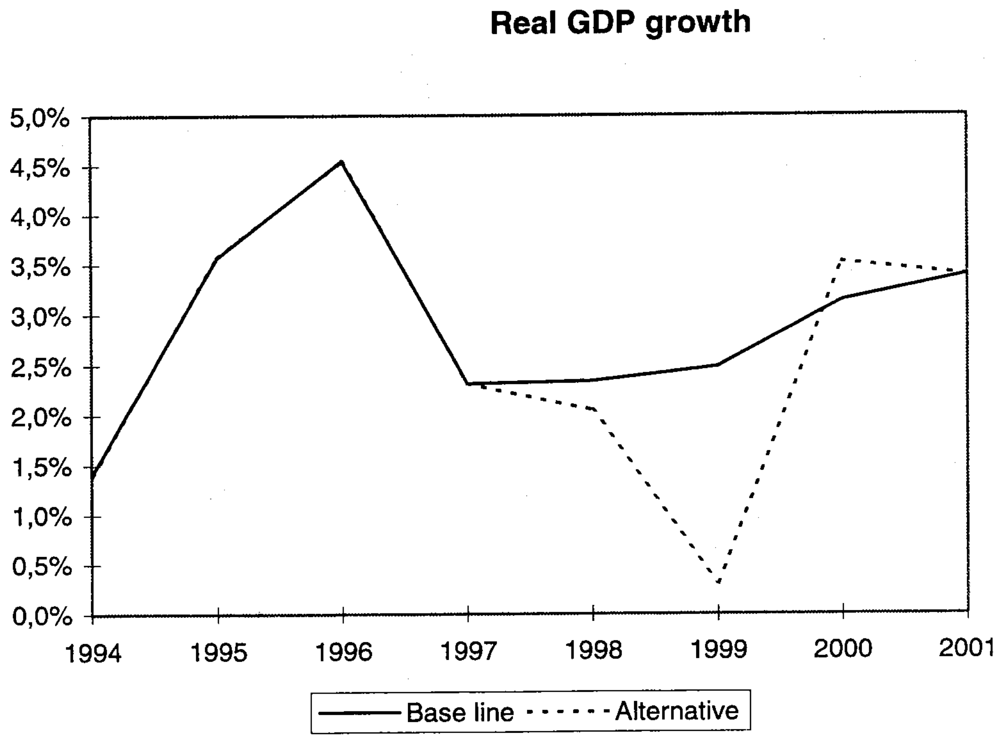


Table 7.6 Key results alternative III

	1998	1999	2000	2001
Base line				
real exchange rate	241.1	255.6	260.1	275.1
real interest rate	16	19	24	28
inflation rate	11.1	8.9	6.5	5.7
current account	-155781	-154876	-154659	-158485
Alternative II				
real exchange rate	234.6	247.1	252.1	266.3
real interest rate	16	19	23	28
inflation rate	11.7	9.1	6.7	5.8
current account	-153949	-152440	-152020	-155702

Also in this scenario the current account balance improves. Exports decline due to the appreciation of the exchange rate, but imports decline also due to the income effect being stronger than the price effect.

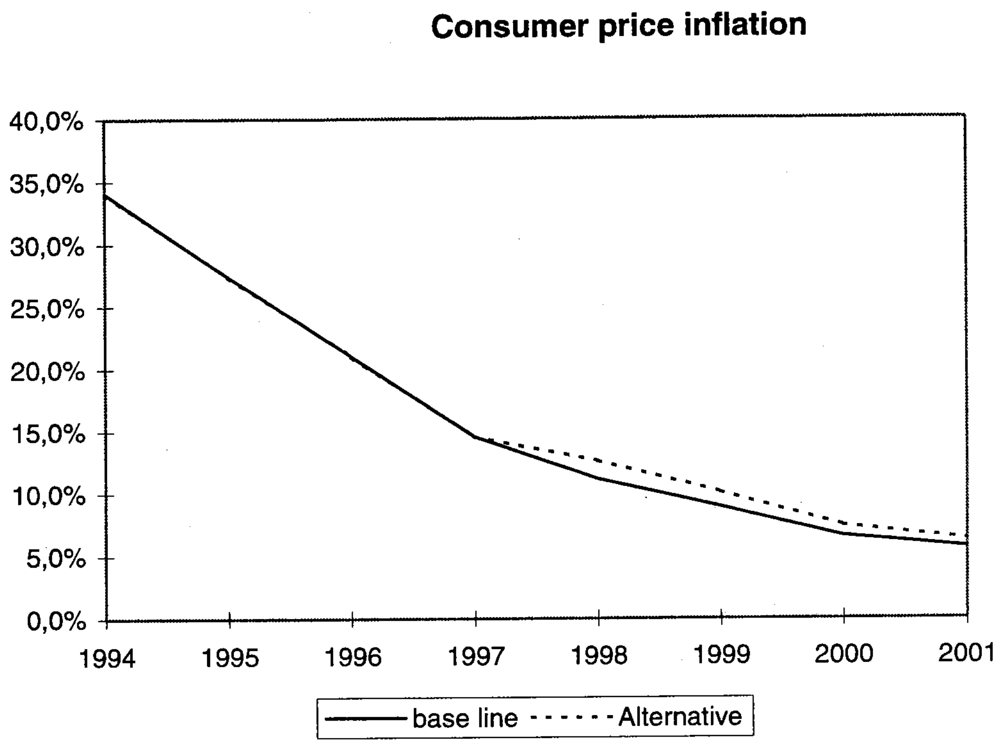
7.4 El Nino, reduced government expenditure and increased money supply.

We finally present a scenario where the objective of avoiding the adverse impact of El Nino on income takes precedence over the objective of curbing inflation, but only in 1998. Thus we assume that money supply is increased in order to stimulate the economy in 1998, but is scaled back to the base line growth rates in subsequent years. The key assumptions are presented in table 7.7, and the inflation and exchange rate forecasts are depicted in figures 7.10 and 7.11 respectively, while GDP forecasts are presented in figure 7.12.

Table 7.7 Key exogenous variables alternative IV

	1998	1999	2000	2001
Base line				
Real increase in GC	2	2.5	3	
Increase in real money supply	1	0	0	0
Rain	0	0	0	0
Alternative I				
Real increase in GC	0	2.5	3	
Increase in real money supply	2	0	0	0
Rain	-2	0	0	0

Figure 7.10



The IS-curve first moves to the left because of the tighter fiscal policy (compared to the base line scenario). However, as the LM-curve moves to the right due to an increase in money supply, the exchange rate depreciates and shifts the IS-curve to the left as well, and an expansion in aggregate demand in 1998 compared to the base line is observed. This scenario yields the highest rate of inflation of the four alternatives, but the impact of El Nino on real income is much less. The largest impact is in fact felt in 1999 in this scenario. The 1999 effect is due to two factors. First, monetary policy is tightened in 1999 instead of 1998. Second, the impact of expected inflation discussed under alternative scenario I strikes in 1999.

