Trade Shocks and Macroeconomic Fluctuations in Africa*

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and

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Abstract: This paper examines the role of external shocks in explaining macroeconomic fluctuations in African countries. We construct a quantitative, stochastic, dynamic, multi-sector equilibrium model of a small open economy calibrated to represent a "typical" African economy. In our framework, external shocks consist of trade shocks, modeled as fluctuations in the prices of exported primary commodities, imported capital goods and intermediate inputs, and a financial shock, modeled as fluctuations in the world real interest rate. We also study the role of domestic factors in generating macroeconomic fluctuations as these factors are captured by the changes in sectoral productivity. Our results indicate that while trade shocks account for roughly 45% of economic fluctuations in aggregate output, financial shocks play only a minor role. Moreover, we find that adverse trade shocks induce prolonged recessions since they induce a significant decrease in aggregate investment.

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1. Introduction

There is a large and expanding literature suggesting that highly unstable domestic macroeconomic environment is one of the primary reasons for the poor growth performance of African countries in the last thirty years.[1] The implication is that to improve growth performance in Africa, we need to understand why their economies are so volatile. That is the objective of this paper: using a dynamic, stochastic model we establish a link between external shocks and the highly volatile macroeconomic fluctuations in these economies. We study the effects of trade and financial shocks. Surprisingly, we find that, despite the fact that these countries are typically heavily indebted, trade shocks play a much more important role than financial shocks. In particular, it turns out that trade shocks explain almost half of the volatility in aggregate output.

International trade can induce macroeconomic fluctuations in a small open economy by two channels: one channel is through trade in goods and services, and the other one is by trade in financial assets. In African economies, these two channels have distinctively important roles in shaping domestic economic activity: first, the volume of international trade on average accounts for more than 70% of the aggregate output in these countries. Moreover, a narrow range of primary commodities constitutes a significant fraction of their exports, and their main import items are intermediate inputs and capital goods. Their export revenues are highly unstable due to recurrent and sharp fluctuations in the prices of primary commodities. Second, most of the African countries are heavily indebted, and a significant fraction of their export revenues are used to meet their debt service obligations. These make African countries extremely vulnerable to sudden changes in the world interest rate.

A thorough understanding of the sources of macroeconomic fluctuations in African economies requires a good grasp of the impact of trade shocks, namely fluctuations in the prices of exported primary commodities, imported capital goods, and intermediate inputs, and financial shocks, namely fluctuations in the world real interest rate, on domestic economic activity. We address the following questions to shed some light on these issues: first, do trade disturbances account for a significant fraction of macroeconomic fluctuations? Second, how are trade shocks transmitted and propagated through these economies?

We begin by documenting some of the major characteristics of industrial structure, composition of international trade, and dynamics of trade shocks to provide empirical evidence that there is a strong link between international trade disturbances and domestic economic activity in African countries. We, then, construct a multi-sector, dynamic, stochastic small open economy model which reflects the structural characteristics of a "representative" African economy. There are two sectors in the model: primary goods and nontraded final goods sectors. The economy exports

[1] Collier and Gunning (1999) provide a detailed survey of the literature examining the reasons of the slow growth in Africa. Sachs and Warner (1996) and Rodrik (1998a) use a variety of growth regressions to study the determinants of economic performance, and conclude that macroeconomic stability is an important factor for the long-run growth in Africa. Pindyck (1991), and Aizenman and Marion (1993) provide theoretical models where a volatile macroeconomic environment has an adverse impact on growth. Ramey and Ramey (1995), using the data of developing and developed economies, find that countries with highly volatile macroeconomic environment have relatively lower growth.

primary goods, and imports all of its intermediate inputs and a significant fraction of its capital goods. The households in this economy can buy and sell one-period risk free bonds in the world financial markets. We also study the role of domestic factors in generating macroeconomic fluctuations as these factors are captured by the changes in sectoral productivity. We compare the properties of the macroeconomic fluctuations generated by this model with those actually observed in African countries. We find that that the model successfully accounts for several important properties of macroeconomic fluctuations in African economies.

We quantitatively evaluate the contribution of international trade shocks to domestic macroeconomic fluctuations. Our findings indicate that trade shocks play an important role in driving economic activity in African countries: almost 45% of fluctuations in aggregate output is explained by trade shocks. Further, trade shocks account for almost 87% of aggregate investment variation and 80% of labor supply fluctuations. We also find that world interest rate fluctuations have only a minor impact on economic dynamics of African countries in our benchmark experiments. However, the importance of these shocks significantly increases as the ratio of trade balance to aggregate output rises. Impulse response analysis demonstrates that the propagation of economic fluctuations generated by the trade shocks is different than that caused by domestic productivity shocks. In particular, while positive productivity disturbances result in short lived expansions, adverse trade shocks cause prolonged recessions.

Our paper contributes to the large literature examining the links between economic activity and trade shocks in developing economies and is particularly related to some recent papers studying the sources of macroeconomic fluctuations in African countries.[2] Deaton and Miller (1996) employ a vector autoregression (VAR) model to examine the importance of commodity price shocks. Hoffmaister, Roldos, and Wickham (1998) estimate a structural VAR model, where identifying restrictions are derived from a long-run small open economy model, to study the role of terms of trade and world real interest rate shocks. While the former study concludes that price shocks play an important role in driving macroeconomic fluctuations in African economies, the latter one finds these disturbances account for only a small fraction of the variation in output. Mendoza (1995) examines the importance of terms of trade shocks in a small open economy model calibrated for a typical developing economy and finds that these shocks account for almost half of the aggregate output fluctuations.[3]

This study extends the scope of this research program in several dimensions: first, we study the sources of macroeconomic fluctuations in African countries in a fully specified, stochastic,

[2] Balassa (1978), Moran (1983), Feder (1983), and Basu and McLeod (1992) examine the relation between export instability and economic growth. Bevan, Collier, and Gunning (1994) provide a computable general equilibrium model of an open economy to examine the economic experiences of Kenya and Tanzania after the major trade shock in 1976.

[3] Praschnik (1993) studies the role of input price shocks in generating business cycles in developing countries using a closed economy model. Kouparitsas (1997a) investigates the transmission of business cycles from developed Northern countries to developing Southern economies in a two-country model.

dynamic, open economy model reflecting the structural characteristics of these economies.[4] Since the model economy is dynamic, and involves endogenous labor-leisure choice, we are able to examine the link between trade shocks and fluctuations in aggregate investment, foreign asset holdings, and labor markets. The model economy employs domestically produced capital goods, imported capital goods, and imported intermediate inputs in two different sectors. This structure of differentiation in productive factors allows us to study the impact of different types of trade shocks on different sectors of the economy. Moreover, these features of the model help explain the links between economic fluctuations in productive factors and aggregate output volatility.

Second, our study considers a broader definition of trade shocks as it focuses on the price changes of the main export and import items instead of terms of trade disturbances. This is motivated by our empirical examination which reveals that the terms of trade is not able to fully reflect highly volatile movements in relative prices of the main export and import items of African countries. Third, while assessing the role of trade shocks, we investigate the impact of world interest rate fluctuations on domestic economic activity in African countries.

The organization of the paper is as follows: in section 2, we review the empirical regularities of African data. Following this, we present the model. Model calibration is described in section 4. In section 5, we first assess the ability of the model in replicating business cycle dynamics of a representative African country. Then, we quantitatively evaluate the importance of different types of shocks in generating macroeconomic fluctuations. The model dynamics are analyzed using impulse responses. Following this, the sensitivity of the results to changes in the structural parameters of the model is briefly investigated. We conclude with a brief summary in section 6.

2. Analysis of the data

2.1. Structural characteristics of the African economies

We begin with an examination of the decomposition of aggregate output to provide a better understanding of the structural characteristics of the African economies. Our analysis is based on the annual data of twenty-two non-oil exporting African countries for the 1970-1990 period.[5] We present information about the expenditure shares of aggregate output and industrial structure in Table 1a. The G7 average of each magnitude is also provided for comparison purposes. The major difference between these two groups is the role played by international trade in domestic economic activity. In African (G7) countries, exports account for almost 31 (20)% of total GDP while

[4] See Baxter (1995) for a survey on dynamic general equilibrium models of open economies. Kose (1999) examines the role of world price shocks in driving business cycles in developing economies and provides and extensive review of the relevant literature.

