



ELSEVIER

Economic Modelling 15 (1998) 257–286

*Economic
Modelling*

Economic openness, trade restrictions and external shocks: modelling short run effects in Sub-Saharan Africa

Jørn Rattsø*, Ragnar Torvik

*Department of Economics, Norwegian University of Science and Technology, N-7055 Dragvoll,
Norway*

Abstract

The trade restrictions imposed by most sub-Saharan Africa countries have clearly reduced the openness of their economies. However, it is not clear that this protectionism has reduced the impact of external shocks. Instead, the type of restrictions chosen, import rationing, has introduced new transmission channels for external shocks. A dependent-economy model is developed to compare export price shocks with and without import rationing, and the type of trade regime is shown to have quantitative importance in a CGE-model of Zimbabwe. The economies are shown to be more vulnerable to external shocks under import rationing than with trade liberalization, and real exchange rate depreciation can go hand in hand with a positive external shock contrary to the ‘Dutch disease’ story. The outcome is a result of a resource-expansion effect: a higher export price stimulates growth by improving the import capacity in a situation of rationing and unemployment. © 1998 Elsevier Science B.V.

JEL classifications: F41; O11; O45

Keywords: Model closure; Dependent economy model; External shocks; Foreign exchange rationing; Computable equilibrium model

1. Introduction

The sub-Saharan Africa countries have had poor economic performance during the 1980s. The economic systems in place, characterized by strong governmental

* Corresponding author. Tel.: +47 73 591934; fax: +47 73 596954; e-mail: Jorn.Rattso@sv.ntnu.no

controls and intervention, have not delivered the GDP growth necessary to improve living standards for the majority of the population. The economies have both stagnated and fluctuated. The erratic growth pattern is commonly attributed to internal supply shocks, such as varying rainfall, and to external shocks stemming from shifting world market conditions. In this paper we concentrate on the role of the external channel through export price variation.

The claim that the economies are vulnerable to export price shocks has solid empirical foundation. First, Ndulu (1991) (Table 28-3) has documented that changes in the terms of trade are the major explanatory factor accounting for variation in the purchasing power of exports. Second, export revenues, along with foreign transfers, are the main determinant of import capacity, and it has been demonstrated that GDP varies with import compression policy. Helleiner (1990); Ndulu (1991) and Wheeler (1984) provide evidence for the whole region. In a study of responses to shocks in sub-Saharan Africa emphasizing terms of trade, Balassa (1983) (p. 101) concludes that 'adjustment...took largely the form of reductions in imports through decreases in the rate of economic growth'. Davies et al. (1994) show the importance of import compression in Zimbabwe using a CGE-model.

Why are the economies so vulnerable to external shocks? Has the strong regulation of foreign trade dampened or increased the economic effects of the shocks? To study these questions, one has to take into account the regulation of foreign trade as commonly practised throughout most of sub-Saharan Africa. The effects of shocks are not independent of the economic policies in place. The answer to the questions raised above has two dimensions. First, the impact of external shocks depends on the openness of the economy. Trade policy influences the openness of, and thereby the transmission of, export price shifts to the domestic economy. Second, trade restrictions may change the working of the economy and hence introduce new and different transmission mechanisms.

Standard open-economy analysis under full employment provides a simple, but powerful, result regarding the relationship between openness and export price disturbances: The marginal effect on income of a change in the export price is the volume of exports. It follows that trade restrictions will reduce the income effect of external price shocks, because they reduce the openness as measured by the export share of GDP. The more closed the economy is, the lower the variance of income generated by export price shocks will be.

Neary (1993) takes this standard model one step further by including resources devoted to chasing the rents created by rationing. In the case of an import quota, clearly relevant in the African context, the income consequences of the external shock are further reduced because of the dissipating effect of rent-seeking activity. More export revenues drive demand for imported goods up, but the demand cannot be satisfied because the volume of imports is determined by the quota. Instead, the domestic price of imports rises, resulting in increased rents. In the new equilibrium more resources are used to get the same amount of imports. Income therefore rises by less than the increase in the value of exports. The import quota reduces the income effect of the external shock.

Taking the above considerations into account, one might be tempted to conclude that the regulations present in sub-Saharan Africa have made the economies less vulnerable to external shocks. First, they have made the economies more closed. Second, resources devoted to unproductive rent-seeking absorb part of the adjustment that would otherwise produce income. However, actual observations of GDP fluctuations and external shocks to the region belie this conclusion. In fact, we argue the opposite. African-style regulation of foreign trade has stimulated economic fluctuations rather than dampened them.

In order to focus on the trade regime, other government regulations are abstracted from. Clearly, government responses to shock can increase economic fluctuations. If the government receives or taxes part of a shock-induced raise in income and saves a smaller part of increased income than does the private sector, it contributes to the destabilization of the economy. Bevan et al. (1990a) provide evidence of this and other aspects of policy involvement in their analysis of Kenya and Tanzania during the coffee boom in the second half of the 1970s.

Our analysis contains two steps. First, a theoretical model is developed to explain how import regulations can increase the domestic effect of external shocks. The consequences of an export price shock are analyzed for two trade regimes. Section 2 describes a benchmark version of the dependent-economy model with unemployment. The standard closure assuming endogenous traded goods exports and free trade is contrasted with a closure representing the characteristics of sub-Saharan Africa countries in Section 3.

Second, we show how import compression policy can have economic significance using a CGE model of Zimbabwe. Counter-factual simulations throw light on the role of export price variation as a source of economic fluctuations. Section 4 includes a compact description of the calibrated model, which integrates the dependent-economy formulation in a dual agriculture-industry setup. The CGE model has been calibrated with import rationing reproducing national accounts for the baseyear 1985, and for a counterfactual 1985 assuming the elimination of import rationing and protection. To facilitate a comparison with the standard closure of the dependent-economy model, one experiment investigates an export price shift assuming that foreign trade has been liberalized. The other simulation assumes that the import-rationing system is in place, as in 1985, and a counterfactual identifies the macroeconomic equilibrium with a higher export price. The results of the two experiments are reported in Section 5. Finally, Section 6 offers concluding remarks.

2. Export price shock in the dependent economy model

The dependent-economy model serves as a general framework for the analysis of shocks in open economies, as summarized by Devarajan et al. (1990). In contrast to their model, we take into account two characteristics of the region: unemployment and intermediate imports. Excess supply of labour is assumed to be a result of nominal wage rigidity. Minimum wage legislation is typically understood as the

source of this rigidity. The unemployment assumption is included in disequilibrium versions of the dependent-economy model, e.g. Kouri (1979), but departs from most of the literature which takes advantage of the transformation curve (see Dornbusch, 1989). To capture the import dependency in production, imported intermediates are added. The formulation of the production technology is similar to that of Katselli-Papaefstratiou (1990).

We focus here on a static model without explicit intertemporal utility maximization in order to concentrate on short run adjustment mechanisms. The distinction between temporary and permanent shocks consequently vanishes. In our analysis, the distinction is only important for the size of the demand effect, and is determined by the marginal propensity to consume. The qualitative results are not affected.

The model is motivated by the separation of production activities according to their relation to the international market, i.e. the distinction between traded and non-traded goods. In Africa, the traded sector is export oriented, while the non-traded sector includes protected import-substituting activities. The sectoral balances are formulated as in Rattsø (1994a): the traded sector delivers its output X_T to consumption C_T and exports E . The non-traded sector output X_N is applied to consumption C_N and investment. Construction and capital goods production take place in the non-traded sector, and the formulation takes advantage of the stylized fact (Ndulu, 1991) that the import share of investment is stable. A fixed share α of the investment J is produced domestically.

$$X_T = C_T + E \quad (1)$$

$$X_N = C_N + \alpha J \quad (2)$$

The traded sector produces its output X_T with capital and labour according to a neoclassical production function. The capital stock and the world market price P_T are given. By convention, fixed nominal wage and exchange rate are assumed by setting them equal to 1, and labour units serve as numeraire. Profit maximization generates a compact form supply function $X_T = f(P_T)$, where the derivative f_1 with respect to P_T is positive. The non-traded sector applies imported intermediates in addition to capital and labour. The short run supply function depends on the real product prices of labour and imported intermediates. Given the nominal rigidities assumed, they can be represented by the inverse of the real product wage, P_N , in a compact form supply function, $X_N = g(P_N)$, with $g_1 > 0$ (the real product price of imported intermediates follows the real product wage). The demand for imported intermediates depends on the real product wage and the real product price of imported intermediates as well, which in reduced form is $B = B(P_N)$, with $B_1 > 0$.

