Call for Papers and Participation

African Finance and Economics Association
1999 Annual Conference and Meetings

January 3-5, 1999

- Members of the African Finance and Economics Association (AFEA) are invited to submit papers for the AFEA annual meetings, to be held in conjunction with the Allied Social Science Association (ASSA) meetings.

- The AFEA meeting will be held on January 3-5, 1999. Events will include a general membership meeting, and two paper sessions. Paper sessions will focus on theoretical and empirical research in financial and economic issues for African economic development.

- Those interested in having a paper considered for presentation should submit two copies of a completed manuscript, or of a well-developed abstract, no later than June 30, 1998. Papers and abstracts should include a list of references that is as complete as possible. The complete name(s) of the author(s), along with address, telephone, facsimile, and e-mail address should appear only on the title page, and the corresponding author should be indicated if there are multiple authors. At least one author must be a member of AFEA. Individuals interested in serving as session chairs or as discussants also are asked to indicate their preferences to the program chair by June 30.

- Papers, abstracts of papers, participation requests and requests for information on becoming a member of AFEA should be sent to:

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  AFEA President Elect and Program Chair
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EXTERNAL SHOCKS AND ECONOMIC DYNAMICS: 
THE CASE OF AFRICAN COUNTRIES

M. Ayhan KOSE
Brandeis University

and

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University of Iowa

A number of African economies have highly concentrated export and import sectors. Moreover, their export revenues are highly unstable due to recurrent and sharp variations in the prices of main export goods. This paper examines the role of external shocks, which are represented by the fluctuations in the prices of main export and import items, in explaining economic fluctuations in African economies. We construct a stochastic, dynamic, multi-sector small open economy model calibrated to reflect structural characteristics of a typical African economy. Our results suggest that external shocks account for a significant fraction of economic fluctuations in African economies. In particular, more than 45 percent of aggregate output fluctuations and almost 78 percent of investment fluctuations are explained by the external shocks.

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1. Introduction

To minimize the cost of fluctuations in aggregate output, and to keep the economic growth at a steady rate, it has long been recognized that economists should have a good grasp of the sources of macroeconomic fluctuations. As the research program on the interdependence between the long-run growth prospects and the short-run macroeconomic dynamics of economies has been reaching its new heights, a number of studies suggest that large and sudden fluctuations in macroeconomic activity take a heavy toll on the growth performance of developing economies.\(^1\)

The poor growth performance of several African economies has coincided with the highly volatile domestic economic fluctuations over the last thirty years. While several studies try to provide explanations for the reasons of this period of stagnant growth in Africa,\(^2\) the issues associated with the sources of macroeconomic fluctuations have been largely ignored. In this paper, we take on this task, and examine the sources of macroeconomic fluctuations in a group of African countries.

To this end we construct a stochastic, dynamic, business cycle model which is calibrated to represent structural characteristics of the African economies. Not surprisingly, several African countries exhibit a number of common economic characteristics: first, a narrow range of primary commodities constitutes a significant fraction of the exports, and the main import items are intermediate inputs and capital goods. In most of these economies, the volume of international trade accounts for more than half of the aggregate output. Second, and more importantly, their export revenues are highly unstable due to recurrent and sharp fluctuations in the prices of primary commodities. A thorough understanding of the sources of economic fluctuations in these economies requires a good comprehension of the dynamic relations between the external shocks, which are represented by the fluctuations in the prices of main export and import items, and domestic economic activity.

We begin by documenting some of the salient features of the data related to economic structure, economic fluctuations and dynamics of prices to provide empirical evidence that there is a strong link between the external shocks and macroeconomic fluctuations in African economies.\(^3\) This investigation yields several useful insights: first, primary commodities constitute 82 percent of total exports, and capital goods and intermediate inputs account for approximately 80 percent of total imports. Second, payments for imported factors of production are a substantial fraction of the total payments made for productive inputs. Moreover, the production sectors, which depend heavily on imported capital goods and intermediate inputs, such as the manufacturing sector, display more economic variation than those which mainly use domestically supplied factors of production, such as agriculture and service sectors. Third, the relative prices of intermediate inputs and capital goods to primary commodities exhibit more variability than the terms of trade.