[5] We examine the data of 22 non-oil exporting African countries. 18 of these countries are Sub-Saharan African, 4 of them are Arab States: Burundi, Cape Verde, Egypt, Gambia, Ghana, Guinea Buissea, Kenya, Liberia, Madagascar, Malawi, Mauritania, Mauritius, Morocco, Seychelles, Sierra Lione, Sudan, Swaziland, Tanzania, Tunisia, Zaire, Zambia, and Zimbabwe. Egypt, Seychelles, and Tunisia receive a significant fraction of their export revenues from oil. However, these countries are not major oil exporters. When we considered a sample without these countries and

imports constitute more than 40 (18)% of it. Strikingly, the volume of trade on average accounts for more than 71% of GDP in African countries while only 38% of total GDP is attributable to the trade volume in the G7 countries. As Table 1a indicates, African countries have relatively large trade deficits: the average trade deficit is around 10% of the GDP in the African economies in our sample.

African economies' industrial structures also make them highly vulnerable to trade shocks: they have relatively smaller industry and service sectors, and, consequently, the share of agricultural sector is considerably larger in these countries. To be more specific, agricultural goods on average account for 28 (4)% of total GDP while industrial production constitutes roughly 18 (30)% of total domestic income in African (G7) countries. The share of agricultural sector in aggregate output in Africa ranges from a low of 9% in Seychelles to a high of 55% in Burundi.

Table 1b describes the structure of exports. As this table clearly illustrates, the African economies heavily depend on primary goods for their export revenues: the share of primary exports on average is 77% and ranges from 26% in Tanzania to 99% in Sudan. Interestingly, the average share of capital good exports is less than 2% in total exports. If these countries export a variety of primary goods, then their dependency on primary commodities for their export revenues might not be seen as an important problem, since fluctuations in the prices of different types of primary commodities can offset each other, and result in relatively stable export earnings. In order to examine the extent of diversification of exports at a more disaggregated level, we use two different criteria that are presented in the last two columns of Table 1b. Both of these measures suggest that the African countries in our sample seem to be much more concentrated in their exports than the G7 countries. First, we examine the number of commodities exported by the African economies: they export on average 54 different goods. This number is around 213 for the G7. Second, we use the Gini-Herschman coefficient to measure the concentration of exports. A higher value of this coefficient indicates a higher degree of export concentration. While the average coefficient of export concentration is more than 60 for the African countries, it is less than 10 for the G7.

Table 1c provides information about the decomposition of imports. Two points about this table are noteworthy: first, the main import items of these countries are capital goods and intermediate inputs. While the imports of intermediate inputs account for almost half of the total imports, the average share of capital good imports is approximately 28%. Second, the share of agricultural goods is minor in total imports.

repeated our calibration exercise, we saw that the results reported here were not affected in any significant way. See Kose and Riezman (1999) for a detailed documentation of the statistics reported here.

Movements in the cost of servicing external debt also seem to be an important source of macroeconomic fluctuations in several African countries, particularly highly indebted ones.[6] As Table 2 indicates, the average ratio of external debt to GNP is around 89% and the debt service to export ratio, which is a widely used measure of debt burden, is around 20% for the African economies in our sample. Notably, the ratio of short-term debt payments to the export revenues is on average 43%.

We conclude this section with some broad observations. A typical African economy gets the bulk of its export revenues from a narrow group of primary commodities, imports mainly capital goods and intermediate inputs, faces persistent trade deficits, and has to allocate a significant fraction of its export revenues to meet its short term debt obligations. A model designed to examine the sources of macroeconomic fluctuations in African economies should reflect these characteristics.

2.2. Dynamics of Prices

There has been a revival of interest to understand the dynamics of commodity prices since a number of developing countries have faced a sharp downward trend in the prices of their main export items over the last two decades.[7] Since our ultimate objective is to evaluate the effects of trade shocks proxied by relative price fluctuations on macroeconomic dynamics of the African economies, we briefly examine the cyclical features of price series and provide further empirical evidence about the relation between these series and macroeconomic fluctuations in these countries.

Instead of analyzing the terms of trade dynamics only, we also examine a disaggregated measure of the terms of trade and look at the dynamics of relative prices of capital goods and intermediate inputs to primary goods. As we reported above, these three groups of commodities constitute a significant fraction of the trade volume in African countries. Table 3 documents our findings. The relative price of capital goods to primary goods, p_t^k, is calculated as the ratio of the U.S. producer price index of capital equipment to the export price index of the domestic economy. The relative price of intermediate goods, p_t^v, is equal to the ratio of the U.S. producer price index of intermediate materials to the export price index of the domestic economy. The terms of trade is calculated as the ratio of export price index to import price index of each country. Interestingly, the relative prices are more volatile and more persistent than the terms of trade. The relative prices of capital goods (intermediate inputs) to primary commodities are 1.23 (1.11) times more volatile than

[6] Fosu (1996) finds that the debt burden of Sub-Saharan African countries has a strong adverse impact on the growth performance of these countries using regression estimates.
[7] Reinhart and Wickham (1994) find that there has been a steady and considerable increase in the volatility of commodity prices since the early 1970s.

the terms of trade. The persistence of the terms of trade is 0.22 while the persistence of relative price of capital (intermediate) goods is 0.38 (0.35).

There are two major reasons why relative price series exhibit different cyclical dynamics than the terms of trade. First, as we found in the previous section, African countries heavily rely on a limited number of primary commodities for their export earnings. Second, African countries' export and import patterns are quite heterogeneous. These two suggest that it is hard to accurately proxy the extent and duration of fluctuations in the prices of main export and import items of these countries with a single price index, like the terms of trade. In other words, since the terms of trade is simply an aggregate price index, it is unable to fully reflect sharp peaks and deep troughs frequently observed in the prices of major export items of developing countries (see Deaton and Laroque (1992)).[8]

3. The Model Economy

3.1. Preferences

The economy is inhabited by a large number of infinitely lived, identical households.[9] The representative household maximizes expected lifetime utility given by

$$U(c,l) = E_0 \{\sum_{t=0}^{\infty} \beta^t \frac{[u(c_t, l_t) - 1]}{1-\sigma}\}$$
$$\sigma > 0\ ,\ \beta > 0 \qquad (1)$$

where the parameter β denotes the subjective discount factor of the household and σ is the risk aversion parameter. c_t is consumption of the non-traded final good and l_t represents leisure in period *t*.

Neither exported nor imported goods are modeled as utility deriving goods in the model because of the following reasons: first, the empirical evidence provided in the previous section indicates that a significant fraction of exports comes from the primary goods sector in African countries. These exported primary goods are generally used as inputs in producing final goods, so

[8] Kouparitsas (1997b) provides extensive evidence that the relative prices are more volatile than the terms of trade. Although he is using a different data set, his results are very close to ours: he finds that the relative prices of non-fuel commodities to manufactured goods is 1.37 times more volatile than the terms of trade. He also shows that the terms of trade can be written as a linear function of relative prices. Bidarkota and Crucini (1998) examine the commodity price fluctuations and find that commodity prices are much more volatile than the terms of trade.

[9] See Kose (1999) for detailed information about the small open economy model presented here.

the contribution of these goods to utility is via final goods. Second, recent empirical studies indicate that consumer goods are only a small fraction of the total imports of developing countries.[10]

The instantaneous utility function u has the form

$$u(c_t, l_t) = (c_t - \psi(1 - l_t)^{\nu})^{1-\sigma} \qquad \nu > 1, \psi > 0 \quad (2)$$

ν governs the intertemporal elasticity of substitution in labor supply, ψ is a parameter used to set the steady state level of labor hours.

3.2. Technology

The economy produces nontraded final goods and primary goods. Nontraded final goods production, y_t^f, uses labor, n_t^f, capital, k_t^f, and intermediate inputs, v_t:

$$y_t^f = z_t^f (n_t^f)^{\alpha} \, [s(k_t^f)^{-u} + (1-s)v_t^{-u}]^{-(1-\alpha)/u} \quad (3)$$
$$0 < \alpha, s, u < 1$$

z_t^f represents the exogenous productivity shock. α is the share of non-traded output earned by labor and s is the relative weight of capital. The elasticity of substitution between intermediate inputs and capital is governed by u. The CES formulation allows us to analyze the impact of degree of substitutability between domestic capital goods and foreign intermediate inputs on the dynamics of our model.