Figure 7.11

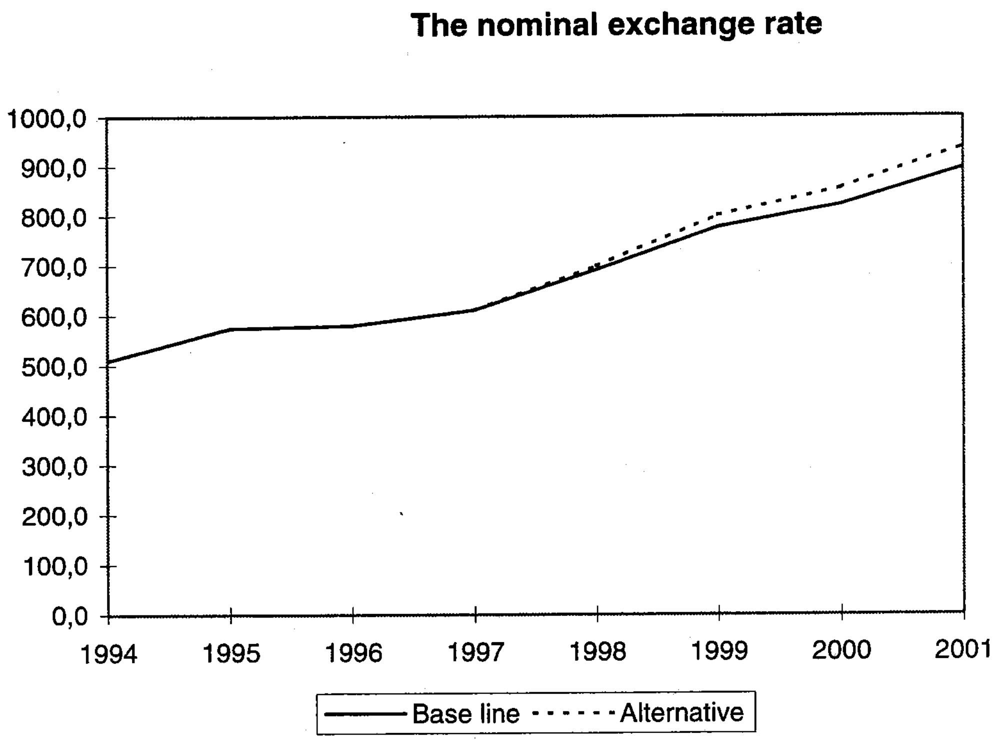


Figure 7.12

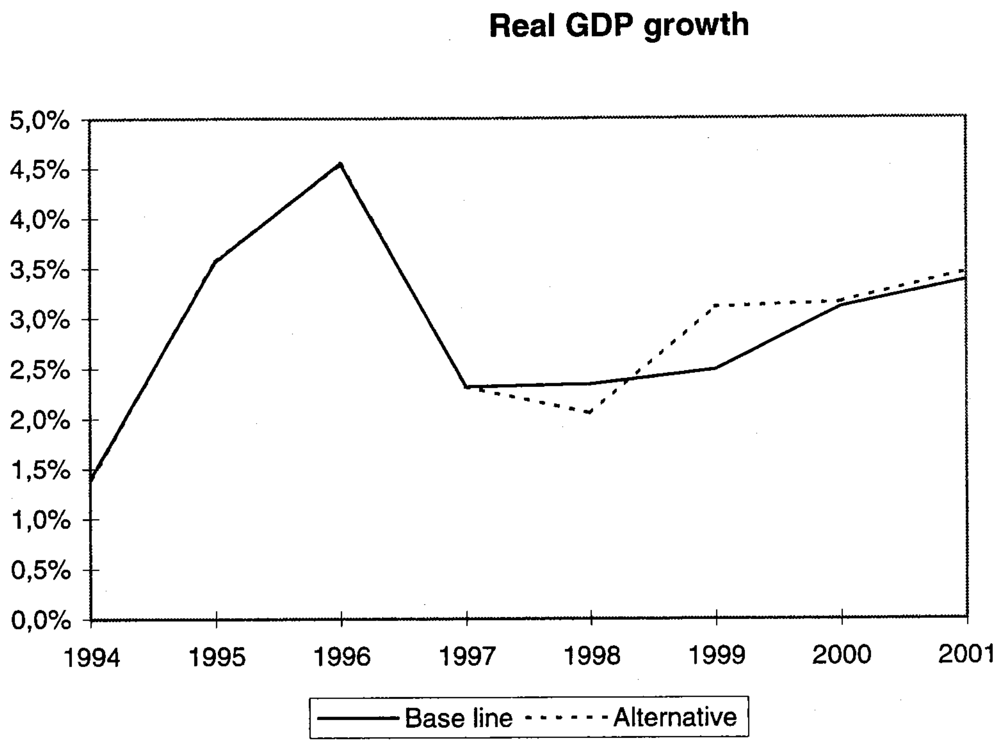


Table 7.8 Key results alternative IV

	1998	1999	2000	2001
Base line				
real exchange rate	241.1	255.6	260.1	275.1
real interest rate	16	19	24	28
inflation rate	11.1	8.9	6.5	5.7
current account	-155781	-154876	-154659	-158485
Alternative II				
real exchange rate	242.8	255.2	260.2	275.9
real interest rate	15	17	22	27
inflation rate	12.9	9.9	7.3	6.3
current account	-155031	-154548	-153677	-157245

The real exchange rate depreciates in this case, and the current account improves slightly compared to the base line as a result. This time, however, the improvement of the current account is due to the price effect of the depreciating shilling rather than the income effect from a slow-down in demand which we have seen in the alternative scenario II and III.

7.5 Concluding remarks

This scenario analysis has discussed how government fiscal and monetary policy may be used to manage an exogenous shock. The policy mix chosen will depend on the policy objectives and how they are prioritized. Thus, there is a trade-off between income and inflation in the short run. The objectives of improving the internal and the external balance are, however, mutually reinforcing. Hence, a reduction in the government deficit leads to a narrowing in the current account deficit.

There are of course a host of other policy mixes that could have been used in order to manage the El Nino exogenous shock. Taxes and subsidies are obvious candidates. It is, however important to maintain a stable and predictable tax regime, and taxes should therefore not often be used in order to handle a short-term exogenous shock.

Some of the exogenous variables over which the government has little or no control may also change as a consequence of El Nino. Foreign transfers may for example increase if emergency aid is called for. In addition, El Nino is a global phenomenon which may affect world market commodity prices. Additional scenarios where these possibilities are explored can therefore be examined.

Finally, note that the real interest forecasts are quite high for all the scenarios. This is due to at least three factors. First, in order to bring down inflation from 15 percent to about 5 percent, the monetary policy needs to be tight, which it is in all the scenarios, but to a varying extent. Second, the interest rate was very high during the period 1994-96 which is the period to which Macmod is calibrated. Third, the degree of capital mobility is quite low in the model, such that the interest rate differential between Tanzania and the rest of the world can be quite high without causing substantial capital flows.

8

Agricultural sector modeling in Macmod: What determines agricultural output in Tanzania?

By Arild Angelsen

8.1. Introduction

Macmod is an analysis tool used in the budget process to ensure macroeconomic consistency and to make forecasts for the economy of Tanzania. The model is being improved and updated regularly. The present work aims to improve the modeling of the agricultural sector. This is to be done by statistical analysis of historical data to answer the questions: which variables determine agricultural production, and thereby, how can agricultural production be predicted? This report and results was used as an input in the present version of Macmod.

8.2. Background on Macmod

The brief history of the agricultural sector in Macmod is the following. The first version included 14 crops, and one aggregate for 'others'. Prices were exogenous, which was not an unrealistic assumption given government policy at that time. Quantities were a function of prices and trend for the important crops, and only trend for the minor ones. This was too much to handle for the model users, and the price forecasts were generally the same for all crops. In the second version of Macmod, the sector was divided into only two subsectors: export crops and the rest, labeled food crops. The production of food crops was a function of rainfall and trend, whereas export quantity was a function of rain, trend and prices.

The modeling of agriculture was changed again in the present, third version of Macmod. The basic structure is an IS-LM/Mundell Flemming model. The agricultural sector is part of the macro (full capacity) production function, cf. equation (5.1). Full capacity is determined by the following variables: capital, including land; labor; and intermediates. Further, an export function for traditional exports (agricultural crops) is given in equation (4.5), including two variables: terms of trade; and a trend.

The weaknesses of the way agriculture was included in Macmod include:

- No explicit modeling of the agricultural sector, in spite of its dominance in the national economy (55-60 percent of GDP).
- Limited role for supply responses of changes agricultural prices or other variables.
- Difficult to make explicit forecasts for the agricultural sector.

The aim for the present revision is therefore to more explicitly model agricultural production, and thereby hopefully produce better forecasts. Furthermore, the revised model should allow for sensitivity analysis, for example, what is the effect on the national economy of a decline in international coffee prices?

8.3. Some facts about the Tanzanian agricultural sector

The Tanzanian agricultural sector has often been used as an illustration of the dangers of state intervention in marketing and pricing, and the neglect in other areas such as infrastructure. Tanzania has one of the most favorable man-land ratios in Africa, and has a potential for food export, even though this may conflict with the aim to make cheap food available to domestic consumers. The present farm practices are characterized by extremely low intensity, with very limited use of manufactured inputs. 70 percent of land is cultivated by hand-hoe (*jembe*), 20 percent by ox-ploughs, and 10 percent by tractors. There is a large unused potential for increasing the agricultural production, both in terms of increasing the yield (output per ha) and by expanding the agricultural land area.

About 6 percent of total land or 13 percent of potentially arable land is cultivated. In addition to the 6.8 mill. ha agricultural land, 10-12 mill. ha is eminently suitable for maize production, 3-4 suitable for rice (World Bank, 1994). However, there is a shortage of land in some regions.

The agricultural sector can be divided between smallholders and commercial farms. The smallholder sector consists of some 3.5 mill. peasant households and 19 mill. people. 4.8 mill. ha of land belongs to these households. The average farm size is 1.39 ha, of which .89 ha is planted annually. Only 3.1 percent of the land is under irrigation. 36 percent of the households did not sell any products in the market, but produced only for subsistence consumption.

The commercial sector is made up of approx. 730 large farms, partly private and partly state owned. They control about 2 mill. ha agricultural land.

The dominating food crop is maize, which in value terms comprises more than 50 percent of the food crops. Other important food crops are paddy, beans, millet/sorgum, and cassava. Among the cash crops, cotton is the dominating crop, followed by coffee.

As part of the general liberalization and market-orientation of the Tanzanian economy, starting in the early 1980s, the agricultural sector has gone through substantial reforms. It has been argued that food production rose significantly between early 1980s and 1988 in response to this liberalization. Also the marketing system has undergone substantial changes, including a revision of the role of marketing boards. As an example, the private sector had by 1993 taken control of 90 percent of the grain market. Overall, the response to the liberalization and structural adjustment can be characterized as a modest recovery.

Related to the modeling of the agricultural sector, the recent developments imply that the Government has got fewer policy handles to influence the development in the sector (e.g., taxes, fixed prices). Generally, the role of the Government has become more one of facilitating the operation of markets rather than direct intervention.