To simplify the handling of rationing later, fixed consumption shares of three consumer goods are assumed in the benchmark version, including that for imported consumer goods C_I (foreign price set to 1). The formulation is consistent with a Cobb-Douglas utility function. Total consumer spending D is defined as the

national income less domestic savings, which are a constant fraction of income:

$$D = (1 - s)[P_T f(P_T) + P_N g(P_N) - B(P_N)] \tag{3}$$

$$C_I = c_i D \tag{4}$$

$$P_T C_T = c_t D \tag{5}$$

$$P_N C_N = (1 - c_i - c_t) D \tag{6}$$

The model is solved by developing the excess demand functions for the traded and non-traded markets:

$$[c_t(1 - s) - 1]P_T f(P_T) + c_i(1 - s)[P_N g(P_N) - B(P_N)] + P_T E = 0 \tag{7}$$

$$[(1 - c_i - c_t)(1 - s) - 1]P_N g(P_N) + (1 - c_i - c_t)(1 - s)[P_T f(P_T) - B(P_N)] + P_N \alpha J = 0 \tag{8}$$

The compact form of the model shows how exports and the real product wage of non-traded goods clear the two markets. Fig. 1 presents the unemployment version of the Salter-Swan diagram. The differentiation of the market balances is given in Appendix A, while the logic of the model is explained here. Excess demand of traded goods rises with P_N (reduced non-traded product wage) because demand based on non-traded income goes up. To drive the excess demand to zero, exports E have to decline, allowing more supply of traded goods on the domestic market to satisfy the increased demand. The equilibrium locus T of the traded goods sector hence slopes downward. The equilibrium locus N of non-traded goods is horizontal in dependent-economy models when the law of one price holds for traded goods. The exports are a residual and they do not affect the market for non-traded goods. Excess demand for non-traded goods is eliminated by reduced product wage (higher P_N), implying reduced demand and increased supply. The savings-investment equilibrium point is denoted m in Fig. 1.

The expansionary effect of a rise in the export price in the conventional case is well understood and can be dealt with briefly. The dotted lines in Fig. 1 show the

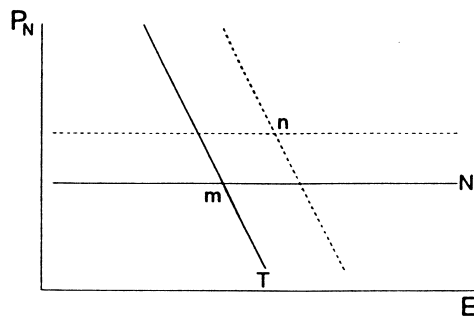


Fig. 1. The standard closure model.

responses. The traded sector equilibrium locus shifts out. Excess supply of traded goods, the combined result of higher output supply and consumption demand switching towards non-traded goods, allows higher exports. The non-traded sector equilibrium locus shifts up. The real product wage is driven down (and P_N up) by excess demand, the effect of higher demand due to traded goods revenue generation. The equilibrium moves from m to n in Fig. 1, and production in both sectors is higher than before the price shock. Exports are expected to increase, assuming that economic expansion is not so strong that increased domestic consumption of the traded good dominates the rise in supply.

The analysis of the ‘Dutch disease’ has been a major application of the dependent economy model. The disease effect of higher export prices shows up in this model as higher non-traded production, a result of reduced real product wage and real product price of imported intermediates. It should be noted that the real exchange rate, the relative price of traded to non-traded final goods, may go up or down, dependent on the strength of the real product factor price adjustments in the non-traded sector. The full-employment version is described in the influential article of Corden and Neary (1982). They show how a real export boom leads to increased real product wage in the non-traded sector in a short run version with sector specific capital. The resource-movement effect drives up the wage level when labour moves to the booming export sector, and the higher wage is transmitted to higher non-traded price. In our unemployment model, the relative price adjustment follows the income effect. By using Cramers rule on the differential system in Appendix A, it can be verified that the real product wage of the non-traded sector falls more the higher $X_T(1 + \epsilon_T)$ and the lower $X_N(1 + \epsilon_N)$. ϵ_T and ϵ_N denote the elasticity of supply with respect to the price for the traded and non-traded sectors respectively. Hence, the real product wage response is stronger, and real exchange rate appreciation more likely, the more open the economy as measured by the relative size of the sectors, and the higher the supply elasticity in the traded compared to the non-traded sector.

3. Export price shock in a stylized Sub-Saharan Africa model

Most countries of the sub-Saharan Africa region have combined tariffs with quantitative trade restrictions during the 1980s. The World Bank (1993) has documented these import controls and their gradual elimination when some countries embarked upon trade liberalization programs. The import rationing systems must be taken into account in order to understand the adjustment mechanisms of the economies during the control period. Our formulation describes the general characteristics of the import rationing systems, as presented by Davies (1991) for Zimbabwe and Ndulu (1986) for Tanzania: consumer and intermediate imports have been compressed, while investment imports have had priority. The rationing of consumer and intermediate goods is dependent on import capacity, a system which Bevan et al. (1990a) call endogenous trade policy. Endogenous rationing is the policy response to shortages of foreign exchange. Fix-price ra-

tioning (import quotas), as compared to flex-price rationing (the exchange rate), is used to allocate scarce foreign exchange.

The rationing rule produces a new relationship between the traded and the non-traded sectors: the export of traded goods influences the capacity to import intermediates to the import-dependent, non-traded sector. This intersectoral linkage was proposed by Gibson (1985) in a model of Nicaragua. A similar formulation of the rationing system is applied by Rattsø (1994a,b) in theoretical studies of the dynamics of sectoral balances and macroeconomic policy effects. Consequences of alternative rationing rules are analyzed by Torvik (1994).

Foreign exchange scarcity is represented by the exogenous trade balance. The scarcity can be the direct result of government interventions or rationing in international credit markets, or both. The allocation of the residual import capacity (foreign savings and export revenues less priority investment imports) between consumer and intermediate goods is determined by fixed policy-determined shares. The two import rationing functions are:

$$B = \beta [P_T E - (1 - \alpha)J + S_f] \quad (9)$$

$$C_I = (1 - \beta) [P_T E - (1 - \alpha)J + S_f] \quad (10)$$

Rationing influences both the demand and supply sides of the economy. Even if the production technology is the same as in the standard model, the rationing of imported intermediates implies a modified reduced form supply function for the non-traded sector, $X_N = h(P_N, B)$. Since imported intermediates are rationed to firms, they are forced to apply an inefficient mix of labour and intermediates. The supply is lower for each P_N compared to the non-rationed case. Improved access to imported intermediates increases the supply of non-traded goods, $h_2 > 0$. Although we will stick to this interpretation throughout, h_2 can also be thought of as representing other channels by which foreign exchange rationing can have adverse effects on supply (since B is proportional to total foreign exchange available for rationed goods). Bevan et al. (1990a) emphasize the impact through rationing of consumer goods. In their model such rationing has an adverse effect on supply because it depresses labour supply.

We will assume that foreign exchange rationing also influences the demand side. When consumer imports are rationed, determined as a share $(1 - \beta)$ of the available foreign exchange, frustrated consumers respond by shifting the composition of demand and savings. Torvik (1997) shows how increased saving is the optimal consumer response to rationing in the expectation of future liberalization. The change of savings behaviour influences the determination of consumer spending in Eq. (11). The larger the gap between desired (C_I^d) and actual non-competitive consumer imports, the smaller is consumer demand. The difference is not fully matched by increased savings, i.e. $\gamma < 1$. The assumption is dependent on the complementarity between the goods and on the intertemporal elasticity of substitution. If $\gamma > 1$, our argument about perverse response to export price shock is strengthened.

Since the underlying utility functions are the same as in the benchmark model, desired non-competitive consumer imports C_I^d are determined by Eq. (4), given D as defined by Eq. (11). As shown by Neary and Roberts (1980), the demand functions for the unrationed goods, when one good is rationed, are given by Eqs. (12),(13). The logic is straightforward. First, as much as possible of the rationed good is purchased. The rest of the demand ($D - C_I$) is directed towards the unrationed goods. Hence, the marginal propensities to consume these goods are scaled up by a factor of $1/(1 - c_i)$. The consumer demand system is equivalent to the standard closure model when $C_I = C_I^d$.

$$D = (1 - s)[P_T f(P_T) + P_N h(P_N, B) - B] - \gamma(C_I^d - C_I) \quad (11)$$

$$P_T C_T = \frac{c_i}{1 - c_i (D - C_I)} \quad (12)$$

$$P_N C_N = \frac{1 - c_i - c_i}{1 - c_i} (D - C_I) \quad (13)$$

The market equilibrium conditions for traded and non-traded goods are revised under rationing:

$$\begin{aligned} & \left[\frac{c_i(1 - s)}{(1 - c_i)(1 + \gamma c_i)} - 1 \right] P_T f(P_T) \\ & + \left[1 - \frac{c_i[1 - \beta s - \gamma(1 - c_i)(1 - \beta)]}{(1 - c_i)(1 + \gamma c_i)} \right] P_T E \\ & + \frac{c_i(1 - s)}{(1 - c_i)(1 + \gamma c_i)} P_N h(P_N, \beta(P_T E - (1 - \alpha)J + S_f)) \\ & + \frac{c_i[1 - \beta s - \gamma(1 - c_i)(1 - \beta)]}{(1 - c_i)(1 + \gamma c_i)} [(1 - \alpha)J - S_f] = 0 \end{aligned} \quad (14)$$

$$\begin{aligned} & \left[\frac{(1 - c_i - c_i)(1 - s)}{(1 - c_i)(1 + \gamma c_i)} - 1 \right] P_N h(P_N, \beta(P_T E - (1 - \alpha)J + S_f)) \\ & + P_N \alpha J + \frac{(1 - c_i - c_i)(1 - s)}{(1 - c_i)(1 + \gamma c_i)} P_T f(P_T) \\ & - \frac{(1 - c_i - c_i)[1 - \beta s - \gamma(1 - c_i)(1 - \beta)]}{(1 - c_i)(1 + \gamma c_i)} [P_T E - (1 - \alpha)J + S_f] = 0 \end{aligned} \quad (15)$$

Figs. 2 and 3 represent the new interactions of exports and the real product wage of non-traded goods. The differentiation is documented in Appendix A. The equilibrium curve in the traded goods market T slopes downwards, but the

equilibrating mechanisms are different from those above. As P_N increases, moving away from its equilibrium point, excess demand for traded goods is created because income increases in the non-traded sector. To restore equilibrium, exports must go down, involving complicated feed-back through the import-rationing system. The reduced import capacity results in tighter rationing of intermediate imports in the non-traded sector, and demand for traded goods based on non-traded production income is reduced. The demand for traded goods is also reduced because savings go up. The two effects are assumed to dominate the forced substitution towards traded goods resulting from tighter rationing of non-competitive consumer goods.