The primary goods sector produces output by using labor, n_t^p, capital, k_t^p, and land, L^p, which is assumed to be inelastically supplied. The production function in the primary goods sector is given as

$$y_t^p = z_t^p (n_t^p)^{\theta_1} (k_t^p)^{\theta_2} (L^p)^{1-\theta_1-\theta_2} \quad (4)$$
$$0 < \theta_1, \theta_2 < 1$$

where z_t^p is the technology shock. θ_1 and θ_2 are the labor and capital income shares respectively. Our modeling of primary goods production is quite different from earlier small open economy business cycle models: since production of primary goods requires substantial amount of land input in African economies, we introduce land into the primary production. This also reduces the variation of the primary sector output by limiting the substitution effects across different factors. This, in turn, decreases volatility of aggregate output, and helps the model to generate realistic volatility properties.

[10] See Ahearne (1997) and Hentschel (1992) for evidence suggesting that the share of imported consumption goods in aggregate consumption is quite small in developing countries.

The production structure in this model also differs from those in earlier models. For example, Mendoza (1995) constructs a small open economy model where capital is perfectly substitutable between exportable and importable goods producing sectors, and domestically produced capital goods in the nontradable goods sector are inelastically supplied. Since the only endogenous factor in nontraded sector is labor, terms of trade disturbances have only an indirect effect on the dynamics of that sector in his model. By contrast, in our model, the supply of nontraded capital goods is endogenously determined. Moreover, we do not allow the perfect substitutability of capital across two sectors, as capital is sector specific in our model. In particular, we assume that primary sector capital is imported and capital used in the nontraded goods sector is domestically produced. These features provide an environment in which spillover effects of the price shocks in the distribution of imported intermediate inputs and capital goods across two sectors can be studied. Further, we are able to examine the impact of different types of price shocks on different types of factors of production. Our approach is also empirically appealing because capital goods used in the primary goods sector are generally machinery and equipment items, and a significant fraction of capital goods used in the nontraded final goods sector are structures.

Capital accumulation is modeled as

$$k_{t+1}^{j} = (1-\delta)k_t^{j} + \phi_j\left(\frac{i_t^{j}}{k_t^{j}}\right)k_t^{j} \quad j = f, p \tag{5}$$

Here δ is the rate of depreciation, i_t^j is the amount of investment in sector j, and $\phi_j(.)$ represents the concave adjustment cost function, with $\phi_j(.) > 0$, $\phi_j(.)' > 0$, and $\phi_j(.)'' < 0$. Adjustment costs prevents excessive volatility of investment (see Baxter and Crucini (1993)).

The resource constraint for the nontraded goods sector is given by

$$c_t + i_t^{f} = y_t^{f} \tag{6}$$

The price of the primary good is numeraire in the resource constraint of the primary good sector which is

$$p_t^k i_t^p + p_t^v v_t + nx_t = y_t^p \tag{7}$$

where nx_t represents the balance of trade. The household, who has a fixed time endowment normalized to one, faces the following labor-leisure allocation constraint[11]

$$l_t + n_t^f + n_t^p = 1 \tag{8}$$

3.3. Financial Markets

While each household has free access to world financial markets, these markets are incomplete in the sense that households can trade only a single financial asset, A_t, with a rate of return, r_t, from period t to t+1. This market structure partly captures the fact that a number of African countries maintain a variety of capital controls. It also allows us to study the impact of the world interest rate shocks on domestic economic fluctuations with ease. The holdings of financial assets evolve according to the formula

$$A_{t+1} = nx_t + A_t(1+r_t) \tag{9}$$

The possibility of the household playing a Ponzi game is ruled out by imposing the condition:

$$\lim_{t\to\infty} E_0 (A_t \frac{1}{(1+r_t)^t}) = 0$$

In addition to this, we assume that $\beta = 1/(1+r^*)$, r^* is the steady state level of interest rate. It is known that when the discount rate is smaller (greater) than the interest rate, the representative household accumulates (decumulates) assets in a deterministic version of the model. In other words, there is no steady state equilibrium in those cases. If the two are equal, the economy is at a steady state equilibrium which is compatible with any level of foreign asset holdings.[12]

3.4. Exogenous shocks and Numerical Solution Method

There are five shocks in the model: two shocks to the relative prices of imported capital and intermediate goods, a world interest rate shock, and two sectoral productivity shocks. The vector of exogenous shocks is represented by $Z_t = [\ln(p_t^k), \ln(p_t^v),\ r_t\ , \ln(z_t^f), \ln(z_t^p)]'$. The evolution of Z_t follows a first order Markov process and is given by

$$\ln Z_{t+1} = \Pi \ln Z_t \ + \varepsilon_{t+1} \tag{10}$$

The vector of innovations is denoted by $\varepsilon_t = [\,\varepsilon_t^k, \varepsilon_t^v,\ \varepsilon_t^r, \varepsilon_t^f, \varepsilon_t^p,]'$ where $\varepsilon_t \sim N(0,\Sigma)$.

We solve the optimization problem of the representative household by maximizing the expected lifetime utility, (1), subject to the constraints (3)-(10). Since this problem cannot be solved analytically, we find an approximate solution using the log-linear approximation method of King, Plosser and Rebelo (1988).

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[11] Our modeling of labor input also differs from Mendoza (1995), who assumes that labor is inelastically supplied in the traded goods producing sectors, as we assume that endogenous labor input is mobile across the sectors.

4. Model Calibration

4.1. Preferences

The risk aversion parameter, σ, is equal to 2.61 which is the GMM estimate from the panel study of a group of developing economies, some of which are African countries, by Ostry and Reinhart (1992). Prior empirical studies show that the value of the intertemporal elasticity of substitution in labor supply, $1/(\nu-1)$, is between 0.3 and 3.2 (see Greenwood, Hercowitz and Huffman (1988)). We set the value of this parameter at 0.83 to produce reasonably volatile labor supply fluctuations. The value of ψ is selected so that the fraction of hours worked in the steady state is consistent with our assumption about the allocation of labor hours between the market and non-market activities.

As the world real interest rate measure, we use the LIBOR (the London Interbank Offer Rate) deflated by changes in the export unit value index of developing countries. The average world real interest rate, r^*, is found to be 3.5% annually. Since the interest rate is equal the discount rate at the deterministic steady state, the discount factor, β, is equal to 0.97.

4.2. Technology

The relative weight of capital, s, is set at 0.55. At the steady state, the capital goods and intermediate inputs shares are equal to 0.23 and 0.32 respectively. These three values together imply that the ratio of intermediate inputs to output and the ratio of investment goods to output are equal to 23% and 15% that are approximately equal to those observed in developing economies. Following Praschnik (1993) we set the share of labor, θ_1, at 0.37. By using sectoral data and the first order condition for primary capital, we find that the share of land, $1-\theta_1-\theta_2$, is equal to 0.45. We select the rate of depreciation at 0.10 that is a widely used value in the business cycle literature. The labor share for the nontraded final goods sector, α, is set at 0.45 to be in line with the earlier studies in the literature (see Mendoza (1995)). We choose a value of 0.58 for the Allen elasticity of substitution between capital and intermediate goods. This value is consistent with the estimates provided by Berndt and Wood (1975).

Following Baxter and Crucini (1993), we assume that $\phi(i_f / k_f) = \phi(i_p / k_p) = \delta$ and $\phi'(i_f / k_f) = \phi'(i_p / k_p) = 1$ at the steady state. The elasticity of the marginal adjustment cost function, $\eta = -(\phi' / \phi'') / (i / k)$, for each type of capital, is set so that the volatility of investment generated by the model is equal to that of the data. Since we assume the equality of the interest rate

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[12] Kim and Kose (1999) show that a small open economy model with an endogenous discount factor produces business cycle dynamics that are very similar to those produced by a model with a fixed discount factor. Our formulation is also similar to the one in Correia, Neves and Rebelo (1995).

to the discount factor, the steady state value of foreign assets is a free parameter, which is determined by the trade balance to output ratio. This ratio is set at the average trade balance-output ratio in our sample (-0.096). Table 4b presents calibrated parameters of the model.