We then construct a multi-sector, dynamic, stochastic small open economy model which reflects the structural characteristics of a "representative" African economy.\(^4\) There are two sectors in the model: primary goods and nontraded final goods. The primary goods sector employs labor, capital and land. The nontraded final goods sector, using labor, capital and intermediate inputs, produces domestic consumption goods. The economy exports primary goods, and imports all of its intermediate inputs and a significant fraction of its capital goods. This environment allows us to examine the relative importance of external shocks, such as disturbances to the relative prices of capital goods and intermediate inputs to primary goods, and domestic shocks, such as productivity disturbances, in explaining aggregate economic fluctuations.

Next, we compare the properties of the economic fluctuations generated by the model with those actually observed in the model economy. Our model is able to replicate some key properties of macroeconomic fluctuations of several aggregates successfully. For example, it is able to reproduce the volatility ordering of sectoral outputs. The primary goods sector exhibits more business cycle variation than the nontraded final goods sector. Further, the model captures comovement properties of sectoral outputs.

The solution of the model is a vector system of autoregressive equations. We employ variance decomposition methods on this vector system to quantify the contribution of different types of disturbances to domestic macroeconomic fluctuations. Our findings indicate that external shocks play a significant role in explaining macroeconomic fluctuations in African economies: more than 45 percent of the variation in aggregate output is explained by the price shocks. Moreover, our simulations suggest that investment and consumption dynamics are heavily affected by the fluctuations in the relative prices of capital and intermediate inputs.

The propagation of economic fluctuations generated by the price disturbances is different than that caused by domestic productivity shocks. First, productivity shocks have a direct effect on investment since they induce movements in the marginal product of factors of production. In contrast, the price fluctuations exhibit a rather indirect impact: shocks to the relative prices of imported capital goods, for example, result in substitution effects which trigger labor supply movements between the two sectors. Second, while positive productivity disturbances result in short lived expansions, price shocks cause prolonged recessions.
Our paper is part of a rapidly growing research program which investigates a variety of issues related to the generation and transmission of economic fluctuations across economies by using stochastic dynamic general equilibrium models. In particular, some recent studies examine the macroeconomic dynamics in developing countries in the context of these models. Mendoza (1995), Correia, Neves and Rebelo (1995), Kose (1997a), and Sadka and Yi (1997) use small open economy models to examine the relative importance of different types of shocks, such as the world interest rate, terms of trade, and government spending shocks, in driving business cycles. Hoffmaister, Roldos, and Wickham (1997) estimate a structural VAR model using the data of several African economies. They conclude that fluctuations in terms of trade and the world interest rate account for only a small fraction of the variation in output in the African economies that implement a flexible exchange rate system. Their results also suggest that a significant fraction of economic fluctuations in the African economies with a fixed exchange rate regime is attributable to external shocks. Gavin and Hausmann (1996) examine the sources of macroeconomic volatility in a large sample of developing economies employing nonstructural methods. They find that the volatility of the terms of trade explains a significant fraction of the cyclical variation in output volatility. While strengthening these findings about the role of external price shocks in driving macroeconomic fluctuations, our results also provide further evidence that it is important to investigate the implications of the fluctuations in the relative prices of the main import and export items. Recently, there has been widespread attention to dynamics of relative commodity prices, since most of the developing economies have faced increasingly volatile prices in their export markets over the past two decades.

The organization of the paper is as follows: in section 2, we review the empirical regularities of the data of several African economies. Then, we present the model. Model calibration is described in section 4. Following this, we discuss the results of our simulations and we examine the relative importance of trade shocks and domestic disturbances in explaining economic fluctuations in African economies. This is followed by an examination of propagation dynamics induced by these shocks. We conclude with a brief summary of our findings and suggestions for future research in section 6.