Endogenous import rationing explains why the equilibrium locus in the market for non-traded goods N is no longer horizontal. Increased exports is associated with excess supply in the non-traded goods market. The higher export revenues allow for more imports of intermediates to the non-traded sector, generating higher supply. At the same time, increased exports create room for more imports of non-competitive consumer goods and demand switches away from non-traded goods. Only a dramatic reduction of savings can turn the excess supply to excess demand. If this does not occur, both the supply and demand sides contribute to excess supply of non-traded goods with increased exports. In order to drive excess supply to zero, P_N has to decrease. Macroeconomic equilibrium is established at point o in Figs. 2 and 3. For the model to be stable, the equilibrium locus of the traded sector must be steeper than the non-traded (see Appendix A).

Before we proceed, it is worth making a remark about trade restrictions and economic openness. Almost by definition, an economy under the African closure is more closed, as measured by imports, than is an economy under the standard closure. In the African version, the volume of imports is less than consumers and producers desire, while demand is satisfied in the standard specification. Rodrik (1994) and others have noted that it is also reasonable to assume that trade restrictions make the economy more closed as measured by exports. In our case, the trade restrictions place a supply constraint on the non-traded sector, resulting in a higher relative price than would otherwise be the case. The price effect drives up costs, and can thereby hurt exports, implying that the export-share is lower in the African model. If the real consumption wage is the same in the two types of economies, the real product wage of the traded sector is higher in the African situation and the volume of exports is lower. If a move from a controlled to a free trade regime involves a devaluation that succeeds in altering the real exchange rate, the difference will be even larger, a point which we will return to below.

In the African model alternative, the two sectors also interact through the rationing system when the economy faces higher export prices. The traded sector is expected to experience excess supply via increased output and decreased domestic demand when the export price goes up, but some additional effects via the non-traded goods market must be taken into account. Import capacity is improved by the new foreign exchange revenues coming in, allowing more imports of non-competitive consumer goods and intermediate imports for the non-traded sector. The import of consumer goods strengthens the shift in demand away from traded goods. At the same time, the demand for traded goods is stimulated by two

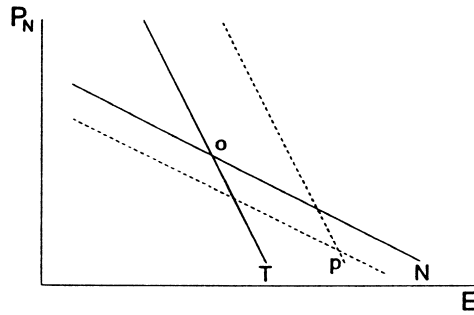


Fig. 2. The African closure model when the supply effect dominates.

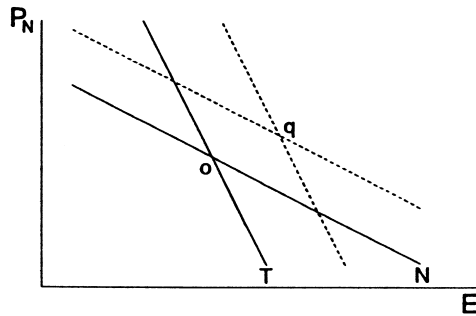


Fig. 3. The African closure model when the demand effect dominates.

factors: a reduction in the savings rate and an increase in demand based on non-traded production income, which has been brought about by the availability of imported intermediates. We assume that the indirect demand-inducing effects do not dominate, so that the equilibrium locus of the traded sector shifts out as described by the dotted lines in Figs. 2 and 3.

In the market for non-traded goods, conflicting demand and supply effects operate after a positive export price shock. On the supply side of the market, increased foreign exchange earnings allow more imports of intermediates and permit a higher output supply, as described above. The switching of consumption away from non-traded goods because of the increased imports of non-competitive consumer goods also pulls in the direction of excess supply. Hence, the effects through the supply side are more likely to dominate the stronger the supply response to intermediate availability (h_2) and the weaker the savings response parameter γ . In this case, the equilibrium locus for the non-traded sector shifts down as drawn in Fig. 2, since the real product wage of non-traded goods must go up (P_N down) in order to eliminate excess supply. The end result is increased exports and a higher real product wage in the non-traded sector, as seen from the movement from point o to p in Fig. 2.

Under African-style rationing, the ‘Dutch disease’ effect of an export price shock may be reversed. When the linkage between traded and non-traded goods via the foreign exchange capacity to import intermediates dominates, the higher output supply may increase the non-traded real product wage (reduce P_N) and depreciate the real exchange rate. Relating to Corden and Neary (1982) terminology, we can call this a resource-expanding effect. The resource expansion is channeled through imports and can be significant because of the unemployment assumption. Note, however, that the mechanism that drives the result is not dependent on the assumption of unemployment. Rather it is dependent on rationing of imported intermediates. Bevan et al. (1990b) reach a similar result with endogenous capital stock adjustment in a conventional version of the dependent economy model. With a temporary positive shock agents save part of the induced income. When the country is faced with an imperfect capital market part of these savings will be invested domestically. The increased capital in the non-traded sector increases supply, and this in isolation pulls the relative price of non-traded goods down.

The alternative situation shown in Fig. 3 reflects the dominating expansionary demand effect of the new income generated in the traded sector. Excess demand in the market for non-traded goods follows the rise in the export price, and the equilibrium locus for the non-traded sector shifts upward. If the non-traded real product wage decreases sufficiently, exports may go down. In Fig. 3, the intermediate case of higher P_N and higher exports is shown, and the equilibrium has moved from point o to q. But also in this situation, the real product wage of the non-traded sector can go up (P_N fall). Independently of which way the real product wage goes, it can be verified from the differential system in Appendix A that the magnitude of the relative price adjustment is stronger the higher $X_T(1 + \epsilon_T)$ and the lower $X_N(1 + \epsilon_N)$ also under the African closure.

The analysis shows how the more closed and controlled economies of sub-Saharan Africa have other transmission channels built in when the economy faces external shocks. The trade restrictions mean that the openness of the economies is reduced. Hence, the first-round income effect of increased export prices is smaller. Also, forced substitution because of the rationing of consumer imports means a smaller effect of the shock. When more imports of non-competitive consumer goods are allowed in by the improved import capacity, consumption demand is switched away from goods produced domestically. Despite the forces pulling in the direction of reduced effects of external shocks, the economies of sub-Saharan Africa may easily experience stronger fluctuations in a closed and controlled regime than they would in a more open and liberalized alternative. Control of the trade deficit and import rationing create a new supply-side linkage: production in the non-traded sector becomes dependent on export earnings. The supply of non-traded goods increases because of access to new intermediate imports, a resource-expanding effect. Reduced savings when consumer imports are made available strengthen the conventional spending effect.

So far we have investigated the pure effects of differences in model closure on the transmission of external shocks. However, one might argue that a move from an African closure to a standard closure (i.e. a trade liberalization) will also involve

other policy measures. The most obvious is a devaluation, that can affect the quantitative results. If the devaluation results in a larger traded sector under the standard closure than would otherwise be the case, the impact effect of the external shock will be higher. In that case, our argument of less impact of external shocks with the standard closure is weakened since the traditional effect discussed above is stronger. On the other hand, with a short run fixed capital stock it is also reasonable to assume that the traded sector price supply elasticity is decreasing with the size of the sector, simply because more and more of the other inputs will be required to increase production when one production factor is fixed. This pulls in the opposite direction, reducing the quantitative effect of the external shock.

It may also be argued that our assumption of no nominal wage response to price changes is rather extreme, and that wage response to nominal shocks in general has stabilizing effects (see e.g. Hardouvelis, 1987, and the references given therein). In our model, nominal wage response will strengthen our argument of less effect of the external shock in the standard than in the African closure model. The reason is that the real wage reduction with nominal rigidity is higher in the standard closure model than in the African closure model, because of the non-traded sector price response. If the nominal wage responds, the wage adjustment will be stronger and production effect more dampened in the standard version.

4. A CGE model of Zimbabwe

The construction of a CGE model of Zimbabwe permits a richer analysis of the channeling of external shocks and a quantification of the effects involved. Conflicting effects in the theoretical model can be sorted out, and the interactions can be analyzed with more disaggregated sectoral balances. In order to compare the effects of export price shocks with and without import rationing, the model is set up with two closures. One version is formulated and calibrated to reproduce the base year, 1985. Davies et al. (1994) apply the model to counterfactual analysis of the sources of growth fluctuation under the control regime of the 1980s. The other version assumes the elimination of protection and rationing, and simulates the liberalized regime of the post-structural adjustment programme of the 1990s. Davies et al. (1998) establish a counterfactual 1985 with liberalization in order to discuss the short run adjustment problems of removing controls. The main features important for the transmission of external shocks are explained here, while full documentation is given in Davies et al. (1998). Rattsø and Torvik (1998) have analyzed the Zimbabwean trade liberalization *ex post* using the model.