4.3. Exogenous shocks

4.3.1. Productivity Shocks

We estimate the total factor productivity in the nontraded goods sector, z_t^f, using the formula of the Solow residual in logarithms

$$\log(z_t^f) = \log(y_t^f) - \alpha \log(n_t^f)$$

y_t^f is the total real value added of industry and service output. n_t^f is equal to the employment index since data on labor hours is unavailable for most of the countries in our sample. The capital stock and intermediate input usage are excluded from the formula for the following reasons: first, it is known that fluctuations in the capital stock are not large in the short-run. Second, the contemporaneous correlation between the capital stock and output is negligible. Third, the data on intermediate input usage is not available. We fit an univariate AR(1) process to find the parameters of the productivity shock for each country and then take an average over the whole sample of these parameters. These averages are assumed to be the relevant parameters for the representative African economy. By following the same steps and using the data of agricultural value added, and employment in manufacturing sector, we estimate the shock process for the primary sector output. Table 4a presents the resulting specifications for exogenous processes.

4.3.2. Trade Shocks

We determine the parameters of the processes of trade shocks by using an univariate AR(1) processes.[13] We do not have any data series or world price indices that are specifically designed for capital goods and intermediate inputs. However, this data is available at the country level. We conjecture that world prices of those goods closely follow the prices of the same goods produced in the U.S. So, the U.S. producer price indices of capital equipment and intermediate goods are used to represent the prices of imported capital and intermediate goods respectively. The price series of primary commodities correspond to the export unit values of each country. This assumption is easily justified because a significant fraction of exports in African countries are primary commodities. The relative price of capital goods (intermediate inputs) to primary commodities is the ratio of the U.S. producer price index of capital equipment (intermediate inputs) to the export unit value index for each economy. In order to estimate the world real interest rate, we use the six-

[13] See Deaton and Miller (1996) for a similar AR(1) modeling of price series.

month LIBOR (the London Interbank Offer Rate) deflated by changes in the export unit value index of African countries.[14] We find the variance-covariance matrix of innovations by using the covariances between the residual terms of estimated processes for each country. Then, we take the average of these matrices over the sample. Table 4a presents the resulting specifications for exogenous processes.

5. Results

This section starts with an evaluation of our model's ability in terms of capturing main regularities associated with macroeconomic fluctuations in a typical African economy. Then, we examine the importance of different types of shocks in generating macroeconomic fluctuations by employing variance decompositions. Next, propagation mechanisms of exogenous shocks in the model economy are analyzed using impulse responses. Following this, we provide a brief discussion about the sensitivity of our results to changes in the parameters of the model.

5.1. How successful is the model?

While it is not our primary objective to examine the ability of our model in terms of matching the main characteristics of macroeconomic fluctuations in African economies, we still think that this is an useful exercise since our model economy is the first one in its class designed to study economic dynamics of African countries. We present some stylized features of macroeconomic fluctuations in these countries along with those of the model economy in Table 5a. All properties of the data refer to moments of Hodrick-Prescott (HP(100)) filtered variables (see Hodrick and Prescott (1997)). We consider the two main features of macroeconomic fluctuations: volatility, measured by standard deviation, and comovement, measured by correlations.

Columns 2, 3, and 4 reveal the following stylized features of business cycles in developing countries: first, the volatility of output in the primary goods sector is roughly two times larger than that of aggregate output. Second, the volatility of consumption is two times greater than that of aggregate output since our consumption series includes durable goods, and African economies do not have well functioning financial markets that can create consumption smoothing opportunities. Third, while investment exhibits high cyclical volatility, the trade balance is the most volatile aggregate. Fourth, except the trade balance, all macro aggregates are procyclical.[15]

We simulate our model with the specification described in the previous section. Each statistic we report is the sample average of across 1000 simulations of the same length as the data

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[14] The LIBOR is used as a benchmark interest rate measure by international organizations and commercial banks when they give loans to developing countries. See World Economic Outlook (1993, p. 83) for the use of this measure as a proxy for real cost of borrowing for developing economies.

(23 years). The simulated data is also detrended with the HP(100) filter. In terms of matching volatility properties of macro aggregates, the model is quite successful as columns 5, 6, and 7 show: qualitatively, it replicates most of the features of actual data. Both trade balance and investment are more volatile than aggregate output. The model also captures the volatility ordering of outputs of production sectors: the primary sector output has the largest variability, and aggregate output is the least volatile series. From a quantitative perspective, the model is able to reproduce some of the stylized facts. For example, it is able to mimic volatilities of sectoral outputs and aggregate output with a small margin. The predicted standard deviation of the trade balance is slightly higher than the actual one. We set the relevant elasticities of adjustment costs so the model can exactly replicate the volatility of investment.

The volatilities of consumption and employment relative to output are seemingly low in the model economy. This result should not be interpreted as a weakness of the model: first, the only available data on consumption in African countries, which we have access to, includes both non-durable and durable consumption expenditures. Unlike the data, our model does not take into account durability. Hence, a direct comparison of the model generated consumption data with the actual one might result in an inaccurate assessment of the model. It is known that the volatility of durable goods consumption is two to four times higher than that of non-durable consumption.[16] Second, the labor supply variation in the model is captured only along the intensive margin. Conversely, we have employment data which measures the labor supply fluctuations only along the extensive margin. Earlier empirical studies indicate that the volatility of employment is two to three times higher than that of labor hours. Interestingly, the prediction of the model concerning employment fluctuations is also consistent with this empirical regularity: the volatility of labor hours in the model is approximately two times smaller than the one of employment series in the data.

We next evaluate the performance of the model in replicating comovement properties of the data. While quite closely matching the correlation between the primary sector output and aggregate output, the model overpredicts the aggregate output-final sector output correlation. The correlations between consumption and output, and between investment and output in the model are higher than those in the data.[17] The output-labor hours correlation in the model is higher than the output-employment correlation in the data. Our preference formulation implies that the marginal rate of

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[15] Kose and Riezman (1999) present a detailed examination of the features of macroeconomic fluctuations in African countries.

[16] Baxter (1996) provides an extensive discussion about the durables vs. nondurables goods differentiation and its macroeconomic implications.

[17] It is possible to remedy near perfect procyclical behavior of consumption by allowing the household to consume a variety of goods, such as exportable and importable goods.

substitution between consumption and leisure depends only on labor supply inducing perfectly procyclical labor hours. One of the important features of the model economy is its ability to generate countercyclical behavior of the trade balance series. Interestingly, compared with the actual data, there is a relatively high negative correlation between the trade balance and aggregate output in the model. This result might be due to the coexistence of productivity and trade shocks that together generate prolonged trade deficits in the model. We further investigate this possibility in section 5.4.

Our model is quite successful in matching some of the salient features of macroeconomic fluctuations in African economies. Several of our results have not been obtained in earlier small open economy business cycle models.[18] For example, our model is able to reproduce the volatility ordering of sectoral outputs. It also captures the comovement properties of sectoral outputs.

5.2. How important are the trade shocks?

Our main objective is to determine the relative contribution of the trade shocks to macroeconomic fluctuations in African economies. We apply the variance decomposition method, which is widely used in the vector autoregression literature, on the solution of the model to determine the relative importance of shocks in explaining economic fluctuations. In other words, we decompose the variances of macroeconomic variables into fractions explained by exogenous shocks.[19] This method requires us to impose a certain information ordering on the shocks because the relative contribution of each disturbance to macroeconomic fluctuations is sensitive to its place in the shock specification. Since our model represents a small open economy, there is a natural ordering of shocks. By construction, the small open economy does not have any control over the external shocks it faces in the world markets. This implies that domestic shocks do not have any impact on the external shocks, i.e. the external shocks precede sectoral productivity shocks in our specification.[20]

The results of the variance decompositions, which are obtained by using the information ordering in (10), are reported in Table 6. We present the fraction of variance due to trade shocks in

[18] Our model does a much better job in terms of matching some moments than the one in Mendoza (1995). For example, Mendoza's model generates that tradables sector output is less volatile than nontradables sector output, and labor supply in the nontraded good sector is countercyclical. These results are not consistent with the empirical evidence presented here. Moreover, his simulations suggest that the volatility of output (investment) is almost three (two) times less than that in the data, the volatility of the trade balance is two times less than that in the data, and the correlation between investment and output is two times less than that in the data.

[19] In a multi-shock model, measuring the contribution of a single shock to business cycle fluctuations is difficult because the shocks are correlated with each other. Mendoza (1995) employs the standard "variance-ratio" approach, which examines each shock in isolation from the other shocks. Some recent papers (see Ingram, Kocherlakota, and Savin (1994) and Cochrane (1994)) argue that the standard approach can yield misleading inferences about the relative importance of shocks. Our approach does not suffer from the problems of the standard variance ratio method.