8.4. Methods and work plan

The approach has been to use historical data for the period 1985-1995 and apply statistical methods (mainly regression analysis) to identify the variables which affect the level of agricultural production. The price and quantity data are taken from the revised national accounts. This process has been divided into three main steps:

1. Review of other studies and discussions with key persons about the potential relevance of different variables. This part was mainly done during the training course in Bergen in February-March 1997, which involved four economists or statisticians from Planning Commission, Bureau of Statistics, Ministry of Finance, and Bank of Tanzania.
2. Collection of relevant data. This was undertaken during a one week mission in Dar es Salaam, 28.4. - 2.5. 1997, in close co-operation with Mr. Oyoke of the Bureau of Statistics.
3. Statistical analysis, and - based on this - specification of the equations to be included in Macmod. The data analysis has been undertaken with the assistance of Narve Rio, CMI.

8.5. Data

The data to be used will cover the period 1985-1995, which is the period used for estimation of other parameters in Macmod, and for which relatively consistent national accounts data are available. This gives 11 observations, which is a very small number for regression analysis. It was therefore considered to combine time series and regional data (panel data analysis). Regional data are, however, for most variables not produced regularly. When available, they are often based on a regional breakdown according to some other variables (e.g., population or census data for a particular year). Using regional data would therefore introduce an additional element of uncertainty in the analysis, and it was decided to work only with national level data.

The analysis has focused on two sub-sectors of agriculture:

1. *Food crops;* GDP estimated at 764 billion Tsh in 1995 (current prices).
2. *Export crops;* GDP estimated at 119 billion Tsh, and comprising some 56 percent of Tanzania's total export (1995).

This implies that two sub-sectors which in terms of GDP contribution are more important than the export sector have been left out of the analysis:

1. *Other crops* (vegetables etc.); GDP estimated at 235 billion Tsh.
2. *Livestock,* which is important with an estimated GDP at 183 billion Tsh.

The production data for these sub-sectors are, however, based on simple extrapolations, using mainly (estimated) population growth. The annual growth rate of the livestock sector is around 3 percent in the period 1985-95 (being 2.74 percent for many years). This is close to the population growth rate, which is estimated at 2.84 percent for each year since 1989. 'Other crops' grows at an annual rate of 2.9-3.0 percent. The same method has also been applied to the two other sub-sectors within the primary sector: fishery and forestry. Forest based output is assumed to grow by 2.7

percent in most years, whereas fishery has a higher growth rate of approx. 4 percent. In other words, data reflect trends and not any annual fluctuations due to changing weather and market conditions. This makes an econometric analysis of these sectors of little value.

The following provides a discussion of data availability, sources, estimation procedure and quality for different variables to be used in the analysis.

8.5.1 Production quantities

Production data are provided by the Bureau of Statistics (BOS). A major source is the Household Budget Survey (HBS) of 1991/92. Data for the two sub-sectors have been estimated in the following manner:

1. *Food crops;* HBS data have been used to calibrate the production of various food crops in 1992. Annual changes for the 1985-95 period are estimated using production data from the Early Warning Unity within the Ministry of Agriculture.
2. *Export crops;* Data are obtained from different Boards. Generally the export data are considered the most reliable of the four sub-sectors.

Compared to previous national accounts data for agricultural production, the revision based on HBS data are considered to represent a significant increase in the agricultural sector estimates.

Production indexes for food and export crops were made using the average real price over the 1985-95 period for the different crops within each sub-sector as weights. This does not correspond to the standard national accounts procedures (using a base year), but is permissible and have some advantages for econometric analysis as done in this report.

8.5.2 Prices

Most price data are provided by BOS, which again is based on information from the Marketing Development Board.

Price indexes were in a similar manner made using average production for 1985-95 as weights.

8.5.3 Rainfall

Historical data for rainfall at various weather stations throughout the country are published by BOS (until 1993). Detailed record where also obtained during the stay from the Directorate of Meteorology, that is, monthly rainfall for the period 1985-1996 at 11 different locations. These will be used to estimate an annual rainfall rate for the country. The data should be quite accurate; the main problem lies in the fact that aggregate figure may hide important seasonal and regional variations.[1] We also used a more rough categorization of the rainfall in different years (good, normal, bad), and it turns out that this gives better predictions than actual rainfall.

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[1] The two main agricultural seasons are short rain (*Vuli*) and long rain (*Masika*) seasons, the harvest being in January-February and April-June, respectively. Thus the relevant rainfall season for a particular year should be from approx. September previous year to August current year. This is also the way the data are presented in the BOS report *Selected Statistical Series, 1951-1993.* March 1995.

8.5.4 Fertilizer use

Application of fertilizers could potentially have a large impact on agricultural production in Tanzania. The impression is, however, that following recent liberalizations the prices have increased to such high levels that ordinary farmers cannot afford to purchase them. Even though hard figures are difficult to get, the clear impression is therefore that fertilizer use has declined significantly over the last years. The privatization of fertilizer distribution and marketing has also made it more difficult to get data on actual use.

Since fertilizer use are not expected to explain much of the annual variation in production or to be very important for the short term (1-3 years, which is the time horizon of Macmod), it was decided *not* to give priority to search for data on this variable and include it in the analysis.

8.5.5 Infrastructure

Roads could provide better market access and thereby a stimuli for higher production. It is hard to find good proxies for this; one possibility is to use national investments on land improvement and roads (Economic Survey) which are already included in the MACMOD database. Some experimental runs including these variables in the regression analysis were done, but did not produce any significant results.

8.5.6 Rural credit supply

Cash constraints and lack of credit limit farmers use of purchased inputs. Credit supply could therefore be an indicator for the use of purchased inputs. No data were, however, obtained for the present analysis, although data may be obtained from the expanded monetary surveys done by Bank of Tanzania.

8.6. Methodological and estimation issues

8.6.1 Agricultural supply studies

There are numerous studies available on individual crop response in tropical agriculture, and also quite a few on aggregate supply. In general, they yield some basic results in accord with economic theory: the short term price response is smaller than the long term, and the aggregate (and sub-sector) price elasticities are smaller than the ones for individual crops.

There is, however, a lot of controversy on *how* responsive agricultural supply is to prices: some tend to believe that production is basically driven by survival needs (i.e. population size), whereas others suggest that farmers' aggregate supply is highly responsive to changes in prices. Empirical studies are not conclusive, and the price elasticities show great variation. As most of the output increase normally will come from an increase in agricultural area rather than in yield, the response will obviously depend on to what extent such an extensive margin exits. Tanzania seen as a whole has a large potential for expansion of agricultural land. As mentioned in section 3, the World Bank has estimated that only 13 percent of the potentially arable land is cultivated. There is, however, land shortage in some regions.

The evidence from studies of tropical agriculture suggests that short-run price elasticities are small for aggregate and sub-sectoral output, normally not more than 0.3 (see Mamingi, 1997). The long run elasticities can be much higher, and many have found elasticities up to 1.0 or even higher.

Besides prices (own and other crops/sub-sectors), a number of other variables are often included in the estimation of agricultural supply, and many are found to be (at least locally) important: population density, technology, income level, literacy, credit supply, road density, etc. According to Mamingi (1997), *'the three favorites'* are: own price, weather (rain), and a trend factor, reflecting technological progress and/or population growth. These three variables were the determinants of export crops production in the second version of Macmod, and are also the main ones used in the present analysis.

Many studies use lagged prices, that is, last year's price is used to explain this year's production. There are at least three good reasons for doing so. First, production is not instantaneous, and the prices are not known when decisions are made about which crops to plant, area size, inputs to be used, etc. Second, the problem of simultaneity of variables is a serious one when prices and quantities are from the same year, and simple reduced form equations are used: price is determined within a supply-demand framework, thus quantity may explain price more than price explains quantity. Third, forecasting is made easier as this year's price is used to predict next year's production.

8.6.2 Studies on agricultural production in Tanzania

Mamingi (1997) reports four different studies from Tanzania. Three are for individual crops and find elasticities of short term elasticities to be 0.35 (tea), 0.26 (cotton), and 0.21-0.28 (sisal), whereas the long term elasticities are 0.38 (cotton) and 0.48 (sisal). The aggregate short term supply elasticity is in a study by Lopez et al. (1991) found to be as high as 0.47, which contrasts the three individual crop studies.

Bagachwa et al. (1995) also contains an econometric analysis of the *area* cultivated (not output) response for a variety of crops. The own price elasticities vary from -1.3 for sorghum to 2.4 for paddy, most of them being in the range between 0.3 to 1.0.

Angelsen et al. (1996) is a panel data study of area expansion in the period 1981-1991. They find a price elasticity of about 1.0; this is, however, reduced to less than half when population growth is included in the regression equation.

8.6.3 Some specific problems of the present study

As normally is the case, data availability/quality was a major constraint in the present analysis. Some of the quantity (and price?) data are estimated, using some proxies to extrapolate data from the household survey.

Another significant constraint is the small number of observations (11 years; 10 when using lagged variables), which reduces the number of independent variables that can be included. Related to this, the small number of degrees of freedom also makes it hard to get statistically significant results, even with only 2-3 explanatory variables.