The model brings together two types of dual models familiar from development economics. The Africa version of the dependent-economy model in Section 3, which distinguishes between traded and non-traded sectors, can be seen as a starting point. With a view to including terms of trade effects and differences in import rationing, traded goods production is disaggregated to importables, exportables, and food agriculture. Since production structure and demand linkages differ, non-traded production is disaggregated to services and construction. The dual

flexprice-fixprice approach of Taylor (1983), distinguishing between agriculture and the rest of the economy, is included by separating out food agriculture. Our formulation is different from Taylor since both food agriculture and non-agriculture outputs are supply driven.

The sectors are disaggregated into the following categories: food agriculture, non-traded consumer goods ('services'), non-tradable capital goods ('construction'), exportables, and importables. Output of food agriculture is exogenous in the short run. In the liberalized standard closure model, the agricultural price is given by the world market and net exports clear the domestic market. In the controlled African closure model, foreign trade in food is regulated and the domestic price clears the market. The service sector is characterized by mark-up pricing and demand determined output in both closures.

The supply side is important for understanding price and output responses in the two alternative closures. The production technology of construction, importables, and exportables is nested CES functions in skilled labour, unskilled labour, domestic intermediates, imported intermediates, and fixed sectoral capital stocks. Skilled labour is in short supply, and the wage rate adjusts to achieve equilibrium. Excess supply prevails in the market for unskilled labour, and the nominal wage is set exogenously. In the standard closure model the demand functions for imported intermediates are allowed to operate without rationing. The sectors have rising supply curves because of fixed sectoral capital stocks. The export sector is a price taker in the world markets, and the residual output, taking into account domestic demand, is exported. In the construction sector, a falling demand curve combined with the rising supply curve equilibrate supply and demand. The same is the case for the importables sector because of imperfect substitution between domestic and imported importables goods. A combination of imports and domestic production equilibrate supply and demand for the composite good. With imperfect substitution there is room for endogenous determination of the domestic price. The importables sector has some of the characteristics of a non-traded sector.

Under the African closure model the supply-side mechanisms are somewhat different. Several assumptions are made about the import rationing system. First, available foreign exchange is allocated to satisfy priority needs (investment goods, intermediates for the exportables sector, and food). Second, the importables sector is protected, and only a limited volume of importables is allowed to be imported. Third, any remaining foreign exchange is allocated as policy-determined shares to meet requirements of construction and importables for imported intermediates, and to non-competitive consumer imports. Since the inputs to export production have priority, the supply side of the export sector is the same as under the standard closure. The import compression of manufacturing and construction supply is endogenously determined, and dependent on the existing capacity to import. The formulation is consistent with the description of Davies (1991) and the econometric results of Mehlum and Rattsø (1996).

When imported intermediates are rationed in the construction and importables sectors, these sectors are forced to substitute towards domestic goods, resulting in an inefficient mix of inputs. The availability of imported intermediates influences

the supply curves. Implicit rents are created because the prices in these sectors are higher under the African closure than under the standard closure.

The import-rationing system also includes protection of domestic final-goods markets. Here, the import compression almost eliminates both importables and non-competitive consumer-goods imports. In addition, a domestic market for the imports allowed in is nearly absent in Zimbabwe. This is surprising, given the rents potentially associated with the overvalued exchange rate, but it motivates our assumption of the fixed price rationing of final goods. In the model, the government receives the rents.

Two effects of this protection are captured on the demand side, similar to those that the theoretical model outlines in Section 3. First, demand switches to domestic goods when foreign goods are not available. The linear expenditure formulation under rationing is modified as suggested by Neary and Roberts (1980). Since consumer imports are rationed, the ratio of imported- to domestically-produced consumption is lower than desired at the prevailing prices. The notional price of consumer imports is higher than the actual. Second, when demand for imports is not satisfied, part of the income can be set aside as savings—in the expectation of less severe rationing in the future. Empirical evidence is identified by Chhibber et al. (1989) and Morande and Schmidt-Hebbel (1991). In the model this stylized fact is taken care of by linking private savings rates to the rationing of non-competitive consumer imports.

Investment imports are assumed to have priority in the rationing system. The investment level is fixed exogenously, and the import share responds to relative prices. The formulation reflects the problem of identifying a well-defined investment function (see Mehlum and Rattsø, 1996; Chhibber et al., 1989), and the understanding that investment demand is restricted by political and business uncertainty (see Dailami and Walton, 1992). Our formulation, which assumes a given total investment, is consistent with the alternative understanding that investment has been restricted by import rationing. In comparing the two regimes, the investment level is held constant.

We are interested in the degree of economic openness in the two closures. The African closure model is calibrated to reproduce the export and import shares of GDP in 1985, which are 28% and 29%, respectively. The export and import shares of the counterfactual liberalized model depend on our assumptions about the degree of rationing of economic agents under controls, as explained in Appendix B. The key parameters to be determined include the desired switching to foreign consumer goods, the degree of substitution between domestic and imported importables, and the drop in private savings rates that occurs when imports are available. Given the assumptions stated in Appendix B, the standard closure operates with an export share of 32%, and an imports share of 36%.

The difference between the two model versions, measured by the ratio of imports to GDP, is almost self-explanatory: under the African closure there is excess demand for imports that is not satisfied because of import rationing. The move to a deregulated economy means that this excess demand is satisfied. The economy is more open, also as measured by the ratio of exports to GDP, under the

standard closure. Because access to imported intermediates is limited under the African closure, the supply constraint pushes up the price of inputs to the export sector. Hence, a side effect of the import regulations is decreased exports. Regardless of what measure of economic openness one chooses, the economy is more open when import rationing is done away with.

5. The consequences of an export price shock in Zimbabwe

The analysis of Davies et al. (1994) shows that the major shocks affecting Zimbabwe during the 1980s were related to weather conditions and policy-induced import compression. They show that the foreign terms of trade in this decade were fairly stable. In the base year reproduced, 1985, the terms of trade were basically constant, agriculture had favourable conditions, and the investment level fell. The GDP growth was close to 7%, inflation was below 10%, and imports were compressed in order to balance with the export revenues. The model enables us to investigate economic performance for a case in which export prices are assumed to be higher. Two counterfactuals are constructed. First, a counterfactual 1985 assuming the elimination of rationing and protection is calibrated. Given this benchmark, the effects of an export price shift are explored. Second, based on the reproduction of the actual 1985 national accounts assuming import rationing, a counterfactual 1985 with a higher export price is simulated.

The analysis confirms the strong domestic impact of the export price fluctuation that accompany import rationing. In the standard liberalized closure, a positive shift in the export price is channeled to a general demand-driven expansion of the economy. The import-compression version generates an expansionary effect that is double the size of the liberalized situation. The expansion is first and for all channeled through the supply side via improved availability of imported intermedi-

Table 1

Model simulations: effects of 5% positive shift in export price, percentage deviation from benchmark, Zimbabwe

	Standard closure model	African Closure model
GDP	+1.0	+2.1
GDP Services	+1.4	+2.2
GDP Construction	+0.1	+2.9
GDP Exportables	+1.5	+2.1
GDP Importables	+1.2	+4.3
Priv. Cons.	+2.1	+6.0
CPI	+2.4	+1.7
Exports	+1.4	+2.6
Imports	+2.2	+7.6
Unsk. employment	+2.0	+3.7

ates. Because of fixed capital stocks and supply of skilled labour, the relative increase in unskilled employment is somewhat stronger than the relative increase in GDP. The experiment, which assumes a permanent positive shift in the export price of 5%, is reported in Table 1.

The immediate effect of a higher export price is to increase export revenues and expand the supply of export goods. In the standard closure model, the repercussions are driven by the increased income and private consumption demand. The overall GDP increases by 1%, signifying an elasticity of about 0.2. All sectors benefit from the general rise in demand. Since the demand for construction is basically determined by the fixed investment level, the sector is least affected. On the other hand, services are sensitive to fluctuations in demand and experiences a strong demand-driven expansion.

The Consumer Price Index (CPI) is influenced directly by the export price shift and indirectly by the demand multiplier. The model suggests a rise in the general price level by about 2.4%. As demonstrated by the theoretical model in Section 2, expansion in all sectors goes along with higher prices. It is the inducement necessary to stimulate supply when the nominal wage level and the exchange rate are fixed.

The net expansion of export volume reflects the adjustment of both export production and domestic demand. The expansion of demand means that more of the export goods are consumed domestically. The higher level of economic activity increases the imports of intermediates and consumption goods. Higher prices in domestic production sectors reduce the relative price of imports. More import intensive production, consumption, and investment result. The rise in import volume is larger than the export volume response, but the trade balance improves because of the terms of trade shift.

The import rationing regime has a stronger output response to external shocks. The combined effect of a higher export price and a higher export volume is to increase the import capacity by about 7.5%. Assuming a permanent excess demand for imports, the total imports are determined by this capacity. The availability of more intermediate goods allows for a positive shift of the supply curves for intermediates and construction. The overall GDP expansion amounts to more than 2%, which indicates an elasticity with respect to the export price above 0.4.