[20] We also analyzed the sensitivity of these results to different orderings of the shocks. This investigation indicates different information orderings do not cause significant changes in the results reported here.

the first three columns. Strikingly, a significant fraction of macroeconomic fluctuations is explained by trade shocks. They account for roughly 45% of the variation in aggregate output. Our results indicate that shocks to the relative price of capital goods to primary goods play a more important role than shocks to the relative price of intermediate inputs. While almost 25% of variability in aggregate output is due to the changes in relative prices of capital goods, less than 20% of the fluctuations is due to the disturbances to relative prices of intermediate inputs. The domestic productivity disturbances also play an important role in driving economic activity: roughly 55% of the output variation is due to productivity disturbances. Interestingly, most of the variation explained by the productivity shocks is due to the domestic productivity movements in the final goods sector.

In our model, trade shocks have a direct impact on output fluctuations, since both sectors of the economy use imported goods as factors of production. A significant fraction of the macroeconomic volatility in the final goods producing sector, that heavily relies on imported intermediate inputs and domestic capital goods, is explained by the trade shocks. Roughly 46% of the output variation in the nontraded final goods producing sector is due to the trade shocks. Interestingly, trade disturbances play a more important role in explaining consumption fluctuations than they do in output variation: almost 80% of the variation in consumption is due to the trade shocks.

Our results also show that trade shocks have a large impact on macroeconomic fluctuations in factors of production: more than 86% of the volatility of aggregate investment is explained by trade disturbances. In particular, shocks to the relative prices of primary capital goods account for more than 98% of the variation in primary investment. This result can be explained by the fact that all investment goods in the primary good producing sector are imported capital goods. More than 42% of the variation in intermediate inputs is explained by the disturbances to the relative prices of intermediate goods. Shocks to the prices of capital goods and intermediate inputs also play an important role in inducing fluctuations in the labor market. Movements in the relative prices of capital goods (intermediate inputs) account for more than 42 (37)% of the variation in the total labor hours.

Trade balance dynamics and foreign asset holdings are also heavily affected by the price fluctuations in the world markets. This is an intuitively appealing result as it establishes the connection between highly volatile price shocks and trade balance dynamics: almost 74% of the fluctuations in the trade balance is accounted for by the trade shocks. Shocks to the relative prices of capital goods explain more than 45% of the volatility in the foreign asset holdings.

Deaton and Miller (1996) analyze the importance of international commodity prices in driving economic fluctuations in African countries using vector autoregression analysis. Their results suggest that while a sudden 10% increase in commodity prices results in a 6% increase in output, the price shocks most heavily affect investment dynamics in African economies. Hoffmaister, Roldos, and Wickham (1998) estimate a structural VAR model, where identifying restrictions are derived from a long-run small open economy model. They consider terms of trade, world output, domestic supply, fiscal policy, and nominal policy shocks. Their results suggest that terms of trade shocks play only a minor role in accounting for aggregate output fluctuations. Mendoza (1995) uses a similar model to the one presented here and finds that terms of trade shocks explain roughly one half of the output volatility in developing countries. Our results regarding the link between trade shocks and price fluctuations are in line with those in Mendoza (1995) and Deaton and Miller (1996). However, these studies do not consider the importance of price shocks in inducing business cycles in different sectors and factors of production. One important contribution of this study is that it examines the impact of different types of price shocks on cyclical fluctuations in different sectors and different types of factors of production. In particular, our results show the substantial role played by these shocks in generating economic fluctuations in traded and nontraded sectors of the economy and all factors of production. For example, Mendoza (1995) finds that terms of trade shocks induce only negligible changes in nontraded output because capital is inelastically supplied in the nontraded sector in his model. Our findings suggest that changes in the relative prices directly affect the dynamics in the nontraded good sector, because the nontraded sector employs imported intermediate inputs in my model. In particular, we find that roughly 46% of the output variation in the nontraded final goods producing sector is due to the trade shocks. Our findings also emphasize the importance of studying the impact of the fluctuations in the prices of the major export and import goods.

Interestingly, we find that world real interest rate shocks do not play a significant role in driving domestic economic activity in our model. For example, they account for less than 1% of the output volatility. As expected, these shocks have a relatively more important role in driving the dynamics of asset holdings, but their influence is still very small compared to the role of other shocks: less than 6% of the variation in foreign asset holdings is explained by interest rate disturbances.

We consider four possible reasons why world real interest rate shocks play only a minor role in inducing macroeconomic fluctuations: first, we study a highly stylized incomplete asset market structure in our model. A more complex asset market construction, which includes borrowing constraints, might lead to different results. Second, our interest rate data suggests that there are only a few large interest rate changes over the time period we consider.[21] Capturing the effects of those large and short-lived interest rate fluctuations on economic activity might require the use of different techniques.[22] Third, since our sample size is quite small, it might be the case that the persistence coefficient of the world real interest rate shock we estimate is biased downwards. This, in turn, might reduce the effect of these shocks in generating business cycles.[23] Fourth, and probably the most important, it might be the case that since the ratio of foreign interest rate payments to output is not sufficiently large in our benchmark calibration, world real interest rate shocks unable to generate strong enough income and substitution effects to have a sizeable impact on economic fluctuations. In section 6.3 we study the last two possibilities and show that as the steady state trade deficit-output ratio gets larger world real interest rate shocks become more important in driving macroeconomic activity in African countries.

5.3. The dynamic effects of shocks

We study the dynamic effects of trade and productivity shocks by using impulse response analysis. This investigation provides information about the differences between the propagation mechanisms of productivity and trade disturbances. We analyze the impulse responses of model variables to a 1% temporary shock. The results, presented in Figures 1-2, are plotted as percentage deviations from the initial steady state.

We present the impulse responses of model variables to a temporary 1% increase in productivity of both sectors in Figure 1. A sudden increase in productivity results in an economy-wide boom: output increases in both sectors. This causes a rise in demand for imported capital goods, intermediate inputs and labor supply. Since the increase in exports (primary goods) is less than the rise in imports (the sum of the imported investment and intermediate goods), the economy has a substantial trade deficit. The representative household increases its consumption. Qualitatively, the sectoral productivity shocks lead to more pronounced effects in investment and trade balance compared to the those in output and consumption.

Figure 2 shows the time paths of model variables in response to a 1% temporary increase in the relatives price of capital goods and intermediate inputs. This type of adverse price shock pushes the economy into a recession. Investment in primary goods sector sharply drops; however this decrease does not lead to a significant decline in aggregate investment since the share of primary investment in the aggregate investment is relatively small. The household runs down its foreign assets as the trade balance improves. In other words, the decrease in imports is larger than that in

[21] Kose and Riezman (1999) provide an extensive analysis of the interest rate data.

[22] See Blankenau, Kose, and Yi (2000) for a methodology, which allows backing out world real interest rate shocks in a small open economy model. They show that interest rate shocks, which are perfectly consistent with the data of major macroeconomic variables, can account for a significant fraction of output fluctuations.

exports. These impulse response plots clearly show the typical propagation mechanism of price shocks in several African countries which are often subjected to adverse price fluctuations in their export markets: contraction in the export sector, following a fall in the relative price of exports, causes a substantial decline in the imports of productive inputs. This then decreases consumption and investment

Since labor supply in each sector is endogenously determined in our model, we can analyze the movement of labor across the two sectors. Our results suggest that the magnitudes of labor supply responses in the traded and non-traded sectors of a typical African economy, are comparable with those of the other variables when the model is subjected to domestic productivity and international trade shocks. For example, in response to a 1% temporary productivity shock in the primary sector, there is a considerable increase in the labor supply in that sector, a decrease of labor supply in the non-traded goods sector, and an increase in the aggregate labor supply. Correspondingly, primary sector output increases and the production in non-traded final goods sector slightly decreases due to a shortage of productive inputs.[24]

The overall effect of trade shocks in our model is the opposite of that of domestic productivity shocks since trade shocks act like negative productivity shocks. While positive productivity shocks stimulate the economy and result in short lived expansions, negative trade disturbances have adverse implications: they cause negative income effects which are accompanied by a fall in consumption, and a contraction in demand for productive inputs. Furthermore, trade shocks lead to prolonged recessions by having a detrimental impact on aggregate investment: in response to a positive productivity shock, aggregate output reaches its steady state level after 15 periods, in other words, the economic expansion generated by the improvement in domestic productivity lasts 15 periods. After receiving a negative shock to the relative price of intermediate inputs (capital goods), it takes 25 (35) periods to attain the steady state level of aggregate output for the model economy.[25]

5.4. Sensitivity Analysis

In this section, we first analyze the individual roles of productivity and trade shocks in our model. In table 5b, the results of a simulation when only productivity shocks are present are

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[23] We would like to thank the referee for suggesting this exercise.