8.7. Results

Due to the above mentioned specific problems with the present study, in addition to the general uncertainty involved in econometric analysis of this type, dozens of different regression equations were attempted for the two sub-sectors selected for analysis. The idea has been to explore the range of coefficient values under different assumptions:

First, linear and logarithmic versions were attempted. Generally the fit and significance in terms of (adjusted) R^2, F- and t-values were about the same, and the coefficients were also in the same order (the coefficients in the linear equations being transformed to elasticities at means, to make them comparable to the logarithmic equations). It was therefore decided to use the logarithmic version since the coefficients are more easily interpretable, and one could also argue that it corresponds better with economic theory to assume fixed percentage effects rather than fixed absolute effects of, say, price changes.

Second, a number of different variables and in different forms (lagged – non-lagged) were also explored. Error correction and partial adjustment models were to some extent explored, but in general they failed to yield any statistically significant results although some of them gave quite meaningful coefficient values.[2]

Given the quality of data, one may risk using sledgehammers to crack open (or maybe rotten) peanuts. We did therefore not enter into more advanced methods of time series analysis. In the end, we settled for a relatively simple model of using three explanatory variables for both the food and export sub-sectors:

- Previous year's price index for sub-sector
- Rainfall: bad-normal-good year
- Trend

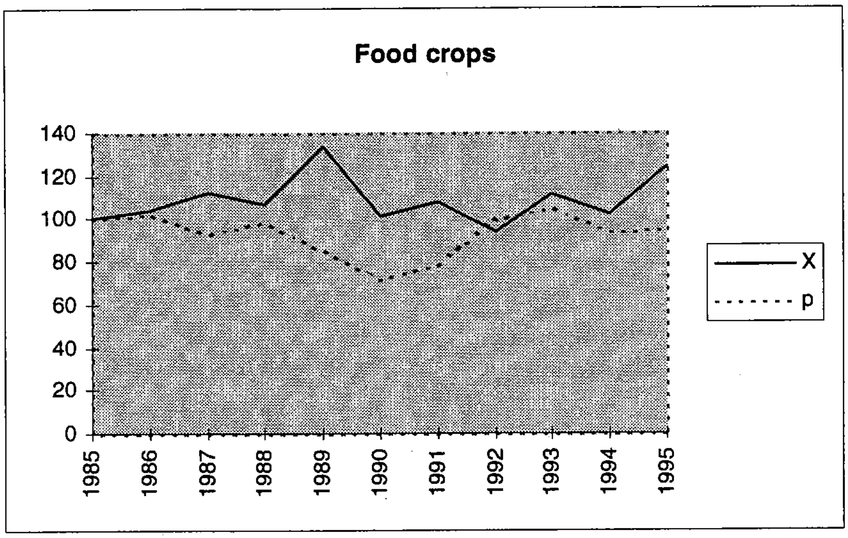
These three variables turned out to be the most economic significant (large coefficients) and statistically significant (high t-values). The latter were not, unfortunately, always satisfactory at standard levels of significance, reflecting the small sample size.

8.7.1 Food crops

The development of the quantity and price index for food crops is shown in figure 8.1 below (see also annex).

[2] An error correction model has the form: $x_t = b_1 + b_2p_t + b_3p_{t-1} + b_4x_{t-1}$ + dummies + error term, the intuition being that adjustment to the new prices (a new equilibrium) takes time.

Figure 8.1



The graph displays that there has been no clear trend in either the price or quantity variables. The production peaked in 1989, but fell and reached its lowest point in 1992 (a drought year).

Using standard OLS regression analysis to look in more details how the three variables above have influenced food crops production gave the following result (see annex for list of variables):[3]

Dep Var: XLN_FOOD N: 10 Multiple R: 0.696 Squared multiple R: 0.484

Adjusted squared multiple R: 0.226 Standard error of estimate: 0.090

Effect	Coefficient	Std Error	td Coef	Tolerance	t	P(2 Tail)
CONSTANT	6.253	2.193	0.0	.	2.851	0.029
PLNLA_FOOD	0.263	0.243	0.322	0.975	1.083	0.321
DROUGHT	0.080	0.040	0.621	0.886	1.993	0.093
TREND	0.009	0.010	0.273	0.887	0.876	0.415

Analysis of Variance

Source	Sum-of-Squares	DF	Mean-Square	F-Ratio	P
Regression	0.045	3	0.015	1.874	0.235
Residual	0.048	6	0.008		

** WARNING ***

Case 5 is an outlier (Studentized Residual = 2.110)

Durbin-Watson D Statistic 2.892

First Order Autocorrelation -0.538

First, one notes that only DROUGHT (a variable which is *-1* in years with below-

[3] The analysis was done using the statistical package SYSTAT®.

normal rain, *0* in normal years, and *1* in years with above-normal rain) is statistically significant at the 5 percent level (1 tail test). The impact of rainfall is also significant in economic terms, a good/bad year increases/reduces the harvest by some 8 percent.[4]

Second, the price elasticity found (0.26) corresponds well with both the general studies and specific studies on Tanzania. A third, and possibly the most surprising, result is that the trend factor is small and statistically insignificant.

A number of variations of this equation were employed. One was to distinguish between good and bad years of rain (i.e. make two dummies, with the value of one in good and bad years, respectively). This gave the following result:

Dep Var: XLN_FOOD N: 10 Multiple R: 0.750 Squared multiple R: 0.563

Adjusted squared multiple R: 0.213 Standard error of estimate: 0.090

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	6.049	2.221	0.0	.	2.723	0.042
PLNLA_FOOD	0.287	0.246	0.351	0.965	1.166	0.296
TREND	0.013	0.011	0.372	0.799	1.126	0.311
GOOD_RAIN	0.032	0.065	0.164	0.815	0.501	0.637
BAD_RAIN	-0.153	0.086	-0.631	0.687	-1.770	0.137

Analysis of Variance

Source	Sum-of-Squares	DF	Mean-Square	F-Ratio	P
Regression	0.053	4	0.013	1.610	0.304
Residual	0.041	5	0.008		

*** WARNING ***

Case 5 is an outlier (Studentized Residual = 3.541)

Durbin-Watson D Statistic 2.909

First Order Autocorrelation -0.509

This result suggests an asymmetry in which the negative impact of a bad year is much larger than the positive impact of a good one. Note, however, that only two years are categorized as bad, whereas four are good, and four normal (five when including 1985). Further, only the coefficient for bad rain is statistically significant at the 10 percent level (1 tail test).

Excluding 1989, which is an outlayer, did not improve the fit. The coefficient values were lowered: the weather coefficient was lowered to 5.8 percent and the price elasticity to 0.21.

The correlation matrix shows a negative, but weak, correlation between food production and food prices (-0.087), as also indicated by the above figure. One could make the hypothesis that the price fluctuations are mainly caused by variation in supply, whereas demand is inelastic and has small random fluctuations. The annual price fluctuations could therefore be explained as movements along a more or less

[4] One should note that drought (rainfall) affects different food crops quite differently: cassava, millet, sorgum and some maize varieties are fairly drought resistant, whereas rice is not.

stable demand curve, hence a *negative* correlation between food production and prices could be expected. Including the current year's price of food crops gave a very low coefficient value and a t-value close to zero. Thus this hypothesis is *not* confirmed by the analysis. Including this variable did not have any major impact on the other coefficients.

Another hypothesis is that there exists a trade-off (competition for land and labor) between export and food crops, that is, high prices of export crops (possibly lagged) would result in lower production of food crops. As expected, inclusion of lagged export prices gave a negative coefficient, but the elasticity was very low (-0.1), and far from being statistically significant. It increased the direct price elasticity to 0.35, and the trend variable to 1.5 percent.

The replacement of the variable DROUGHT with RAIN (rainfall in mm), reduced the fit in terms of lower (adjusted) R^2. The elasticity for rainfall was 0.77, whereas the direct price elasticity increased (compared to the base run) to 0.39 and the trend to 1.5 percent.

The linear model gave a value for the trend variable of 1 percent, for the DROUGHT of 8.4 percent and a price elasticity of 0.28 (elasticities at means), which are close to the results of the logarithmic model. Using rainfall instead of drought in the linear model, however, increased the trend variable to about 1.6 percent (as it did in the logarithmic model).

Finally, we ran regressions with each of the independent variables at the time. This will yield biased estimates of the coefficients, but on the other hand have lower variance – the extent of this depending on the correlation between the independent variables. The climatic variable again stands out as the most significant, with a coefficient of 7.7 percent (t-value 2.1); splitting this into good and bad years resulted in factors of 6.4 and –9.4 percent, respectively. The price elasticity was also close to the base equation; the elasticity was 0.3, but still not statistically significant (t-value 1.1). The trend factor was only 0.5 percent (0.5) and not significant. The lower value of the trend factor compared with the base equation is explained by the fact that drought and trend are negatively correlated (see correlation matrix in appendix), thus some of the impact of bad rain is included in the trend factor when only the latter is included in the regression.