2. Analysis of the data

2.1 Structural characteristics of the African economies

To have a better understanding of the structural characteristics of the African economies, we start with an examination of the decomposition of aggregate output. Our analysis is based on the annual data of fifteen non-oil exporting African countries for the 1970-1990 period. Table 1a presents information about the expenditure shares of aggregate output and industrial structure. The G7 average of each magnitude is also provided for comparison purposes. On average, the trade volume to GDP ratio is two times larger in African economies than in the G7. Another major empirical regularity, as Table 1a indicates, is that African countries have relatively large trade deficits. The average trade deficit is around 9 percent of the GDP in the African economies in our sample. The difference between the average consumption shares of the two groups is also noticeable: for African countries, the average share is around 70 percent that is 10 percent more than the G7 average. The industrial structure of these economies also makes them highly vulnerable to external shocks: the African economies have relatively smaller industry and service sectors, and, consequently, the share of agricultural sector is considerably larger in these countries.

We then look at the decomposition of exports and imports to determine the relative importance of different commodity groups in the international trade. 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 is, on average, 82 percent. Food products and metals constitute 51 percent and 24 percent of total exports respectively. Strikingly, the average share of machinery and equipment exports is less than 1 percent in total exports. In order to investigate the extent of diversification of exports at a more disaggregated level, we use two different criteria, which are presented in the last two columns of Table 1b. First, we examine the number of exports in these two country groups. The African countries in our sample seem to be much more concentrated in their exports than the G7 countries do: the number of commodities exported by the African economies is on average 48. This number is around 213 for the G7 countries. 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 of the coefficient of export concentration for the African economies is 54, it is around 10 for the G7.
### Table 1a
Decomposition of GDP
(in percent)

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<tr>
<td>Mean</td>
<td>16.9</td>
<td>69.7</td>
<td>22.1</td>
<td>31.5</td>
<td>40.3</td>
<td>71.8</td>
<td>-8.8</td>
<td>31.6</td>
<td>18.6</td>
<td>11.7</td>
<td>4.6</td>
<td>45.2</td>
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<tr>
<td>Med.</td>
<td>16.3</td>
<td>73.7</td>
<td>22.3</td>
<td>27.3</td>
<td>36.0</td>
<td>60.6</td>
<td>-6.3</td>
<td>31.0</td>
<td>13.7</td>
<td>10.3</td>
<td>3.7</td>
<td>44.3</td>
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<tr>
<td>G7</td>
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<td></td>
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<tr>
<td>Mean</td>
<td>16.6</td>
<td>59.3</td>
<td>23.9</td>
<td>19.7</td>
<td>18.3</td>
<td>38.0</td>
<td>1.3</td>
<td>3.7</td>
<td>29.7</td>
<td>25.4</td>
<td>6.6</td>
<td>60.0</td>
</tr>
<tr>
<td>Med.</td>
<td>18.0</td>
<td>59.0</td>
<td>24.3</td>
<td>20.3</td>
<td>20.3</td>
<td>40.7</td>
<td>0.7</td>
<td>3.7</td>
<td>28.0</td>
<td>23.8</td>
<td>6.3</td>
<td>62.0</td>
</tr>
</tbody>
</table>

*Gvt.=government final expenditure; Con.=private final consumption expenditure; Inv.=gross domestic investment; Exp.=exports; Imp.=imports; T.V.=(Exp.+Imp.)/GDP; T.B.=(Exp.-Imp.)/GDP; Agr.=agriculture; Indus.=industrial activity (manufacturing+mining and quarrying + electricity + gas+water); Man.=manufacturing; Cons.= construction; Ser.= services. To get the mean and median values, we use the data of 15 non-oil exporting African economies and G7 countries. For most of the countries in our sample, the data are averages over the years 1970, 1980, and 1990. The source of the data is the Handbook of International Trade and Development Statistics (various years).*