[24] These results are in line with those findings by van Wincoop (1992) who argues that whether export sector expands or contracts in response to an exogenous shock depends on the labor supply movements between that sector and the other sectors of the economy in developing countries which face extremely volatile export prices. Mendoza (1995) assumes that labor is inelastically supplied in the traded sector and finds that productivity shocks induce only negligible changes in labor supply. Our results suggest that when this assumption is relaxed these shocks can generate sizeable fluctuations in labor supply.

reported. Lacking trade shocks, the model is not able to match the volatilities of aggregate output and its components. The model underpredicts the volatility of primary sector output. It matches neither the variation of aggregate output nor the one of final sector output. Further, the model does a very poor job in replicating consumption, investment and labor dynamics when the trade shocks are absent.

We then simulate the model with only trade shocks. The results of this experiment are also given in Table 5b. The model is not able to match the volatilities of aggregate output and its components. However, it does a better job in terms of capturing the volatility of consumption, investment, labor hours, and the trade balance. When the model is simulated with only trade (productivity) shocks, it predicts that the correlation between the trade balance and output is around –0.85 (-0.66). This suggests that both trade shocks and productivity shocks are responsible for the relatively high negative correlation between the two variables.

We investigate the sensitivity of our results to the changes in the structural parameters of the model. We briefly discuss the results of this investigation for five parameters: the elasticity of substitution in intermediate and capital goods, the intertemporal elasticity of substitution in labor supply, the risk aversion parameter, share of land in the primary sector, and the elasticity of marginal adjustment cost. An increase in the elasticity of substitution in intermediate and capital goods causes a fall in the volatility of the trade balance. The other variables of the model show slightly larger variability in response to this type of change. This result can be explained with the following intuition: the representative household uses international markets less often to buy intermediate inputs, and faces less fluctuations in the trade balance. The variability of other macro aggregates slightly increases, since she substitutes domestic capital into imported intermediate inputs more often, and this results in a rise in the volatility of investment. Changes in the relative weight of capital, s, have also similar effects on the moments of model variables.

The other two parameters, ν and σ, do not play important roles in the dynamics of the model. An increase in ν causes a minor decrease in the variability of labor hours. The volatility of the trade balance decreases in response to an increase in the risk aversion parameter, σ. Inelastically supplied land limits substitution effects across factors of production in the primary goods sector. This dampens the impact of these factors of production on output and allows the model to produce realistic volatility properties. When the share of land, $1-\theta_1-\theta_2$, decreases, the model exaggerates the volatility of macroeconomic aggregates. As one would expect, changes in

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[25] The impulse responses of a 1% temporary increase in the world interest rate are not presented here because of the space considerations. This shock does not generate significant movements in the model variables except the trade balance and foreign asset holdings.

the elasticity of marginal adjustment cost affects the volatility properties of model variables. In particular, higher elasticity values result in higher volatility of investment in the model.

We also examine the sensitivity of our variance decompositions to changes in some of the parameters of the model and stochastic processes in Table 7. We find that an increase in the volatility or persistence of productivity (trade) shocks, increases the importance of productivity (trade) shocks in explaining output variation. An increase in the elasticity of marginal adjustment cost has almost no impact. However, a decrease in the share of land increases the importance of relative price shocks of capital goods as imported primary capital goods and labor become more important in the production process.

We examine the impact of interest rate shocks by considering two different experiments: first, we study whether the changes in the persistence and volatility of interest rate shocks result in any changes. When the volatility of interest rate shocks is raised by 20%, the fraction of output volatility explained by these shocks rises from 0.9% to 1.3%. Increasing the persistence terms does not induce any major change either. For example, increasing the autocorrelation coefficient of the interest rate shocks by 100% causes the share of output fluctuations accounted by these shocks go up from 0.9% to 3.7%. Second, we examine whether changes in the trade balance output ratio affect the results. In particular, we run an experiment in which the trade deficit output ratio is equal to the largest one in our data set (-51%, Cape Verde). This makes world interest rate shocks quite important as they now explain 52% of output variation. When the trade deficit output ratio is equal to the smallest value in our sample (-0.3%, Zimbabwe), interest rate shocks account for only 0.1% of output volatility. In other words, as the ratio of foreign interest rate payments to output increases, world real interest rate shocks account for a much larger output variation by generating stronger income and substitution effects.

6. Conclusion

We examine the effects of trade shocks, namely fluctuations in the relative prices of capital goods to primary goods, and relative prices of intermediate goods to primary goods on macroeconomic fluctuations in African countries using a dynamic, stochastic, multi-sector, small, open economy model. Our model is able to replicate volatility and comovement properties of sectoral outputs in African countries. Our estimations suggest that trade shocks have a significant role in driving macroeconomic fluctuations in African economies. In particular, more than 44% of the economic fluctuations in aggregate output is explained by trade shocks. More importantly, these shocks play a very important role in inducing business cycles in factors of production as they account for more than 86% of investment and 80% of labor supply fluctuations. While the world interest rate shocks have a minor effect on economic dynamics in our benchmark experiments, we find that these shocks are quite important in those economies that have to allocate a significant fraction of their export revenues to foreign debt payments. Examination of impulse responses shows that adverse trade shocks cause prolonged recessions in these economies while positive productivity shocks induce relatively short lived expansions.

As our model is the first dynamic model capturing main structural characteristics of these economies, we have not dealt with those issues associated with complex trade policies, well documented market rigidities, and political economy considerations all of which are important aspects of African countries. Extensions of this model along these dimensions are important steps to be taken in future research. We plan to examine the welfare costs of highly volatile trade shocks and their interaction with tariff rates in a dynamic model.

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Table 1a
Decomposition of GDP
(in percent)

	Expenditure Shares*				Industrial Structure*		
Country	**Exp.**	**Imp.**	**T.V.**	**T.B.**	**Agr.**	**Ind.**	**Ser.**
African							
Mean	30.8	40.4	71.1	-9.6	28.0	18.2	48.5
Median	26.8	34.8	60.8	-7.2	28.8	16.2	48.2
G7							
Mean	19.7	18.3	38.0	1.3	3.7	29.7	60.0
Median	20.3	20.3	40.7	0.7	3.7	28.0	62.0

* Exp.=exports; Imp.= imports; T.V.=(Exp.+Imp.)/GDP; T.B.=(Exp.-Imp.)/GDP;Agr.= agriculture; Ind.= industrial activity (manufacturing +mining and quarrying + electricity +gas+water); Ser.= services. The mean and median values are calculated using the data of 22 non-oil exporting African economies and the G7 countries. For most of the countries in our sample, the data are averages over the years 1970, 1980, and 1990. Source: Handbook of International Trade and Development Statistics (various years).

Table 1b
Decomposition of Exports
(in percent)

Country	**Food**	**Agr.**	**Metals**	**Prima.**	**Man.**	**Cap.**	**Inter.**	**Fuels**	**Total Inter.**	**Num. Exp.**	**Concen Index**
African											
Mean	47.4	9.7	20.0	77.1	14.4	1.8	12.7	6.9	19.7	54.3	60.1
Median	52.4	4.6	6.9	82.6	9.8	0.9	7.8	1.3	11.4	44.0	64.4
G7											
Mean	8.9	3.2	4.6	16.7	76.8	40.7	36.2	4.5	40.7	213	9.6
Median	7.3	1.6	3.6	12.8	76.9	38.5	39.4	3.5	42.9	216	9.1

*Agr.= agricultural raw materials; Primary= Food+Agr.+Metals; Man.=manufactured goods; Cap.=capital goods=machinery and equipment; Inter.= intermediate inputs(all manufactured items less machinery); Total Inter.= Inter+Fuels; Number Exp.=number of commodities exported; Concen. Index= export concentration index. The mean and median values are calculated using the data of 22 non-oil exporting African economies and the G7 countries. For most of the countries in our sample, the data are averages over the years 1970, 1980, and 1990. Source: Handbook of International Trade and Development Statistics (various years).