In conclusion, the overall fit for the variables included in the analysis of food production is not too impressive. Rainfall is the most significant variable, even though the exact magnitude of the effect of a good/bad year is hard to determine. Lagged price has some impact, and the price elasticity (lagged) seems to be in the range of 0.25-0.4. The trend factor is varying around 1 percent, but not statistically significant, and surprisingly low compared to the annual population growth of 2.7-2.8 percent.

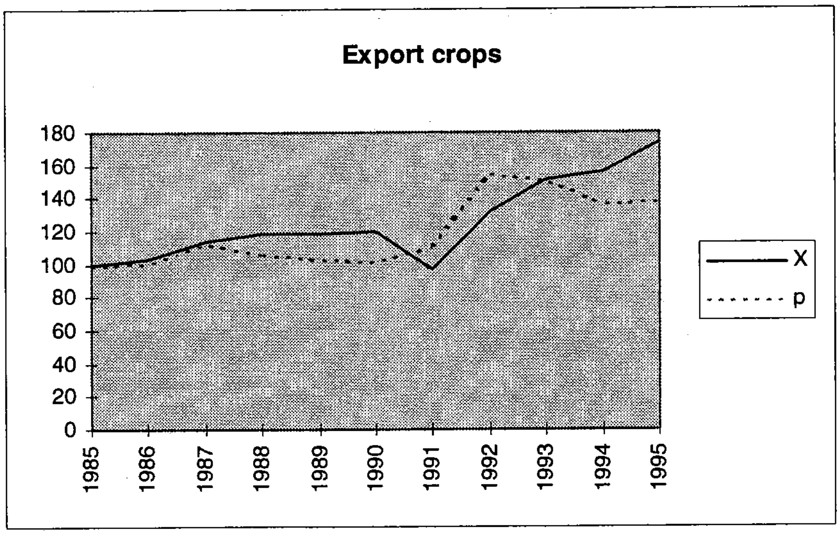
8.7.2 Export crops

Figure 8.2 below illustrates the development in price and quantity index of export crops. Contrary to food crops, there is a clear upward trend in the production: the production of export crops is 74 percent higher in 1995 than in 1985. Except for 1991, the production has increased every year.[5] With regard to prices, 1991/1992 appears to

[5] To be correct, there was also a very small decrease in 1989 of 0.2 percent.

be a watershed: in 1992 the price index increase by 41 percent, whereas it shows no clear trend in the periods before and after that year.

Figure 8.2



Using the same explanatory variables as for food crops, that is, own price (lagged one year), qualitative assessment of rainfall (DROUGHT), and a trend factor, in the regression analysis gave the following result for export crops (logarithmic model):

Dep Var: XLN_EXP N: 10 Multiple R: 0.901 Squared multiple R: 0.812

Adjusted squared multiple R: 0.719 Standard error of estimate: 0.099

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	-1.535	2.880	0.0	.	-0.533	0.613
PLNLA_EXP	0.688	0.316	0.632	0.372	2.179	0.072
DROUGHT	0.032	0.044	0.135	0.881	0.717	0.500
TREND	0.022	0.018	0.356	0.372	1.228	0.265

Analysis of Variance

Source	Sum-of-Squares	DF	Mean-Square	F-Ratio	P
Regression	0.253	3	0.084	8.663	0.013
Residual	0.058	6	0.010		

*** WARNING ***

Case 7 is an outlier (Studentized Residual = -5.337)

Durbin-Watson D Statistic 2.736

First Order Autocorrelation -0.431

First, one notes that the fit is much better than for food crops (although one generally should be very careful with comparing (adjusted) R^2 when the dependent variables are different). The F-ratio is also satisfactory.

Second, the coefficient values are also quite different; the price elasticity is about 0.7, and also the trend factor is significantly higher. The impact of rainfall is, however, lower than for food crops. These differences can be given intuitive economic explanations. In particular, the higher price sensitivity for export crops can be due to the fact that these are guided by a profitability calculus rather than a subsistence logic as for food crops (even though markets exists also for food crops).

Excluding the outlier (1991, which had a low production), improved the adjusted R^2 to 0.78, and increased the price elasticity to 0.96 and the effect of drought to 7.7 percent, whereas the trend factor was reduced to 1.0 percent. Thus the results are sensitive to whether this year is included or not.

Using a linear model gave results not too different from the logarithmic version. The elasticities at means were 0.62 for own lagged price, whereas the drought and trend factors were 4.1 and 2.8 percent, respectively.

Including current year's export price slightly lowered the lagged price elasticity (0.58), whereas the drought increased to 6.8 percent and the trend factor was reduced to 1.0 percent annual growth. The elasticity of current export price was quite high (0.44), but the t-value was low (1.1) and the adjusted R^2 at about the same level (72 percent), suggesting that it may be left out.

Replacing the DROUGHT variable with two dummies for good and bad years gave the following result: The effect of a good year was to increase production by 9.6 percent, whereas a bad year also *increased* it by 6.3 percent, the latter, however, being far from statistically significant (t-value of 0.7). The price elasticity was 0.77 (and significant at 5 percent level), whereas the trend factor was 1.4 percent (and not significant). Excluding 1991 in this analysis, made the bad-year coefficient slightly negative, and still far from being significant. The good-year coefficient was 10.5 percent, while price and trend factors were close to the ones when 1991 is included.

Using actual rainfall instead of the more subjective variable DROUGHT reduced the (adjusted) R^2 and gave a statistically insignificant (and positive) coefficient for rainfall (t-value of 0.26). The price and trend factors were almost identical to the base equation.

Finally, production of export crops were regressed using each of the three variables at the time. The price variable was found to be the most significant, with an elasticity of 0.95, and a high t-value (5.0) and adjusted R^2 (72 percent), which means that the latter is as high as when all three variables are included in the equation. The trend factor was also found to be significant with an annual increase of 4.8 percent (t-value of 4.6 and adjusted R^2 of 67 percent). The DROUGHT variable was negative (!) and insignificant, with an adjusted R^2 of zero. The higher values for price and trend compared to the base equation follow from the fact that these two variables are highly correlated (0.78)., cf. annex.

In conclusion, the export crop production is strongly influenced by last year's price and a positive trend factor, whereas there was little evidence on the impact of the weather variable.

8.8. Summary and suggested revisions of Macmod

There is a general consensus on the need to improve the modeling of the agricultural sector in Macmod, and that this could represent a significant improvement of the model. At the same time, the difficulties involved in making predictions about agricultural production is realized. As expected, data availability and quality was a major constraint in the work. Nevertheless, data for the major variables, that is production quantities, prices and rainfall seem to be of acceptable quality for inclusion in the analysis.

The formal results of the regression analysis should be interpreted with great caution. The final decision on which variables to include in Macmod and the parameter values should be taken not only based on this analysis, but also on similar studies, sound economic intuition, and knowledge about the Tanzanian agricultural sector and economy.

The main suggestion from this report is to revise Macmod in order make the production of food and export crops depending on three variables:

- an index of last year's prices of the sector;
- a qualitative variable for rainfall (as now);
- a trend factor.

These variables are both common in econometric analysis of agricultural supply, and also turned out to be the most significant variable for which data were available for the present analysis. Furthermore, data for making predictions for the next year should be readily available, except for rainfall, for which one will assume a normal year and then update the estimate if rainfall turn out to be significantly different from average.

The results of the analysis of the values of these parameters are presented in the table below. Each of the recommended parameter values is then discussed.

	Base equation	**Range in experimental equations**	**Recommended parameter in MACMOD**
Food Crops:			
Own price elasticity (lagged)	0.26	0.21 - 0.39	0.3
Rainfall (drought)	8.0 percent *	5.8 - 8.4	Good year: 3% Bad year: -3 % Drought: -8 %
Trend	0.9 %	0.9 - 1.6 %	1 %
Export crops:			
Own price elasticity (lagged)	0.69 *	0.58 - 0.96	0.7
Rainfall (drought)	3.2 %	3.2 - 7.7 %	Good year: 2 % Bad year: - 2 % Drought: - 6 %
Trend	2.2 %	1.0 - 2.8 %	2 %

* Significant at 10 percent level.

The most significant revision of Macmod should be the inclusion of **price** responses in the agricultural sector. The suggested elasticity for the **food crop** sector is **0.3**, which is in the upper end of what agricultural supply studies in general find, but in the middle range of other studies on Tanzania. A smaller price elasticity may, however, be considered.

Previous versions of Macmod have included **rainfall** as a variable, assuming that a good year in terms of rainfall would increase production by 2 percent, a bad year decrease it by 2 percent, whereas drought would decrease production by 6 percent The results indicate that the variations in agricultural output due to fluctuations in rainfall may be even larger than assumed in previous Macmod versions. The large annual variations are also seen from the production index in the appendix. It is therefore suggested to increase the rainfall adjustments to **3, - 3 and - 8 percent,** respectively.

A **trend** factor is suggested to be included, reflecting mainly population growth. If food prices do not increase (and rainfall not increase!), the suggested trend of **1 percent** implies a *decline in per capita food production* which should be explained and justified. One reason is that land in some areas is a limited, and even though if labor increases, the overall output increase will be smaller. Another reason may be a switch from food crops to export crops, which has clearly been taking place during the past decade.