### Table 1b
Decomposition of Exports
(in percent)

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<tr>
<td>African</td>
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</tr>
<tr>
<td>Mean</td>
<td>50.7</td>
<td>7.5</td>
<td>23.8</td>
<td>82.0</td>
<td>14.0</td>
<td>0.9</td>
<td>13.2</td>
<td>2.8</td>
<td>16.0</td>
<td>48.3</td>
<td>53.7</td>
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<tr>
<td>Median</td>
<td>55.1</td>
<td>4.6</td>
<td>6.9</td>
<td>86.8</td>
<td>11.6</td>
<td>0.7</td>
<td>11.0</td>
<td>1.1</td>
<td>11.4</td>
<td>38.5</td>
<td>56.3</td>
</tr>
<tr>
<td>G7</td>
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</tr>
<tr>
<td>Mean</td>
<td>8.9</td>
<td>3.2</td>
<td>4.6</td>
<td>16.7</td>
<td>76.8</td>
<td>40.7</td>
<td>36.2</td>
<td>4.5</td>
<td>40.7</td>
<td>213</td>
<td>9.6</td>
</tr>
<tr>
<td>Median</td>
<td>7.3</td>
<td>1.6</td>
<td>3.6</td>
<td>12.8</td>
<td>76.9</td>
<td>38.5</td>
<td>39.4</td>
<td>3.5</td>
<td>42.9</td>
<td>216</td>
<td>9.1</td>
</tr>
</tbody>
</table>

*Agr.= agricultural raw materials; Prima.= 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. To get the mean and median values, we use the data of 15 non-oil exporting African economies and G7 countries. For most of the countries in our sample, the data are averages over the years 1970, 1980, and 1990. The source of the data is the Handbook of International Trade and Development Statistics (various years).*
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. Imports of intermediate inputs account for almost half of the total imports. Second, the average share of capital good imports is approximately 30 percent. Table 1b and 1c together present an interesting picture: while the export structures of the G7 economies and African economies are quite different, their import structures are similar on some dimensions. For example, both the G7 economies and African countries heavily rely on manufactured goods imports.

2.2. Main regularities of macroeconomic fluctuations

We document some of the regularities associated with the macroeconomic fluctuations in African economies in Tables 2a-2c. This investigation serves two purposes: first, we get a better understanding of the magnitude of economic fluctuations in these economies. Second, we set up a group of benchmark statistics that are going to be used in evaluating the performance of our model economy in the following section. All properties of the data refer to moments of Hodrick-Prescott (HP(100)) filtered variables. We focus on the three main features of macroeconomic fluctuations: volatility, measured by standard deviation, comovement, measured by correlations, and persistence, measured by autocorrelations.

Tables 2a and 2b present the properties of economic fluctuations for main macroeconomic aggregates: among the components of aggregate output, manufacturing production is the most volatile one. This evidence compounded with the observations in the previous section implies that outputs of production sectors, such as manufacturing, which heavily depend on imported capital goods and intermediate inputs, show more aggregate volatility than the ones, such as agriculture sector, which mainly use domestically produced inputs. The variation in consumption is greater than aggregate output, since our consumption series include durable consumption. As expected, investment exhibits high cyclical volatility. Analysis of the disaggregated external trade data indicates that both exports and imports are highly volatile. The trade balance is as volatile as investment. On average, exports are less volatile than imports. Except the trade balance, all macro aggregates are procyclical. Employment is weakly procyclical.
### Table 2a
Properties of Macroeconomic Fluctuations *Volatility*