The production responses of the input-rationed construction and importables sectors imply a stronger demand expansion than is seen in the unrationed case. The combination of intermediate input availability and demand explains the rise in output to above 4%. As discussed in the theoretical section, the price formation of the rationed sectors is influenced by conflicting effects from demand and supply. In the Zimbabwe model, the supply effects dominate, the situation described in Fig. 2. The inelastic demand for construction goods means that the price drops by almost 7%. In the importables sector, the shift in the demand curve is stronger, but the effects pulling in the direction of reduced prices still dominate, producing a fall in the sectoral price of 1.4%. The counter-cyclical price response of the rationed sectors explains the stronger output expansion in the exportables sector under this closure. The reason for this stronger expansion is that the export sector experi-

ences lower prices for some of its inputs in addition to higher export prices. Because of the stronger overall expansion, the service sector also grows more than in the standard closure version. However, demand in the service sector is dampened by lower prices for importables goods, in contrast to the higher prices of these goods under the standard closure.

The economic expansion brings with it a much higher increase in private consumption than in the standard closure model. Of course the stronger expansion in itself explains part of this increase, but it is not the only reason. The increased amount of foreign exchange means more imports of non-competitive consumer goods. As a result, private savings rates drop, so that more of a given income is consumed. In addition, income-distribution effects play a greater role in the African closure model. The import rationing of intermediates creates an implicit rent to profit earners because the quota holders get cheap imports and high prices for their goods in the domestic market. Increased imports of intermediates reduce these rents, and a larger share of total income is then shifted towards groups with lower propensities to save. This adds to increased consumption demand. In contrast to models with a representative consumer, such as Neary (1993) and the theoretical model presented above, the income distribution effects of rents do indeed matter.

Even with the stronger economic expansion, the CPI increases less than in the standard closure case. The fall in prices in the rationed sectors is not great enough to outweigh the direct effect of increased export prices and the cost-push effect on the service sector. The rise in the CPI is 0.7 percentage points below the standard model.

Note that in the experiment reported in Table 1 we have investigated the pure effect of a change in the model closure. But it may be the case that the change in model closure toward a liberalized regime goes hand in hand with a devaluation. As discussed above it can not be determined a priori which way this affects the quantitative results. To check if our argument is still valid when the change in model closure is combined with a devaluation, we take the argument to its extreme, and assume that the exchange rate is adjusted so that the trade balance (in foreign currency) is the same as before the liberalization. See Davies et al. (1998) for documentation of such a devaluation in the model. In Collier (1991) terminology this is a trade liberalizing devaluation as opposed to a payments improving devaluation. This exercise (not reported in Table 1) in fact shows that the argument is even more valid under a trade liberalizing devaluation. GDP increases by 0.9% with an export price shock after the trade liberalizing devaluation, marginally less than the 1% increase in the standard closure model when no devaluation has been undertaken. This comes from the fact that a devaluation itself works expansionary in the model, moving the economy upwards steeper and steeper supply curves because of the fixed capital stocks. Hence, after a trade liberalizing devaluation it is more difficult to expand the economy further, and this effect outweighs the effect of a larger export sector.

It follows that the consequences of external shocks in Zimbabwe might be quite different before and after the liberalization program.

6. Concluding remarks

Modifying the dependent-economy model to fit the import rationing of the sub-Saharan African region introduces new transmission mechanisms for external shocks. The more closed economy and the forced substitution in consumption do tend to reduce the effects of external shocks. However, as identified in the theoretical model, two effects of the trade restrictions pull in the other direction. First, rationing of imported intermediates creates a supply constraint in the economy. The output of imported-input intensive sectors producing for the domestic market becomes dependent on the availability of foreign exchange, thus introducing a source of economic instability. Export earnings are not only important for the rest of the economy as a source of income and demand: supply curves of import-dependent sectors are also affected. Second, the rationing of imported consumer goods is likely to affect private savings. The rationing of consumer goods introduces an element of ‘consume what you can get, save the rest’. The result is lower savings rates when the access to imports is improved. Thus, a positive export price shock means lower private savings rates. The effect may be strong enough to reverse the result from conventional analysis, where a (temporary) positive export price shock increases savings rates. In the African closure model the savings response tends to strengthen the effects of external shocks.

The lessons from the simple theoretical model are important to bear in mind when the results from the more fully specified CGE model of Zimbabwe are evaluated. The simulation results show that the Zimbabwean policy of strongly regulating foreign trade has made the economy vulnerable to external shocks. The strong effects of external shocks observed in sub-Saharan Africa have not been dampened by economic regulations in foreign trade. Instead, the regulations themselves form part of the explanation for the high output variability.

Acknowledgements

The Norwegian Ministry of Foreign Affairs has provided financing. We are grateful for discussions with Paul Collier, Rob Davies, Jan Gunning and Lance Taylor, and have benefitted from comments at seminars at Harvard University, Oxford University, University of Oslo and Yale University. The Zimbabwe model has been developed in cooperation with Rob Davies. The usual disclaimer applies.

Appendix A. Documentation of the theory models

In this appendix we show the differentiation of the market balances with respect to the two endogenous variables E and P_N , and the shock variable P_T . We start out with the standard closure model. Differentiating the two market balances (Eq.

(7) and Eq. (8)) yields:

$$a_1 dE + a_2 dP_N = a_3 dP_T \tag{A1}$$

$$b_1 dE + b_2 dP_N = b_3 dP_T \tag{A2}$$

where

$$a_1 = P_T \quad (> 0)$$

$$a_2 = c_i(1 - s)[X_N(1 + \epsilon_N) - B'] \quad (> 0)$$

$$a_3 = [1 - c_i(1 - s)]X_T(1 + \epsilon_T) - E \quad (> 0)$$

$$b_1 = 0$$

$$b_2 = -[1 - (1 - c_i - c_t)(1 - s)]X_N(1 + \epsilon_N) - (1 - c_i - c_t)(1 - s)B' + \alpha J \quad (< 0)$$

$$b_3 = -(1 - c_i - c_t)(1 - s)X_T(1 + \epsilon_T) \quad (< 0)$$

Here, ϵ_j denotes the supply elasticity with respect to the price for sectors $j = T, N$. B' is the derivative of B with respect to P_N . The sign of a_2 follows from the first order condition for profit maximization. The sign of a_3 results from the traded market balance and the condition that the value of production must be larger than the value of imported intermediates. The sign of b_3 , which ensures stability of the model, holds if J is not too large. The stability condition is that a_1 must be positive (increased E creates excess demand at the traded goods market), b_2 must be negative (increased price of non-traded goods creates excess supply), and that the determinant $a_1 b_2 - a_2 b_1$ is negative (the cross effects do not dominate). The stability condition implies that the equilibrium locus of the traded sector in Fig. 1 is steeper than that of the non-traded sector. Since the cross effects disappear under this closure ($b_1 = 0$), it can be verified that the model is stable.

We next turn to the African closure model. Differentiating the market equilibrium conditions (Eq. (14) and Eq. (15)) yields:

$$d_1 dE + d_2 dP_N = d_3 dP_T \tag{A3}$$

$$e_1 dE + e_2 dP_N = e_3 dP_T \tag{A4}$$

where

$$d_1 = \left[1 - \frac{c_t[1 - \beta s - \gamma(1 - c_i)(1 - \beta)]}{(1 - c_i)(1 + \gamma c_i)} \right] P_T + \frac{\beta c_i(1 - s)}{(1 - c_i)(1 + \gamma c_i)} P_N P_T h_2' \quad (> 0)$$

$$\begin{aligned}
d_2 &= \frac{c_i(1-s)}{(1-c_i)(1+\gamma c_i)} X_N(1+\epsilon_N) \quad (> 0) \\
d_3 &= \left[1 - \frac{c_i(1-s)}{(1-c_i)(1+\gamma c_i)} \right] X_T(1+\epsilon_T) - \frac{\beta c_i(1-s)}{(1-c_i)(1+\gamma c_i)} P_N E h'_2 \\
&\quad - \left[1 - \frac{c_i[1-\beta s - \gamma(1-c_i)(1-\beta)]}{(1-c_i)(1+\gamma c_i)} \right] E \quad (> 0) \\
e_1 &= - \frac{(1-c_i-c_t)[1-\beta s - \gamma(1-c_i)(1-\beta)]}{(1-c_i)(1+\gamma c_i)} P_T \\
&\quad - \left[1 - \frac{(1-c_i-c_t)(1-s)}{(1-c_i)(1+\gamma c_i)} \right] \beta P_N P_T h'_2 \quad (< 0) \\
e_2 &= - \left[1 - \frac{(1-c_i-c_t)(1-s)}{(1-c_i)(1+\gamma c_i)} \right] X_N(1+\epsilon_N) + \alpha J \quad (< 0) \\
e_3 &= - \frac{(1-c_i-c_t)(1-s)}{(1-c_i)(1+\gamma c_i)} X_T(1+\epsilon_T) \\
&\quad + \left[1 - \frac{(1-c_i-c_t)(1-s)}{(1-c_i)(1+\gamma c_i)} \right] \beta P_N E h'_2 \\
&\quad + \frac{(1-c_i-c_t)[1-\beta s - \gamma(1-c_i)(1-\beta)]}{(1-c_i)(1+\gamma c_i)} E \quad (?)
\end{aligned}$$

h'_2 denotes the derivative of the supply function with respect to the imported intermediates. We assume that the first parenthesis on the right hand side of the expression for d_1 is positive, the indirect effects are not sufficiently strong to have increased exports lead to excess supply at the traded goods market. As discussed in Section 4, we also assume that the indirect effects do not dominate the sign for d_3 . Stability requires that the determinant $d_1 e_2 - d_2 e_1$ is negative, that is the equilibrium locus of the traded sector is steeper than that of the non-traded sector, as drawn in Figs. 2 and 3.