For **export crops**, the results on the **price** elasticity are more convincing than for food crops, and a value of **0.7** seems to be reasonable.

The impact of **rainfall** appears to be smaller than for food crops, and it is suggested to maintain the fluctuations as included in the present version of Macmod.

Finally, the **trend** factor is suggested to be set at **2 percent**. The experimental regression showed some variation, but trend was found to have an impact in all regressions.

For **other sectors** of agriculture, the data did not permit any econometric analysis. It is therefore suggested to continue using trends and weather only. 'Other crops' is probably comparable to food crops production, and the weather impact could be made similar to that. The small trend factor found for food crops (1 percent) questions the use of the presently rates of extrapolating data (around 3 percent), and one should consider reducing the trend factor for 'other crops'.

Annex 1

Variables, core model, SS-DD block and sector block

Endogenous:

adj =	excess supply
CM =	imports of consumer goods
CA =	current account on the balance of payment
ΔCOM =	real growth, transport, storage and communication
ΔCON =	real growth, construction
DREV =	government domestic revenue
e =	the real exchange rate
E =	the nominal exchange rate
ΔEC =	real growth, export crops
ΔE&W =	real growth, electricity and water
ΔFC =	real growth, food crops
ΔFI =	real growth, finance, insurance etc.
G =	total government expenditure
ΔGBB =	government bank borrowing
GDPD =	GDP deflator
$\Delta GDPD$ =	percentage change in the GDP deflator
GDPfc =	GDP at factor cost
GFR =	government financing requirement
GNBB =	the outstanding stock of government non-bank borrowing
INTM =	imports of intermediate goods and services
INVM =	imports of investment goods
K =	the capital stock valued at constant 1992 prices
KA =	capital account on the balance of payment
L_d =	labor demand
M =	total imports
M_d =	money demand
M_{sd} =	money supply local component
ΔMA =	real growth, manufacturing
ΔMI =	real growth, mining
NFSM =	imports of non-factor services
NFSX =	exports of non-factor services
NTX =	non-traditional exports
ΔOTH =	Real growth, other agriculture
P =	consumer price index
$\dot{P}$ =	consumer price inflation
P_c =	price of capital goods
ΔPA =	real growth, public administration etc.
$P\dot{p}$ =	producer price inflation, local = MC = marginal cost
P_m =	market price, local goods
PBB =	credit to private sector
PC =	real private consumption
PI =	real private investment
r =	the real interest rate

$\dot{T}_j$ = change in tax index j. j = cm, intm, l, invm

ΔTR = real growth, wholesale and retail trade, hotels and restaurants.

TX = traditional exports

$\dot{w}$ = the wage rate inflation

X = total exports

Y= Real GDP at market prices

$\overline{Y}$ = Capacity output

$\hat{Y}$ = Gross output (including imported intermediates)

Exogenous

A = productivity level

BOP = overall balance on the balance of payments (= 0 in equilibrium)

FTR = total transfers from abroad, USD

FTRG = transfers from abroad to government; USD

FTRP = transfers from abroad to private; USD

GC = government consumption

GI = real government investment

GFB = stock of government foreign borrowing, USD

GTRP = government transfers to private

L = the labor force

M_s = money supply

NFA = net foreign assets, weeks of import coverage

P_{tx} = world market price index for export crops

P_w = "world" consumer price index

q_i = Compliance rate for tax revenue, item i

r_f = world market interest rate

Rain = weather conditions dummy

RESC = rescheduling of external debt, USD

s = the household savings rate

t_{cm} = effective ad valorem import tax on consumer goods

t_y = effective tax on income

t_l = effective ad valorem tax on local goods

t_{intm} = effective ad valorem import tax on intermediate goods

t_{oth} = other taxes

tr_i = trend growth sector i. i = export crops, food crops, other agriculture, mining, manufacturing, electricity and water.

tr_j = shift parameter, export functions. j = TX, NTX, NFS

TRNFSX = trend, exports of non-factor services

TRNTX = trend, non-traditional exports

TRTX = trend, traditional exports

δ = the depreciation rate of capital

Parameters

a_1 = the capital share of GDPfc

a_2 = the labor share of GDPfc

$\hat{a}_1$ = the capital share of gross output

$\hat{a}_2$ = the labor share of gross output

$\hat{a}_3$ =	imported intermediate goods share in gross output
a_4 =	import share of investment demand
α_1 =	degree of international capital mobility
α_2 =	degree of concessionary terms on foreign borrowing
α_4 =	impact of power and water shortages on the growth rate of manufacturing
cm_p =	price sensitivity, imports of consumer goods
cm_y =	marginal propensity to import consumer goods
$intm_p$ =	price sensitivity, imports of intermediate goods
$intm_y$ =	marginal propensity to import intermediate goods
m_r =	interest sensitivity, money demand
m_y =	income sensitivity, money demand
$nfsm_p$ =	price sensitivity, imports of non-factor services
$nfsm_y$ =	income sensitivity, imports of non-factor services
$ntxp_p$ =	price sensitivity, non-traditional exports
$nfsx_p$ =	price sensitivity, non-factor services
pi_y =	income sensitivity, private investment
pi_{ftrp} =	foreign transfers sensitivity, private investment
pi_r =	interest sensitivity, private investment
$rain_i$ =	sensitivity of output growth to weather conditions sector i. i = export crops, food corps, other agriculture, electricity and water.
σ_1 =	wage increase elasticity to consumer price inflation
σ_2 =	wage increase elasticity to excess demand
tx_p =	price sensitivity, traditional exports
y_{rain} =	shift parameter capacity output growth sensitivity to weather conditions

Annex 2

Solving the IS-LM-BP model.

Combining the IS and LM equations yields:

$$Y = k_e e + k_m \frac{\overline{M}_s}{P} + k_f EXOGIS \qquad \text{A2.1}$$

Combining the IS and BP equations yields:

$$Y = \kappa_e e + \kappa_f EXOGIS + \kappa_t EXOGBP \qquad \text{A2.2}$$

Combining these two equations determines the real exchange rate as a function of parameters and exogenous variables only as follows:

$$e = \frac{1}{\kappa_e - k_e}\left(k_m \frac{\overline{M}_s}{P} + (k_f - \kappa_f) EXOGIS - \kappa_t EXOGBP \right) \qquad \text{A2.3}$$

The result is substituted into A2.1, which then gives the real output of the economy. Finally, Y and *e* are substituted into the IS equation, and the interest rate is found.

The parameters in equations A2.1 - A2.3 are determined as follows:

$$k_f = \frac{1}{fm_y / m_r + k}$$ The fiscal multiplier

$$k_m = \frac{1}{m_y + m_r k / f}$$ The monetary multiplier

$$k_e = \frac{1}{\frac{f}{b}\frac{m_y}{m_r} + \frac{k}{b}}$$ The trade multiplier

The following parameters are adjustments to the familiar IS-LM multipliers when the balance of payments restriction is added:

$$\kappa_f = \frac{1}{\gamma f / \beta + k}$$

$$\kappa_t = \frac{1}{\gamma + \beta k / f}$$

$$\kappa_e = \frac{\beta b + \lambda f}{\gamma f + \beta k}$$

Annex 3

Estimating the capital stock

The capital stock was estimated on the basis of Kaldor's stylized fact that the capital/output ratio is constant over time and across countries. The procedure is as follows:

First, the capital stock was estimated applying

$$\frac{\dot{Y}}{Y} = a_1 \frac{PI + GI + EFDI}{K} + a_2 \frac{\dot{L}}{L}$$

We abstract from productivity growth, which appears to be reasonable in this context. All the variables in the equation, except one, the capital stock K, are known (GDP growth on the left hand side of the equation; private, government and foreign investment, the labor force growth rate and the shares of labor and capital in GDP on the right-hand side are known). The equation can therefore be solved for the capital stock. However, since capacity utilization is generally much less than unity and investment is fluctuating substantially from one year to the next, a single year would give a somewhat arbitrary measure of the capital stock. In order to improve the estimate, we estimated the stock for every year between 1985 and 1996.

Next we compared the change in capital stock from one year to the next, net of depreciation, assumed to be 5 percent, resulting from this method to actual investment as reported in the national accounts.

When the labor and capital shares given in the national accounts and presented in table A3.1 below were used, a very large discrepancy between the two estimates appeared. In fact, depreciation according to the capital stock estimate was larger than investment according to the national account. Unless we believe that the capital stock actually declined during the period in question, our first estimates appears to overestimate the capital stock to a great extent.

Table A3.1

Factor shares of output as reported in the National Accounts.

Year	Capital	Labor
1985	0.82	0.18
1986	0.85	0.15
1987	0.86	0.14
1988	0.89	0.11
1989	0.92	0.08
1990	0.90	0.10
1991	0.91	0.09
1992	0.90	0.10
1993	0.88	0.12
1994	0.88	0.12

The large capital share in this table is presumably due to the large share of agriculture in GDP, where it may be difficult to distinguish between returns to land, resource rent and the contribution from labor.