<table>
<thead>
<tr>
<th></th>
<th>$\sigma_y$</th>
<th>$\sigma_{\text{ind-ser}}$</th>
<th>$\sigma_{\text{agr}}$</th>
<th>$\sigma_{\text{ind}}$</th>
<th>$\sigma_{\text{man}}$</th>
<th>$\sigma_{\text{ser}}$</th>
<th>$\sigma_{\text{f}}$</th>
<th>$\sigma_{\text{emp}}$</th>
<th>$\sigma_{\text{th}}$</th>
<th>$\sigma_{\text{exp}}$</th>
<th>$\sigma_{\text{imp}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>4.06</td>
<td>4.90</td>
<td>7.28</td>
<td>8.33</td>
<td>11.91</td>
<td>5.58</td>
<td>9.44</td>
<td>16.43</td>
<td>7.95</td>
<td>16.36</td>
<td>11.69</td>
</tr>
<tr>
<td>Median</td>
<td>4.16</td>
<td>4.89</td>
<td>7.73</td>
<td>7.85</td>
<td>7.27</td>
<td>5.01</td>
<td>9.04</td>
<td>15.75</td>
<td>6.52</td>
<td>15.41</td>
<td>11.94</td>
</tr>
</tbody>
</table>

* $\sigma$ is the percent standard deviation of the variable $x$. $y$=aggregate output; ind+ser=industrial activity (manufacturing+mining and quarrying + electricity + gas + water); services+agriculture; agr=agriculture; ind=industrial activity (manufacturing+mining and quarrying + electricity + gas + water); man=manufacturing; ser=services; c=private final consumption expenditure; $l$=gross domestic investment; emp=labour supply; th=(exp-imp)/y; exp=exports; imp=imports. We use the annual data of fifteen non-oil exporting African economies for the period 1970-1992. The data is in terms of real domestic prices, constructed for per capita quantities, logged and filtered using HP(100) filter. The data comes from the World Bank World Tables (1994).

### Table 2b
Properties of Macroeconomic Fluctuations *Comovement*

<table>
<thead>
<tr>
<th></th>
<th>$\rho_{\text{agr}}$</th>
<th>$\rho_{\text{ind,agr}}$</th>
<th>$\rho_{\text{man,agr}}$</th>
<th>$\rho_{\text{ser,agr}}$</th>
<th>$\rho_{\text{f,agr}}$</th>
<th>$\rho_{\text{emp,agr}}$</th>
<th>$\rho_{\text{th,agr}}$</th>
<th>$\rho_{\text{exp,agr}}$</th>
<th>$\rho_{\text{imp,agr}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.56</td>
<td>0.58</td>
<td>0.57</td>
<td>0.71</td>
<td>0.40</td>
<td>0.44</td>
<td>0.31</td>
<td>-0.16</td>
<td>0.26</td>
</tr>
<tr>
<td>Median</td>
<td>0.60</td>
<td>0.71</td>
<td>0.78</td>
<td>0.78</td>
<td>0.52</td>
<td>0.50</td>
<td>0.43</td>
<td>-0.20</td>
<td>0.25</td>
</tr>
</tbody>
</table>

* $\rho_{xy}$ is the contemporaneous correlation between the variables $x$ and $y$. $y$=aggregate output; ind+ser=industrial activity (manufacturing+mining and quarrying + electricity + gas + water); services+agriculture; agr=agriculture; ind=industrial activity (manufacturing+mining and quarrying + electricity + gas + water); man=manufacturing; ser=services; c=private final consumption expenditure; $l$=gross domestic investment; emp=labour supply; th=(exp-imp)/y; exp=exports; imp=imports. We use the annual data of fifteen non-oil exporting African economies for the period 1970-1992. The data is in terms of real domestic prices, constructed for per capita quantities, logged and filtered using HP(100) filter. The data comes from the World Bank World Tables (1994).
Next, we look at the stylized business cycle facts of particular price series. Instead of analyzing the terms of trade dynamics only, we also examine a disaggregated measure of the terms of trade and provide information about the dynamics of relative prices of capital goods and intermediate inputs to primary goods. As we reported above, these three groups of commodities, intermediate inputs, capital goods, and primary goods, constitute a significant fraction of the trade volume of African countries. Table 2c documents our findings. The relative price of capital goods to primary goods, ̄p_t^i, 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^c, is equal to the ratio of the U.S. producer price index of intermediate materials to the export price index of the domestic economy. Interestingly, the relative prices are more volatile and more persistent than the terms of trade. We also provide a visual inspection by presenting the plots of annual change for the prices of main export and import items of developing countries in Figures 1a-1d. As these figures clearly illustrate, these prices exhibit very high cyclical volatility. The year-to-year variations have become increasingly magnified since the early 1970s. Very short lived price booms have been generally followed by prolonged troughs (see Deaton and Laroque (1992) and Bevan, Collier and Gunning (1993)).