Appendix B. Model documentation

The essentials of the CGE model are presented here, while the full documentation of the Africa closure model is available by Rattsø and Torvik (1992). The complete set of equations and symbols are shown below. The supply side of the model is described by Eqs. (2)–(25) and is brought together with the demand side by the market clearing Eq. (1). The output of agriculture, sector 1, is exogenously

given by capacity [Eq. (2)] and a flexible price level arranges the market-clearing. Services, sector 2, are assumed to be demand determined with markup pricing [Eq. (3)].

In the other three sectors, production functions include skilled and unskilled labor, domestic and imported intermediates, and real capital. They are specified as multi-level CES and Leontief functions. For each sector, output X is produced by a value added aggregate and an intermediate goods aggregate, N , in fixed proportions. The value added is a CES function of the capital stock, K , and a labor aggregate, L , [shown by the term in parentheses in Eq. (4)]. The capital stock is historically given. Labor is a CES-aggregate of unskilled L_u and skilled labor L_s . Intermediate goods, N , are a CES-aggregate of imported intermediates, II , and domestic intermediates, DI . Domestically produced intermediate goods are linked to aggregate DI by fixed coefficients.

The allocation of intermediate imports is a key aspect of the supply side adjustment. Exportables [sector 4] are assumed to have priority, so that their demand for imported intermediate is satisfied [Eq. (6)]. However, construction [sector 3] and importables [sector 5] are both import dependent and rationed. These sectors are assumed to consume whatever quantity of imported intermediates they are given through the allocation system. The rationed imported intermediates feed into the CES-aggregate for intermediate goods [Eq. (8)].

Prices in the three sectors are set equal to marginal costs [Eq. (9)], and the marginal costs are the weighted sum of the marginal costs of intermediates and value added [Eq. (10)].

The exportables sector is a price taker in the world market [Eq. (11)]. Since the sector is not rationed, the marginal cost of its intermediate goods aggregate is the price of the aggregate [Eq. (12)]. The marginal cost of the value added aggregate is derived from the value added production function in the normal way [Eq. (13)]. Export volume is determined as a residual given the supply function and the domestic demand for exportables.

The use of domestic intermediates in the rationed sectors is determined by standard cost-minimizing conditions. The part of the marginal cost associated with intermediates is influenced by the rationing of imported intermediates [Eq. (14)]. Eqs. (15)–(20) define costs and input-output coefficients, while the labor market is described by Eqs. (21)–(25). This combines a fixed-wage demand determined unskilled labor market and a full employment wage-clearing skilled labor market. Unit labor costs are determined as a CES-aggregate, and substitution between the two skill types follows from varying demand for skilled workers.

The income generation and consumption demand aspects of the model capture distributional effects and rationing of imported consumer goods [Eqs. (26)–(34)]. The four income groups defined above have different propensities to save, an important aspect of overall savings formation. Savings rates are influenced by access to noncompetitive imported consumer goods [Eq. (31)]. The level of imports consumers desire is determined as a constant fraction of net consumer expenditures [Eq. (32)]. However, rationing of consumer imports means that these desires

cannot be fulfilled, leading to postponed consumption and increased demand for domestic consumer goods.

Eqs. (35)–(37) model the public sector accounting. Eqs. (38)–(41) handle the foreign exchange rationing. The outlays for competitive imports, investment goods and priority intermediate imports to exportables are subtracted from the sources of foreign exchange to determine the rationed amount (assumed to be positive) [Eq. (38)]. This is then allocated between imports of agricultural goods (Eq. (39)), imported intermediates for construction and importables (Eq. (40)) and imported noncompetitive consumer goods (Eq. (41)). The specification implies priority of imported food over intermediates and consumption goods; food imports are related to a target C_1^* for food consumption.

Investment is assumed to be a CES aggregate of sector 3, sector 5 and imported investment goods. The composition of the investment aggregate is made dependent on relative prices as in Eqs. (42),(43). The price of the investment aggregate follows by Eq. (44). Finally, Eq. (45) is a consistency check of the investment-savings balance.

The Africa closure model

$$X_i = \sum_{j=1}^5 a_{ij} \cdot X_j + C_i + G_i + J_i + E_i - M_i + DS_i \quad (i = 1-5) \tag{1}$$

$$X_1 = XB_1 \tag{2}$$

$$P_2 = \frac{(1 + t_2)(1 + \tau_2)}{1 - (1 + t_2)(1 + \tau_2)} \frac{a_{12} \cdot P_1 + a_{32} \cdot P_3 + a_{42} \cdot P_4 + a_{52} \cdot P_5 + q_2 \cdot b_2}{a_{22}} \tag{3}$$

$$X_i = \frac{1}{1 - n_i} \left(\left[\mu_{1i} \cdot L_i^{-\frac{1-\eta_i}{\eta_i}} + \mu_{2i} \cdot K^{-\frac{1-\eta_i}{\eta_i}} \right]^{-\frac{\eta_i}{1-\eta_i}} \right) \quad (i = 3-5) \tag{4}$$

$$N_i = n_i \cdot X_i \quad (i = 3-5) \tag{5}$$

$$II_4 = \epsilon_{14}^{\delta_4} \left(\frac{e \cdot P_{04}^*}{MC_{N4}} \right)^{-\delta_4} N_4 \tag{6}$$

$$DI_4 = \epsilon_{24}^{\delta_4} \left(\frac{P_{DI4}}{MC_{N4}} \right)^{-\delta_4} N_4 \tag{7}$$

$$N_i = \left[\epsilon_{1i} \cdot II_i^{-\frac{1-\delta_i}{\delta_i}} + \epsilon_{2i} \cdot DI_i^{-\frac{1-\delta_i}{\delta_i}} \right]^{-\frac{\delta_i}{1-\delta_i}} \quad (i = 3, 5) \tag{8}$$

$$P_i = MC_i \quad (i = 3-5) \tag{9}$$

$$MC_i = n_i \cdot MC_{Ni} + (1 - n_i)MC_{VAi} \quad (i = 3-5) \tag{10}$$

$$P_4 = e \cdot P_4^* \tag{11}$$

$$MC_{N4} = \left[\epsilon_{14}^{\delta_4} (e \cdot P_{O4}^*)^{1-\delta_4} + \epsilon_{24}^{\delta_4} \cdot P_{DI4}^{1-\delta_4} \right]^{\frac{1}{1-\delta_4}} \tag{12}$$

$$MC_{VAi} = \frac{q_i}{\mu_{1i}} \left[\mu_{1i} \cdot L^{-\frac{1-\eta_i}{\eta_i}} + \mu_{2i} \cdot K^{-\frac{1-\eta_i}{\eta_i}} \right]^{\frac{1}{1-\eta_i}} \cdot L_i^{\frac{1}{\eta_i}} \quad (i = 3-5) \tag{13}$$

$$MC_{Ni} = \frac{P_{DII}}{\epsilon_{2i}} \left[\epsilon_{1i} \cdot II_i^{-\frac{1-\delta_i}{\delta_i}} + \epsilon_{2i} \cdot DI_i^{-\frac{1-\delta_i}{\delta_i}} \right]^{\frac{1}{1-\delta_i}} \cdot DI_i^{\frac{1}{\delta_i}} \quad (i = 3, 5) \tag{14}$$

$$P_{DIj} = \sum_{i=1}^5 f_{ij} \cdot P_i \quad (j = 3-5) \tag{15}$$

$$B_j = \sum_{i=1}^5 a_{ij} \cdot P_i + a_{0j} \cdot e \cdot P_{0j}^* + q_j \cdot b_j \quad (j = 2-5) \tag{16}$$

$$A_{ij} = f_{ij} \cdot DI_j \quad (i = 1-5, j = 3-5) \tag{17}$$

$$a_{0j} = \frac{II_j}{X_j} \quad (j = 3-5) \tag{18}$$

$$a_{ij} = \frac{A_{ij}}{X_j} \quad (i = 1-5, j = 3-5) \tag{19}$$

$$L_i = b_i \cdot X_i \quad (i = 2-5) \tag{20}$$

$$q_i = \left[\alpha_i^{\sigma_i} \cdot w_{ui}^{1-\sigma_i} + \beta_i^{\sigma_i} \cdot w_s^{1-\sigma_i} \right]^{\frac{1}{1-\sigma_i}} \quad (i = 2-5) \tag{21}$$

$$L_{ui} = \alpha_i^{\sigma_i} \left(\frac{w_{ui}}{q_i} \right)^{-\sigma_i} L_i \quad (i = 2-5) \tag{22}$$

$$L_{si} = \beta_i^{\sigma_i} \left(\frac{w_s}{q_i} \right)^{-\sigma_i} L_i \quad (i = 2-5) \tag{23}$$

$$L_u = \sum_{i=2}^5 L_{ui} + L_{ug} \tag{24}$$

$$L_s = \sum_{i=2}^5 L_{si} + L_{sg} \tag{25}$$

$$Y_a = P_1 \cdot X_1 \tag{26}$$

$$Y_u = \sum_{i=2}^5 w_{ui} \cdot L_{ui} + w_{ug} \cdot L_{ug} \quad (27)$$

$$Y_s = \sum_{i=2}^5 w_s \cdot L_{si} + w_s \cdot L_{sg} + NFPA \quad (28)$$

$$Y_z = \sum_{i=2}^5 P_i \cdot X_i - B_i \cdot X_i - \frac{t_i}{1 + t_i} P_i \cdot X_i \quad (29)$$