Our second estimate is therefore based on Kaldor and other's observation that the capital share of GDP is fairly stable across countries at about a third. Hence we repeated the exercises reported above with capital and labor shares in total output at a third and two thirds respectively. This gave us estimates of the change in capital stock from one year to the next much closer to the investment data from the national accounts.

In order to improve our estimate further, we picked the year in which the discrepancy between the two estimates of investment was the lowest (1988, 13 percent) and used that as a basis for further estimates. Thus, our estimate of the capital stock by the end of 1989 is the 1988 estimate less depreciation plus real investment during 1989. The same method is applied for all subsequent years. The result is presented in table A3.2

Table A3.2
Estimated capital stock, Tsh mill.

Year	Estimated capital stock, 1992 prices
1992	2140178
1993	2331260
1994	2514769
1995	2640669

Annex 4

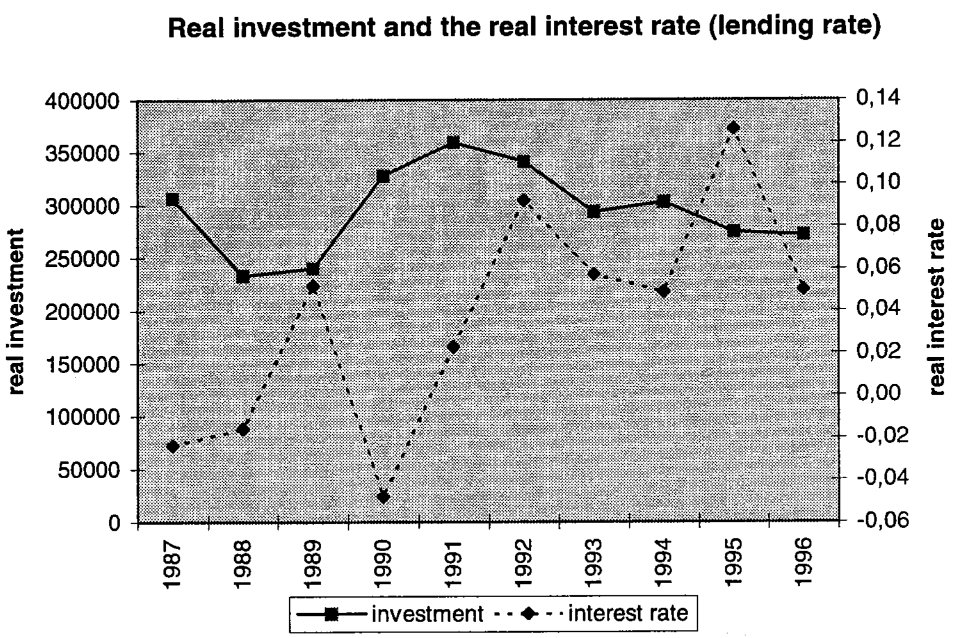
Specification of parameters

Several techniques for parameter estimations are applied depending on available data and what turned out to be reasonable. The following procedure was followed:

Behavioral equations were first estimated by means of OLS regressions. Where this gave reasonably good fits, acceptable significance levels and parameters with the correct sign (from a theoretical point of view) the regression results are applied. They are, however run on relatively short time series (1987-1996), and should be updated as new data become available.

Two areas of particular difficulty related to estimating behavioral functions are investment and international trade. From theory, there should be a negative correlation between the real interest rate and private investment. As figure A4.1 illustrates, the two variables appear to be unrelated, and indeed the correlation coefficient between the two is close to zero (-0.075).

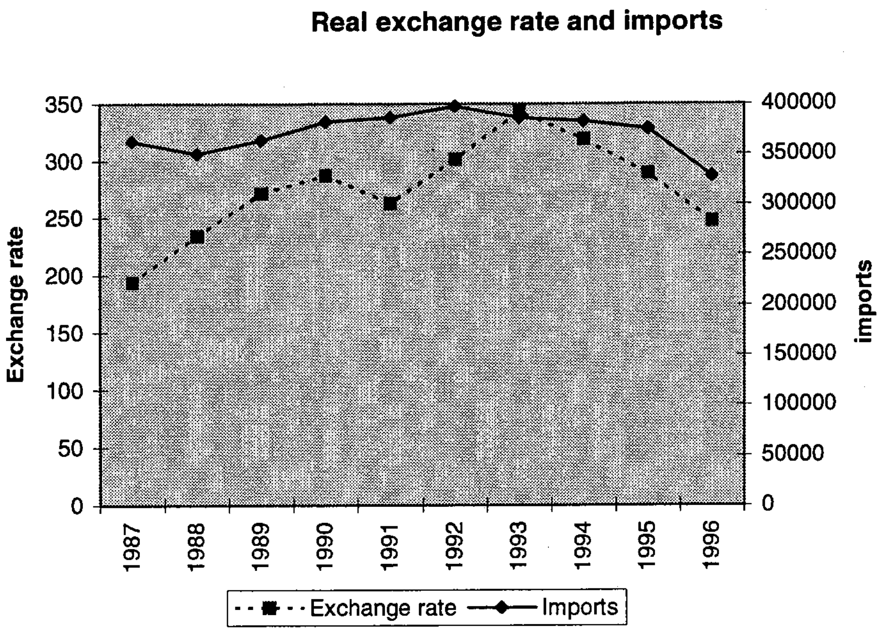
Figure A4.1



As a consequence, it was not possible to find significant parameter values for the investment function through regression methods on available data. Moreover, also calibration (see below) produced interest-inelastic investment demand.

Turning to trade and the exchange rate, theory predicts a negative correlation between the real exchange rate (measured in local currency per US $) and imports, and a positive correlation between the real exchange rate and exports. However the Tanzanian data over the past decade suggest that other developments have dominated the impact of the exchange rate effects, particularly as far as imports are concerned. Here the regression tuned out parameter estimates with the wrong sign. This is most likely explained by increased inflows of transfers from abroad and possibly increased import capacity from unregistered exports, particularly from the mining sector. Figure A4.2 below plots the real exchange rate with base year 1992 and imports at constant 1992 prices. The figure suggest a positive correlation between imports and the real exchange rate. The correlation factor between the two is in fact 0.62.

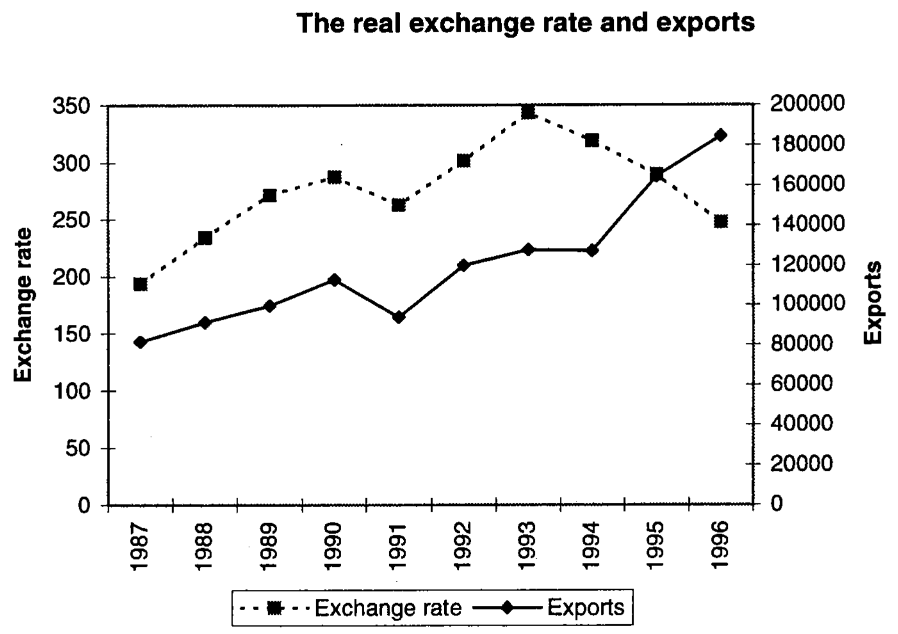
Figure A4.2



Should this result be incorporated in the model? E.g. should we let the exchange rate elasticity of imports have positive sign? This would have given us a model in which solutions would be difficult to find, and if a solution could be found, it would be unstable. Thus, the adjustment process following policy measures or exogenous shocks would most likely have pushed the economy further away from equilibrium. Therefore, the regression result for imports could not be used, and again we resorted to calibration.

Exports appear to behave more according to expectation, at least up to 1993. Since 1993, however, export growth has accelerated in spite of a relatively sharp appreciation of the real exchange rate, as shown in figure A4.3. This can to some extent be explained by favorable commodity prices during this period. Furthermore, this trend appears to have been reversed in 1997. To summarize the statistical analysis of trade behavior, the correlation coefficient between exports and the real exchange rate and imports and the real exchange rate have the same sign and it is strongest for imports (0.33 for exports and 0.62 for imports).