3. The Model Economy

In the previous section, we provided substantial empirical evidence suggesting that the economies of African countries exhibit a number of common structural features. In this section, we construct a multi-sector dynamic stochastic small open economy model which reflects the main structural features of a typical African economy.

3.1. Preferences

The representative household maximizes expected lifetime utility given by

\[ U(c, l) = E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left\{ (c_t - \psi (1 - l_t)^\nu)^{1-\sigma} - 1 \right\} \right\} \]

\[ \frac{1 - \sigma}{\nu} \]

where \( \sigma, \beta, \psi > 0, \ \nu > 1 \).
Figure 1. Price Fluctuations

1a. Non-Fuel Commodity Prices

1b. Prices of Agricultural Commodities

1c. Relative Prices of Capital Goods

1d. Relative Prices of Intermediate Inputs
where the parameter $\beta$ denotes the subjective discount factor of the household, $\sigma$ is the risk aversion parameter, $\psi$ is the level parameter for labor supply, and $\nu$ governs the intertemporal elasticity of substitution of labor. $c_{t}^i$ is the consumption of the nontraded final good, and $l_t$ represents leisure.

### 3.2. Technology

In our model, the representative household produces nontraded final goods and primary goods. Nontraded final goods production, $y^f_t$, uses labor, $n^f_t$, capital, $k^f_t$, and intermediate inputs, $v^f_t$:

$$
y^f_t = z^f_t (n^f_t)^{\alpha} \left[ s(k^f_t)^{-\alpha} + (1 - s)v^f_t \right]^{(1 - \alpha)/\alpha}
$$

$$
0 < \alpha, s, u < 1
$$

(2)

$z^f_t$ represents the exogenous productivity shock. $\alpha$ is the share of nontraded 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 primary goods sector produces output by using labor, $n^p_t$, capital, $k^p_t$, and land, $L^p_t$, which is assumed to be inelastically supplied. The production function in the primary goods sector is given as

$$
y^p_t = z^p_t (n^p_t)^{\theta_1} (k^p_t)^{\theta_2} (L^p_t)^{1 - \theta_1}
$$

$$
0 < \theta_1, \theta_2 < 1
$$

(3)

where $z^p_t$ is the productivity disturbance. $\theta_1$ and $\theta_2$ are the labor and capital income shares, respectively.

### 3.3 Accumulation of capital

Capital accumulation is modeled as

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

(4)

Here $\delta$ is the rate of depreciation and $\phi_j(.)$ represents the concave adjustment cost function, with $\phi_j(.) > 0$, $\phi_j(.)' > 0$, and $\phi_j(.)'' < 0$. This adjustment cost prevents frequent excessive volatility of investment.

### 3.4. Financial Markets

Each household has free access to world financial markets. However, these markets are incomplete in the sense that the household can trade a single financial asset, $A_t$, with a rate of return, $r_t$, from period $t$ to $t+1$. Kose (1997b) provides empirical evidence about the limited access of households in developing countries to international financial markets. In these markets the household can trade a risk free financial asset, $A_t$, with a rate of return, $r_t$, from period $t$ to $t+1$. The holdings of financial assets evolve according to the formula

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

(5)

where $nx_t$ represents the balance of trade. With this formulation, the household can partially smooth her consumption stream by borrowing and lending in the international financial markets. We assume that $\beta = 1 / (1 + r^*)$. $r^*$ is the steady state level of interest rate.