$$D = (1 - s_a)Y_a + (1 - s_u)Y_u + (1 - s_s)Y_s + (1 - s_z)(1 - t_z)Y_z \quad (30)$$

$$s_j = s_j^* + \gamma_j \left(\frac{CIMP_D - CIMP_A}{CIMP_D} \right)^2 \quad (j = a, u, s, z) \quad (31)$$

$$CIMP_D = \frac{m_c}{e \cdot P_{0c}^*} (D - DB) \quad (32)$$

$$DB = \sum_{i=1}^5 P_i \cdot \theta_i \quad (33)$$

$$C_i = \theta_i + \frac{m_i}{(1 - m_c)P_i} (D - DB - e \cdot P_{0c}^* \cdot CIMP_A) \quad (i = 1-5) \quad (34)$$

$$GREV = t_z \cdot Y_z + T^{IND} \quad (35)$$

$$T^{IND} = \sum_{i=1}^5 \frac{t_i}{1 + t_i} P_i \cdot X_i \quad (36)$$

$$GEXP = \sum_{i=1}^5 P_i \cdot G_i + w_{ug} \cdot L_{ug} + w_s \cdot L_{sg} - (P_1 - e \cdot P_1^*) M_1 - (P_5 - e \cdot P_5^*) M_5 \quad (37)$$

$$RAT = -e \cdot P_5^* \cdot M_5 - e \cdot P_{0j}^* \cdot J_0 - e \cdot P_{04}^* \cdot II_4 + DEF + P_2 \cdot E_2 + P_4 \cdot E_4 + NFPA \quad (38)$$

$$M_1 = M_1^* + h_{01} \cdot (C_1^* - C_1) \quad (39)$$

$$II_i = II_i^* + h_{0i} \cdot \frac{(RAT - e \cdot P_{03}^* \cdot II_3^* - e \cdot P_{05}^* \cdot II_5^* - e \cdot P_1^* \cdot M_1)}{e \cdot P_{0i}^*} \quad (i = 3, 5) \quad (40)$$

$$CIMP_A = h_{0c} \cdot \frac{(RAT - e \cdot P_{03}^* \cdot II_3^* - e \cdot P_{05}^* \cdot II_5^* - e \cdot P_1^* \cdot M_1)}{e \cdot P_{0c}^*} \quad (41)$$

$$J_i = \pi_i^\Gamma \left(\frac{P_i}{P_J^{COMP}} \right)^{-\Gamma} \cdot J \quad (i = 3, 5) \quad (42)$$

$$J_0 = \pi_0^\Gamma \left(\frac{e \cdot P_{0j}^*}{P_J^{COMP}} \right)^{-\Gamma} \cdot J \quad (43)$$

$$P_J^{COMP} = \left[\pi_0^\Gamma \cdot (e \cdot P_{0j}^*)^{1-\Gamma} + \pi_3^\Gamma \cdot P_3^{1-\Gamma} + \pi_5^\Gamma \cdot P_5^{1-\Gamma} \right]^{\frac{1}{1-\Gamma}} \quad (44)$$

$$P_3 \cdot J_3 + P_5 \cdot J_5 \cdot + e \cdot P_{0j}^* \cdot J_0 + \sum_{i=1}^5 P_i \cdot DS_i \\ = s_a \cdot Y_a + s_u \cdot Y_u + s_s \cdot Y_s + s_2(1 - t_2) Y_z + GREV - GEXP + DEF \quad (45)$$

Definition of variables

Endogenous variables

The model consists of 117 equations. A total of 116 of these are independent since the investment-savings balance can be calculated from the rest of the equations. We therefore have the following 116 endogenous variables:

- A_{ij} : intermediate deliveries $i = 1-5, j = 3-5$
- a_{0j} : intermediate imports–output coefficients sectors $j = 3-5$
- a_{ij} : intermediate input–output coefficients sectors $j = 3-5, i = 1-5$
- B_i : variable costs pr. unit of output sectors $i = 2-5$
- b_i : labor-output coefficients sectors $i = 3-5$
- C_i : total consumption levels, $i = 1-5$
- $CIMP_D$: desired non-competitive consumer imports
- $CIMP_A$: actual non-competitive consumer imports
- D : consumer spending
- DB : spending for floor consumption
- DI_i : domestic intermediate goods aggregate sectors $i = 3-5$
- E_4 : exports
- $GEXP$: gov. spending
- $GREV$: gov. revenue
- J_i : investment deliveries from sectors $i = 0,3,5$
- II_i : intermediate imports sectors $i = 3-5$
- L_{ui} : unskilled workers sectors $i = 2-5$
- L_{si} : skilled workers sectors $i = 2-5$
- L_u : total unskilled workers
- L_i : labor aggregates sectors $i = 2-5$
- M_1 : imports of agricultural goods
- MC_i : marginal cost sectors $i = 3-5$
- MC_{Ni} : marginal cost of intermediate goods aggregate sectors $i = 3-5$
- MC_{VAi} : marginal cost of value added aggregate sectors $i = 3-5$
- N_i : intermediate goods aggregate to sectors $i = 3-5$
- P_i : sectoral price levels, $i = 1-5$

P_{DIi} :	price of domestic intermediate goods aggregate sectors $i = 3-5$
P_J^{COMP} :	price of investment aggregate
q_i :	labor cost sectors $i = 2-5$
RAT :	foreign exchange available for rationed goods
s_i :	savings rates $i = a, u, s, z$
T^{IND} :	indirect taxes
w_s :	wage rate skilled workers
X_i :	sectoral output levels, $i = 1-5$
Y_a :	agr. income
Y_s :	wage income skilled workers
Y_u :	wage income unskilled workers
Y_z :	profit income

Parameters

a_{ij} :	input-output coefficients, $i = 1-5, j = 1-2$
b_2 :	labor-output coefficient sector 2
C_1^* :	target on food consumption
f_{ij} :	shares in domestic input aggregate sectors $j = 3-5, i = 1-5$
h_{0i} :	rationing parameters, $i = 1,3,5,C$
II_i^* :	minimum level of imported intermediates sectors $i = 3,5$
M_1^* :	constant in agricultural imports function
m_c :	propensity to consume noncompetitive imports
m_i :	marginal propensity to consume, $i = 1-5$
n_i :	intermediate goods-output ratio sectors $i = 3-5$
s_i^* :	constant in savings functions, $i = a,u,s,z$
t_i :	indirect tax rates sectors $i = 1-5$
t_z :	tax rate of profit income
α_i :	distribution parameter of unskilled labor in CES aggregate
β_i :	distribution parameter of skilled labor in CES aggregate
γ_i :	savings respond parameter, $i = a,u,s,z$
Γ :	elasticity of substitution in investment aggregate
δ_i :	elasticity of substitution in intermediate goods aggregate sectors $i = 3-5$
ϵ_{1i} :	distribution parameter of intermediate imports in intermediate goods aggregate sectors $i = 3-5$
ϵ_{2i} :	distribution parameter of domestic intermediates in intermediate goods aggregate sectors $i = 3-5$
η_i :	elasticity of substitution in value added aggregate sectors $i = 3-5$
θ_i :	floor consumption levels, $i = 1-5$
μ_{1i} :	distribution parameter of labor in value added aggregate sectors $i = 3-5$
μ_{2i} :	distribution parameter of capital in value added aggregate sectors $i = 3-5$
π_i :	distribution parameter in investment aggregate from sectors $i = 0,3,5$
σ_i :	elasticity of substitution in labor aggregate, $i = 2-5$
τ_2 :	markup rate sector 2

Exogenous variables

- DS_i : changes in stocks, $i = 1-5$
- DEF : trade deficit
- E_2 : exports sector 2
- e : exchange rate
- G_i : gov. demand for commodities, $i = 1-5$
- J : investment aggregate
- K_i : capital in sectors $i = 3-5$
- LB_s : supply of skilled labor
- L_{ug}, L_{sg} : government employment
- M_5 : competitive imports, sector 5 goods
- $NFPA$: net factor payments from abroad
- P_i^* : foreign price of sectoral goods, $i = 1,4,5$
- P_{0i}^* : foreign price of intermediate imports to sector i , $i = 3-5$
- P_{0j}^* : foreign price of investment goods
- P_{0c}^* : foreign price of non-competitive consumer imports
- w_{ui}, w_{ug} : wage rates unskilled workers, $i = 2-5$
- XB_1 : output level sector 1

The standard closure model

The elimination of the rationing influences many aspects of the economy. When the rationing of imported intermediates is removed, intermediate demand functions for sectors 3 and 5 operate as for the initially unrationed exports sector 4. The rationing rule (Eq. (40)) is eliminated, and the demand is determined as in Eq. (6). The demand for domestically produced intermediates is determined as in Eq. (7), and Eq. (8) can be eliminated. The rationed marginal cost functions (Eq. (14)) are replaced by Eq. (12). The rationing rules (Eqs. (39),(41)) are eliminated. The trade deficit is endogenous, and follows from the revised Eq. (38):

$$DEF = e \cdot P_1^* \cdot M_1 + e \cdot P_5^* \cdot M_5 + e \cdot P_{03}^* \cdot II_3 + e \cdot P_{04}^* \cdot II_4 + e \cdot P_{05}^* \cdot II_5 + e \cdot P_{0c}^* \cdot CIMP_A + e \cdot P_{0j}^* \cdot J_0 - P_2 \cdot E_2 - P_4 \cdot E_4 - NFPA$$

In addition, the protection from imported importables and non-competitive consumer goods is abolished. A composite importables good is introduced, a CES aggregate of domestically produced and imported importables. The demand for the composite is X_5^* , and the composition of the composite is determined by

$$X_5 = \xi_1^\psi \left(\frac{P_5}{P_{COMP}} \right)^{-\psi} \cdot X_5^*$$

$$M_5 = \xi_2^\psi \left(\frac{e \cdot P_5^*}{P_5^{COMP}} \right)^{-\psi} \cdot X_5^*$$

$$P_5^{COMP} = \left[\xi_1^\psi \cdot P_5^{1-\psi} + \xi_2^\psi (e \cdot P_5^*)^{1-\psi} \right]^{\frac{1}{1-\psi}}$$

where ξ_1 and ξ_2 are distribution parameters for domestically produced and imported goods in the CES aggregate, ψ the elasticity of substitution, and P_5^{COMP} the price of the aggregate (replaces P_5 in all demand functions). Eq. (1) for sector 5 is now a market balance for only the domestic components of demand, and M_5 is left out of the equation.