Figure A4.3



We have just presented three cases where regressions did not produce reasonable results. Where regressions did not give plausible results, the following procedure was followed:

a) Parameters considered constant over time were estimated as period averages. This applies to parameters such as the import content of demand for capital goods and the share of capital and labor in GDP.

b) Parameter values were sought in the literature for similar models in similar countries; or

c) "Guesstimates" on the background of the theories on which the model is built and knowledge of the Tanzanian economy were made.

d) All the parameters derived from regressions, and methods a-c above were applied for estimating the endogenous variables of the model for the three latest year for which a full set of data is available, 1994, 1995, 1996.

e) The model was then calibrated to reproduce the actual figures for these three years by adjusting the parameters derived from methods b and c above, while reasonable regression results and parameter estimates from method a) were maintained.

Parameter estimates and corresponding elasticities for the trade equations are presented in table A3.1:

Table A3.1

Parameter	Value	Elasticity, 1996
tx_p	292	1
ntx_p	300	1
$nfsx_p$	580	1
cm_p	345	1
$nfsm_p$	100	0.1
cm_y	0.13	2.2
a_3	0.05	
$nfsm_y$	0.17	1.1
a_4	0.5	
α_1	303822	
α_2	0.33	

The discussion above suggests that the exchange rate elasticity of both imports and exports are low. Nevertheless, we have calibrated the model to produce exchange rate elasticities around unity for both exports and imports. The partial derivatives are adjusted for each year in the projections (with a one year lag) in order to maintain the elasticity at unity around the equilibrium point. This is because empirical evidence from a number of countries suggest that import demand and export supply are price elastic, but that a number of omitted explanatory variables in the export and import function overshadow the response to changes in prices. We can control for such variables by means of the interception term in the functions. The income elasticity of imports, however, is relatively high. This implies that there is a structural current account deficit problem in the economy. Hence, the current account deficit tends to widen as income expands because expansion requires imports of intermediate and capital goods, while export growth is not sufficient to narrow the current account deficit unless there is a significant depreciation of the shilling. Note that the real exchange rate in 1996 was about at the same level as in 1988, when it was believed to be significantly overvalued. Moreover, the real exchange rate has further appreciated in 1997.

Table A3.2 Parameters and elasticities, investment, the money market and production

Parameter	Value	Elasticity, 1996
pi_y	0.18	1
pi_{ftrp}	1	0.1
pi_r	154462	0.1
m_y	0.18	1.2
m_r	213227	0.2
a_1	0.31	
a_2	0.64	
a_3	0.05	

Note the low income derivative of money demand. King and Levine (1993) found that the average ratio M2/GDP in "very poor" countries was 0.26 in 1985. In

Tanzania the ratio has been less than 0.20 on average over the past decade, indicating very weak financial development, even by least developed country standards .

Annex 5

Annexes to chapter 8

List of variables

X quantity
P price
LA lagged one year
LN logarithm
FOOD food sub-sector index
EXP export sub-sector index
OTH index for other crops
RAIN rainfall (average September-August)
DROUGHT dummy variable (-1 bad year, 0 normal year, 1 good year)

Correlation matrix

Pearson correlation matrix

	X_FOOD	X_EXP	X_OTH	P_FOOD	P_EXP
X_FOOD	1.000				
X_EXP	0.190	1.000			
X_OTH	0.045	0.851	1.000		
P_FOOD	0.087	0.342	0.018	1.000	
P_EXP	-0.212	0.729	0.739	0.526	1.000
P_OTH	0.177	-0.508	-0.476	-0.181	-0.612
PLA_FOOD	0.349	0.353	-0.063	0.470	-0.007
PLA_EXP	0.103	0.857	0.783	0.434	0.713
PLA_OTH	0.314	-0.538	-0.505	-0.544	-0.577
RAIN	0.372	-0.539	-0.615	-0.467	-0.633
DROUGHT	0.570	-0.164	-0.379	-0.318	-0.608
TREND	0.037	0.829	0.975	0.038	0.767

	P_OTH	PLA_FOOD	PLA_EXP	PLA_OTH	RAIN	DROUGHT	TREND
P_OTH	1.000						
PLA_FOOD	-0.122	1.000					
PLA_EXP	-0.473	0.423	1.000				
PLA_OTH	0.444	-0.143	-0.572	1.000			
RAIN	0.103	-0.066	-0.643	0.676	1.000		
DROUGHT	0.235	0.106	-0.326	0.482	0.753	1.000	
TREND	-0.565	-0.119	0.777	-0.456	-0.556	-0.326	1.000

Number of observations: 10

Data

	Quantity index			Price index			Rain-fall (mm)	Drought (-1=bad 0=normal 1=good)
	Food crops (maize eq.)	Export crops (coffee eq.)	Other crops (banana eq.)	Food crops	Export crops	Other crops		
1985	5,477	127	5,308	8,772	10,382	7,550	1,201	0
1986	5,693	131	5,435	8,999	10,459	6,405	1,186	1
1987	6,147	144	5,982	8,175	11,711	5,658	1,202	0
1988	5,865	151	6,225	8,611	11,127	12,146	1,009	0
1989	7,297	150	6,158	7,509	10,703	9,587	1,208	1
1990	5,535	153	6,404	6,311	10,645	7,159	1,210	1
1991	5,882	123	6,464	6,884	11,425	6,739	1,142	0
1992	5,124	167	6,673	8,764	16,096	5,663	1,030	-1
1993	6,126	191	6,860	9,244	15,677	4,890	1,080	0
1994	5,618	198	7,175	8,268	14,238	4,359	946	-1
1995	6,787	220	7,278	8,308	14,306	4,380	1,096	1
Growth (annual percentage increase)								
1986	3.93	3.29	2.38	2.59	0.74	-15.16		
1987	7.99	9.92	10.07	-9.15	11.97	-11.66		
1988	-4.58	4.73	4.05	5.33	-4.98	114.67		
1989	24.41	-0.24	-1.08	-12.80	-3.81	-21.07		
1990	-24.14	1.65	3.99	-15.95	-0.54	-25.33		
1991	6.27	-19.38	0.95	9.07	7.33	-5.86		
1992	-12.89	35.43	3.22	27.31	40.88	-15.98		
1993	19.56	14.42	2.80	5.47	-2.61	-13.64		
1994	-8.30	3.79	4.59	-10.55	-9.18	-10.86		
1995	20.81	11.23	1.45	0.48	0.48	0.48		

Index; 1985=100				
	Food crops		Export crops	
	X	p	X	p
1985	100	100	100	100
1986	104	103	103	85
1987	112	93	114	75
1988	107	98	119	161
1989	133	86	119	127
1990	101	72	121	95
1991	107	78	97	89
1992	94	100	132	75
1993	112	105	151	65
1994	103	94	156	58
1995	124	95	174	58

Bibliography and references

Angelsen, E.F.K Shitindi, and J. Aarrestad, 1996, 'Causes of Deforestation: An Econometric Study from Tanzania'. Paper presented at the Annual Conference of the Norwegian Association for Development Research, CMI, Bergen, 22-24 May.

Bagachwa M.S.D *et al., 1995, Structural Adjustment and Sustainable Development in Tanzania.* Dar es Salaam University Press.

Bank of Tanzania, "Economic and Operations report," various issues

Bergman, L., D. Jorgenson and E. Zalai, 1990, *General Equilibrium Modeling and Economic Policy Analysis,* Oxford: Basil Blackwell.

Bureau of Statistics, 1997, "Revised National Accounts."

Bureau of Statistics, Agricultural data provided on disc

International Monetary Fund , "International Financial Statistics," various issues

International Monetary Fund, "World Economic Outlook," various issues

King R. G. and R. Levine, 1993, "Financial intermediation and economic development," in Mayer and Vives (eds), *Financial Intermediation in the Construction of Europe,* London: Centre for Economic Policy Research.

Lopez, R. *et al.,* 1991 'How trade and environment affects agriculture'. World Bank Working Paper 719.

Mamingi, Nlandu, 1997 'The impact of prices and macroeconomic policies on agricultural supply: a synthesis of available results'. *Agricultural Economics,* 16, 1997: 17-34.

Mans, D., 1994, "Tanzania: Resolute action," in Husain and Faruqee (eds), *Adjustment in Africa: Lessons from Country Case Studies,* World Bank Regional and Sectoral Studies, Washington D.C.: World Bank.

Mariki, W.A, 1996, "The impact of exchange rate policy on export performance of agricultural crops in Tanzania," Masters thesis, United Nations Economic Commission for Africa.

Sachs, J.D and F. Larrain, 1993, *Macroeconomics in the Global Economy,* New York: Harvester Wheatsheaf.

Taylor, L., 1981, *Structuralist Macroeconomics, Applicable models for the third world,* New York: Basic Books Inc., Publishers.

Sharp, L. 1997, "Monetary policy in South Africa", in Nattrass, N., *Macroeconomics, Theory and Policy in South Africa,* Cape Town:David Philip.

Tanzanian Government, Ministry of Finance, Revenue flash reports, various issues.

Tanzanian Government, Planning Commission, "Economic Survey," various issues.

World Bank, 1994, *Agricultural Sector Review. Tanzania.* Country Report Series.

World Bank, "World Debt Tables," various issues

World Bank, "Commodity price forecasts," various issues