Table 1c
Decomposition of Imports
(in percent)

Country	**Food**	**Agr.**	**Metals**	**Primary**	**Man.**	**Cap.**	**Inter.**	**Fuels**	**Total Inter.**
African									
Mean	19.3	2.5	1.6	23.4	63.3	27.8	35.5	12.0	47.5
Median	17.8	1.9	1.5	24.7	62.5	26.8	36.6	11.6	48.3
G7									
Mean	12.6	5.3	7.1	25.0	57.1	26.9	30.3	16.4	46.6
Median	13.6	4.6	7.2	25.5	60.0	24.1	30.2	16.1	48.1

*Agr.= agricultural raw materials; Primary= Food+Agr.+Metals; Man.=manufactured goods; Cap.=capital goods=machinery and equipment; Inter.= intermediate inputs(all manufactured items less machinery); Total Inter.= Inter+Fuels; Number Exp.=number of commodities exported; Concen. Index= export concentration index. The mean and median values are calculated using the data of 22 non-oil exporting African economies and the G7 countries. For most of the countries in our sample, the data are averages over the years 1970, 1980, and 1990. Source: Handbook of International Trade and Development Statistics (various years).

Table 2
Debt Indicators[*]
(in percent)

	ED/GNP	IN/GNP	ED/EXP	TD/EXP	IN/EXP	SH/EXP	SH/ED
Mean	89.0	3.0	379.3	19.9	9.5	42.6	12.3
Median	76.8	2.6	263.0	19.7	8.6	27.5	9.3

[*] GNP=gross national product; ED=total external debt; IN= total interest payments; EXP= exports of goods and services; TD=total debt service; SH=short-term external debt. To get the mean and median values, we use the data of 22 non-oil exporting African economies over the years 1980 and 1990. The source of the data is the World Bank World Debt Tables (various years).

Table 3
Properties of Price Fluctuations[*]

	Volatility			Persistence		
	σ_{pk}	σ_{pv}	σ_{tot}	ρ_{pk}	ρ_{pv}	ρ_{tot}
Mean	14.36	12.97	11.67	0.38	0.35	0.22
Median	13.62	11.81	11.36	0.40	0.36	0.26

	Comovement							
	$\rho_{pk,tb}$	$\rho_{pv,tb}$	$\rho_{tot,tb}$	$\rho_{pk,y}$	$\rho_{pv,y}$	$\rho_{tot,y}$	$\rho_{pk,tot}$	$\rho_{pv,tot}$
Mean	-0.26	-0.23	0.34	-0.08	-0.05	0.03	-0.67	-0.71
Median	-0.24	-0.28	0.41	-0.06	-0.02	-0.02	-0.70	-0.77

[*] σ_x is the percent standard deviation of the variable x. ρ_x is the first-order serial autocorrelation of the variable x. $\rho_{x,y}$ is the contemporaneous correlation between the variables x and y. pk=the relative price of the capital goods to export price index; pv=the relative price of the intermediate inputs to the export price index; tot=terms-of-trade; tb=trade balance; y=aggregate output. The data is in terms of real domestic prices, constructed for per capita quantities, logged and filtered using HP(100) filter. To get the mean and median values, we use the data of 22 non-oil exporting African economies.

Table 4a
Exogenous Shocks

	Description of the Parameter	Value
Π	Persistence of shocks $Z_{t+1} = \Pi Z_t + \varepsilon_{t+1}$ $\varepsilon_t \sim N(0,\Sigma)$ $Z_t = [\ln(p_t^k), \ln(p_t^v), r_t, \ln(z_t^f), \ln(z_t^p)]'$ Sample standard errors are in parenthesis.	$\begin{bmatrix} 0.44(0.07) & 0 & 0 & 0 & 0 \\ 0 & 0.42(0.08) & 0 & 0 & 0 \\ 0 & 0 & 0.34 & 0 & 0 \\ 0 & 0 & 0 & 0.54(0.24) & 0 \\ 0 & 0 & 0 & 0 & 0.32(0.24) \end{bmatrix}$
Σ	Variance-covariance matrix of innovations. Sample standard errors for shocks estimated using the data of 22 non-oil exporting African countries are in parenthesis. The bold values represent the correlations between the innovations.	$\begin{bmatrix} 0.22^2\,(0.07)^2 & \mathbf{0.71} & \mathbf{0.35} & \mathbf{-0.19} & \mathbf{-0.01} \\ 0.18^2 & 0.21^2\,(0.07)^2 & \mathbf{0.29} & \mathbf{-0.30} & \mathbf{-0.05} \\ 0.11^2 & 0.10^2 & 0.17^2 & \mathbf{-0.05} & \mathbf{-0.03} \\ -(0.04)^2 & -(0.04)^2 & -(0.02)^2 & 0.03^2\,(0.01)^2 & \mathbf{0.06} \\ -(0.01)^2 & -(0.02)^2 & -(0.01)^2 & 0.08^2 & 0.04^2\,(0.03)^2 \end{bmatrix}$

Table 4b
Parameters of the model

Parameter	Description	Value
Preferences		
β	Discount factor	0.97
r	Real interest rate, $r = (1/\beta) - 1$	0.035
$1/(v-1)$	Intertemporal elasticity of substitution in labor supply	0.83
σ	Coefficient of relative risk aversion	2.61
ψ	Level parameter for labor supply	5.35
Technology		
Primary Goods Sector		
θ_1	Share of labor income	0.37
θ_2	Share of capital income	0.18
η_p	Elasticity of marginal adjustment cost function $\eta_p = -(\phi' / \phi'') / (i_p / k_p)$	2.2
Final Goods Sector		
α	Share of labor income	0.45
s_k	Share of capital income	0.23
s_v	Share of intermediate input income	0.32
$1/(u+1)$	Elasticity of substitution between intermediate and capital goods	0.77
$\sigma_{k,v}$	Allen elasticity of substitution between intermediate and capital goods	0.55
δ	Depreciation rate	0.10
$tb/(y^p + y^f)$	Trade balance to aggregate output ratio	-0.096
η_f	Elasticity of marginal adjustment cost function $\eta_f = -(\phi' / \phi'') / (i_f / k_f)$	2

See section 4 for details about the calibration of the model.

Table 5a
Business Cycle Properties

	African Average*			Model**		
Variable	**Volatility**	**Relative Volatility**	**Comovement**	**Volatility**	**Relative Volatility**	**Comovement**
Output	4.10 (1.41)	1.00	1.00	4.93 (0.03)	1.00	1.00
Primary	7.99 (3.57)	1.95	0.51 (0.36)	6.20 (0.03)	1.26	0.57 (0.01)
Nontraded Final	4.83 (1.53)	1.18	0.62 (0.33)	5.32 (0.03)	1.08	0.98 (0.00)
Consumption	8.28 (3.80)	2.02	0.39 (0.43)	4.98 (0.03)	1.01	0.77 (0.00)
Investment	15.69 (4.52)	3.83	0.46 (0.26)	15.69 (0.09)	3.18	0.69 (0.00)
Labor Hours	7.33 (4.48)	1.79	0.22 (0.45)	3.40 (0.02)	0.69	0.99 (0.00)
Trade Balance	16.45 (6.15)	4.01	-0.10 (0.30)	19.81 (0.11)	4.02	-0.72 (0.01)

* Average moments of African country sample are averages over the moments of 22 countries. The data is in terms of real domestic prices, constructed for per capita quantities, logged and filtered using HP(100) filter. Trade balance refers to detrended exports minus detrended imports. Volatility is the percentage deviation from the HP trend. Relative volatility is the standard deviation of the respective variable relative to the standard deviation of the output. Comovement is the contemporenous correlation with the output. The sample standard errors of the averages are given in parenthesis. The data, for the period 1970-1992, is from the World Bank World Tables (1994). All model moments are averages over the 1000 simulations of the model each with 23 observations. The simulated data is also filtered by HP(100). The asymptotic standard deviations of the statistics are given in parenthesis. See text for details.

Table 5b
Business Cycle Properties*
(Model)

	With Productivity Shocks		With Trade Shocks	
Variable	**Volatility**	**Comovement**	**Volatility**	**Comovement**
Output	4.46 (0.03)	1.00	1.18 (0.01)	1.00
Primary	5.54 (0.03)	0.45 (0.01)	2.58 (0.02)	0.95 (0.00)
Nontraded Final	4.97 (0.03)	0.97 (0.00)	0.93 (0.01)	0.98 (0.00)
Consumption	2.08 (0.01)	0.99 (0.00)	3.95 (0.02)	0.86 (0.00)
Investment	5.46 (0.03)	0.97 (0.00)	13.23 (0.07)	0.78 (0.00)
Labor Hours	1.42 (0.01)	0.99 (0.00)	2.70 (0.01)	0.99 (0.00)
Trade Balance	12.54 (0.07)	-0.66 (0.00)	14.04 (0.08)	-0.85 (0.00)

* See notes in Table 4a for information about the moments reported here. See text for details.