The liberalization of non-competitive consumer goods implies that imports are determined by demand in Eq. (32) (where $CIMP_D$ is replaced by $CIMP_A$). The consumer demand functions (Eq. (34)) are reformulated to:

$$C_i = \theta_i + \frac{m_i}{P_i} (D - DB) \quad (i = 1-5)$$

Since the domestic market for food is liberalized, imports M_1 are made endogenous and P_1 is determined by the world price and the exchange rate. The market equilibration is changed from a flex-price regime to an import adjusting regime in the standard open economy fashion.

Calibration

The benchmark model is built around a social accounting matrix (SAM) for 1985 documented by Rattsø and Torvik (1992). All variables are calculated in millions of Zimbabwe dollar at 1985 prices. The parameters and the exogenous variables of the model are set to have the endogenous variables consistent with the SAM. The savings rates differs between economic groups ($s_a = s_u = 0.22$, $s_s = 0.27$, $s_z = 0.5187$). The consumption demand parameters follow from assumptions about the income elasticities (0.8 for agriculture and 1.05 for services) and the supernumerary income ratio (0.48).

Other key parameter values used in the simulations are as follows:

Elasticities of substitution

in labor aggregate, $\sigma_i = 0.5$, $i = 2-5$

in intermediate goods aggregate, $\delta_i = 0.333$, $i = 3-5$

in value added aggregate, $\eta_i = 0.5$, $i = 3, 5$ and 0.2 , $i = 4$

in investment aggregate, $\Gamma = 0.5$

in sector 5 Armington aggregate, $\psi = 0.8$

Constants in savings functions, $s_a^* = 0.22$, $s_u^* = 0.18$, $s_s^* = 0.23$, $s_z^* = 0.4$

Savings response parameters, $\gamma_a = 0$, $\gamma_u = \gamma_s = 0.09$, $\gamma_z = 0.2671$

Rationing parameters, $h_{01} = 1$, $h_{03} = 0.0535$, $h_{05} = 0.3512$, $h_{0C} = 0.5953$

Constant in food import function, $M_1^* = 36$

Minimum levels of imported intermediates, $I_3^* = 90$, $I_5^* = 600$

To investigate the effects of liberalization, the calibration must assume how consumers and producers were rationed. The results are based on the following assumptions:

The production functions determine the desired demand for imported intermediates. Small elasticities of substitution reflect the rigid production structure of the economy. The pure substitution effect of intermediate imports rationing assumes that about 91% of the intermediate imports demand to construction and importables is satisfied in the Africa closure model. Non-competitive consumer imports and imports of sector 5 goods are assumed to be strictly rationed, with the actual imports satisfying only 1/3 of actual demand. The assumption is important for the demand switching and the savings response. Sensitivity analyses of the assumptions regarding the degree of rationing are reported in Davies et al. (1998).

References

- Balassa, B., 1983. Policy responses to external shocks in Sub-Saharan Africa countries. *J. Pol. Mod.* 5, 75–105.
- Bevan, D., Collier, P., Gunning, J.W., 1990a. *Controlled open economies: A neoclassical approach to structuralism*. Clarendon Press, Oxford.
- Bevan, D., Collier, P., Gunning, J.W., 1990b. *Temporary trade shocks and dynamic adjustments*. Discussion Paper No. 93. Institute of Economics and Statistics, Oxford University.
- Chhibber, A., Cottani, J., Firuzabani, R., Walton, M., 1989. *Inflation, price controls, and fiscal adjustment in Zimbabwe*. Working Paper 192, Country Economics Department, The World Bank.
- Collier, P., 1991. Exchange rates and exchange controls in developing countries. *Greek Econ. Rev.* 12, 132–147.
- Corden, W.M., Neary, J.P., 1982. Booming sector and de-industrialisation in a small open economy. *Econ. J.* 92, 825–848.
- Dailami, M., Walton, M., 1992. Private investment, government policy, and foreign capital in Zimbabwe. In: Chhibber, A. et al. (Eds.), *Reviving Private Investment in Developing Countries*. North-Holland, Amsterdam.
- Davies, R., 1991. Trade, trade management and development in Zimbabwe. In: Frimpong-Ansah, J., Ravi Kanbur, S.M., Svedberg, P. (Eds.), *Trade and Development in Sub-Saharan Africa*. Manchester University Press, Manchester.
- Davies, R., Rattsø, J., Torvik, R., 1994. The macroeconomics of Zimbabwe in the 1980s: A CGE-model analysis. *J. Afr. Econ.* 3, 153–198.
- Davies, R., Rattsø, J., Torvik, R., 1998. Short-run consequences of trade liberalization: A CGE-model of Zimbabwe. *J. Pol. Mod.* 20, 305–333.
- Devarajan, S., Lewis, J., Robinson, S., 1990. Policy lessons from trade-focused, two-sector models. *J. Pol. Mod.* 12, 625–657.
- Dornbusch, R., 1989. Real exchange rates and macroeconomics: A selective survey. *Scand. J. Econ.* 91, 401–432.
- Gibson, B., 1985. A structuralist macromodel for post-revolutionary Nicaragua. *Cambr. J. Econ.* 9, 347–369.
- Hardouvelis, G.A., 1987. Optimal wage indexation and monetary policy in an economy with imported raw materials. *J. Int. Mon. Fin.* 6, 419–432.

- Helleiner, G., 1990. Structural adjustment and long-term development in sub-Saharan Africa. Working Paper 18, Centro Studi Luca D'Agliano, Queen Elizabeth House.
- Katselli-Papaefstratiou, L., 1990. Transmission of external price disturbances and the composition of trade. *J. Int. Econ.* 10, 357–375.
- Kouri, P., 1979. Profitability and growth in a small open economy. In: Lindbeck, A. (Ed.), *Inflation and Employment in Open Economies*. North-Holland, Amsterdam.
- Mehlum, H., Rattsø, J., 1996. Import compression and growth constraints in Zimbabwe. Mimeo, Department of Economics, University of Trondheim.
- Morande, F., Schmidt-Hebbel, K., 1991. Macroeconomics of public sector deficits: The case of Zimbabwe. Working Paper 688, Country Economics Department, The World Bank.
- Ndulu, B., 1986. Investment, output growth and capacity utilization in an African economy: The case of the manufacturing sector in Tanzania. *East Africa Econ. Rev.* 2, 14–30.
- Ndulu, B., 1991. Growth and adjustment in Sub-Saharan Africa. In: Chhibber, A., Fischer, S. (Eds.), *Economic Reform in Sub-Saharan Africa*, World Bank, Washington.
- Neary, J.P., Roberts, K.W.S., 1980. The theory of household behavior under rationing. *Eur. Econ. Rev.* 13, 25–42.
- Neary, J.P., 1993. External shocks, policy response and economic performance. Mimeo, Department of Economics, University College Dublin.
- Rattsø, J., 1994a. Medium run adjustment under import compression: Macroeconomic analysis relevant for Sub-Saharan Africa. *J. Dev. Econ.* 45, 35–54.
- Rattsø, J., 1994b. Devaluation and monetary policy with import compression. *Open Econ. Rev.* 5, 159–175.
- Rattsø, J., Torvik, R., 1992. An applied general equilibrium model for Zimbabwe: Documentation of model, social accounting matrix 1985, and calibration. Mimeo, Department of Economics, University of Trondheim.
- Rattsø, J., Torvik, R., 1998. The Zimbabwean trade liberalisation: Ex post evaluation. *Cambr. J. Econ.* (in press).
- Rodrik, D., 1994. Trade and industrial policy reform in developing countries: A review of recent theory and evidence. In: Behrman, J., Srinivasan, T.N. (Eds.), *Handbook of Development Economics*, vol. III. North-Holland, Amsterdam.
- Taylor, L., 1983. *Structuralist macroeconomics*. Basic Books, New York.
- Torvik, R., 1994. Trade policy under a binding foreign exchange constraint. *J. Int. Trade Econ. Dev.* 3, 15–31.
- Torvik, R., 1997. Real exchange rate dynamics and trade liberalization: The case of multiple tariffs and unemployment. *J. Int. Trade Econ. Dev.* 6, 329–344.
- Wheeler, D., 1984. Sources of stagnation in Sub-Saharan Africa. *World Dev.* 12, 1–23.
- World Bank, 1993. *Adjustment in Sub-Saharan Africa: Progress, Payoffs, and Challenges*. Policy Research Report No 2, Washington.