Table 6
Variance Decomposition*
(in percent)

Variable	Trade Shocks: Capital Goods	Trade Shocks: Intermediate Inputs	Trade Shocks: Total	World Interest Rate	Technology Shocks: Final Goods	Technology Shocks: Primary Goods	Technology Shocks: Total
Output	24.72	19.92	**44.64**	0.87	52.77	1.71	**54.49**
Primary	37.94	15.77	**53.71**	2.15	9.44	34.70	**44.15**
Final	24.05	21.59	**45.64**	1.69	51.41	1.27	**52.67**
Consumption	43.6	35.54	**79.14**	2.89	15.77	2.20	**17.97**
Investment	52.77	33.59	**86.36**	0.46	12.81	0.37	**13.17**
Primary	98.7	0.7	**99.40**	0.15	0.32	0.12	**0.44**
Final	42.34	40.78	**83.12**	0.8	15.45	0.64	**16.09**
Intermediate Goods	49.78	42.42	**92.20**	1.83	4.48	1.48	**5.96**
Labor Hours	42.8	37.97	**80.77**	1.41	16.56	1.26	**17.82**
Primary	42.53	29.47	**72.00**	3.11	14.98	9.91	**24.89**
Final	43.44	35.79	**79.23**	3.22	14.91	2.64	**17.55**
Trade Balance	41.18	32.54	**73.72**	4.57	12.87	8.84	**21.71**
Asset Holdings	45.77	30.50	**76.27**	5.84	13.36	4.52	**17.88**

* The ordering of shocks is $p_t^k, p_t^v, r_t, z_t^f, z_t^p$, so world price shocks drive the domestic technology shocks. In each cell, the volatility of the respective variable explained by a particular shock is reported. For example, shocks to the prices of capital goods explain 24.72 percent of the output volatility.

Table 7
Sensitivity Analysis
Variance Decomposition of Output*
(in percent)

Change	Trade Shocks: Capital Goods	Trade Shocks: Intermediate Inputs	Trade Shocks: Total	World Interest Rate	Technology Shocks: Final Goods	Technology Shocks: Primary Goods	Technology Shocks: Total
Benchmark	24.72	19.92	**44.64**	0.87	52.77	1.71	**54.49**
Volatility of Productivity Shocks ↑ 20%	21.02	17.57	**38.59**	0.69	58.81	1.91	**60.72**
Persistence of Productivity Shocks ↑ 20%	22.53	18.67	**41.20**	0.75	56.49	1.57	**58.06**
Volatility of Trade Shocks ↑ 20%	29.14	22.44	**51.58**	0.76	46.16	1.50	**47.66**
Persistence of Trade Shocks ↑ 20%	28.04	21.51	**49.55**	0.79	48.09	1.56	**49.65**
Volatility of Interest Rate Shocks ↑ 20%	24.36	19.88	**44.24**	1.23	52.82	1.71	**54.54**
Persistence of Interest Rate Shocks ↑ 20%	24.53	19.89	**44.42**	1.07	52.79	1.71	**54.5**
Persistence of Interest Rate Shocks ↑ 100%	22.86	19.48	**42.34**	3.66	52.3	1.70	**54.00**
η_p ↑ 50 %	23.81	20.15	**43.96**	0.88	53.42	1.74	**55.16**
η_f ↑ 50 %	23.95	19.13	**43.08**	0.92	54.18	1.82	**56.00**
Trade Balance/Output = -51%	5.02	9.87	**14.89**	51.80	31.56	1.74	**33.37**
Trade Balance/Output = 0.03%	27.02	19.33	**46.35**	0.10	51.03	2.51	**53.54**
$(1-\theta_1-\theta_2)$ ↓ 45% (Share of Land)	33.95	16.52	**50.47**	0.37	47.48	1.68	**49.16**

* The ordering of shocks is $p_t^k, p_t^v, r_t, z_t^f, z_t^p$, so world price shocks drive the domestic technology shocks. In each cell, the volatility of aggregate output explained by a particular shock is reported. For example, shocks to the prices of capital goods explain 24.72% of the output volatility. ↑ sign refers to an increase. For example, in the fifth row volatility of productivity shocks increases by 20%.

Fig. 1: Impulse Response of a 1% Shock to the Productivity of Both Sectors

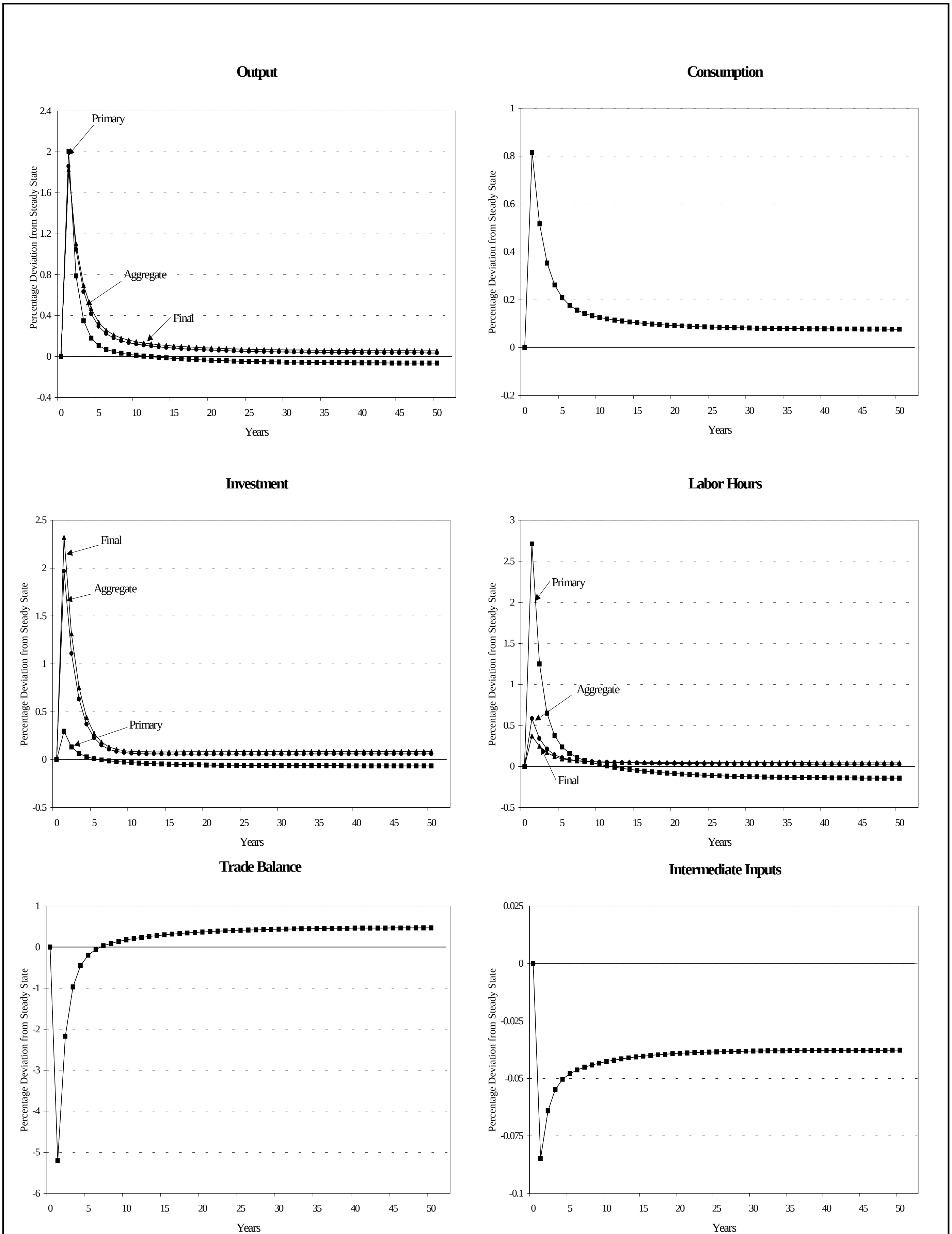

Fig. 2: Impulse Response of a 1% Shock to the Prices of Imported Inputs