### 3.5 Resource constraints

The resource constraint for the nontraded goods sector is given by

$$
c_t^i + i_t^f = y_t^f
$$

(6)

and for the primary goods sector is

$$
p_t^i i_t^p + p_t^i v_t + nx_t = y_t^p
$$

(7)
where $i'^i$ and $i'^p$ are investment in capital goods in the nontraded and primary goods sectors respectively. $p'^i$ and $p'^p$ denote the relative prices of capital goods and intermediate inputs to primary goods respectively. The price of the primary good is numeraire. The household, who has a fixed time endowment normalized to one, faces the following labor-leisure allocation constraint

$$l_i + n_i'^i + n_i'^p = 1$$  \hspace{1cm} (8)

### 3.6 Exogenous shocks

There are four shocks in the model: two sectoral productivity shocks, and two shocks to the relative prices of imported capital and intermediate goods to primary goods. The vector of exogenous shocks is represented by

$$Z_i = [p'^i, p'^p, z'_i, z'^p]'$$. The evolution of $Z_i$ follows a first order Markov process and is given by

$$\ln Z_{i+1} = \Pi \ln Z_i + \epsilon_{i+1}$$  \hspace{1cm} (9)

The vector of innovations is denoted by $\epsilon_i = [\epsilon'^k, \epsilon'^n, \epsilon_i'^i, \epsilon_i'^p]^'$ where $\epsilon_i \sim N(0, \Sigma)$.

### 3.7. Numerical Solution Method

The model economy is solved using the optimization problem of the representative household. This corresponds to a stochastic dynamic optimization problem which is solved by maximizing the expected lifetime utility, (1), subject to the constraints (3)-(9). Since this problem cannot be solved analytically, we find an approximate solution by using log-linear functions of the model variables. This amounts to computing the first order Taylor series expansions of the first order conditions and resource constraints of the model around its deterministic steady state. The solution method we use, namely the log-linear approximation, was shown to be quite accurate in solving these types of stochastic dynamic business cycle models.\textsuperscript{13}

### 4. Model Calibration

Model calibration amounts to selecting a combination of parameter values which are roughly consistent with the long-run features of the economic environment of a representative African economy. The parameters and business cycle statistics of this representative economy correspond to the averages of relevant variables of the African countries in our sample. Table 3 presents the parameters of the model.

#### 4.1. Preferences

The risk aversion parameter, $\sigma$, is assumed to be 2.61 which is the GMM estimate from the panel study of a group of developing economies by Ostry and Reinhart (1992). The intertemporal elasticity of substitution in labor supply, $1/(\nu-1)$, is equal to 0.83. Prior empirical studies show that the value of this parameter is between 0.3 and 3.2. Since we do not have a sufficient amount of data on labor hours allocated to market and non-market activities in African economies, we assume that 22 percent of total labor endowment is allocated to market activity. Earlier calibration exercises also use values between 20 percent and 25 percent for this share. The value of $\psi$ 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 export unit value index of non-fuel commodity exporting developing countries. Using this measure, the average real interest rate, $r^*$, is found to be 2.9 percent annually.

#### 4.2. Technology

The labor share for the nontraded final goods sector, $\alpha$, is assumed to be 0.45. 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). The value of $\nu$, which governs the elasticity of substitution between capital and intermediate goods, is calculated by using the formula

$$u = \frac{1 - (\alpha + \sigma_k - \alpha \sigma_{k,x})}{\alpha + \sigma_k - \alpha \sigma_{k,x}}$$
Table 3
Parameters of the model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preferences</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta$</td>
<td>Discount factor</td>
<td>0.97</td>
</tr>
<tr>
<td>$r$</td>
<td>Real interest rate, $r = (1/\beta) - 1$</td>
<td>0.029</td>
</tr>
<tr>
<td>$1/(v-1)$</td>
<td>Intertemporal elasticity of substitution in labor supply</td>
<td>0.83</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>Coefficient of relative risk aversion</td>
<td>2.61</td>
</tr>
<tr>
<td>$\psi$</td>
<td>Level parameter for labor supply</td>
<td>5.35</td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Primary Goods Sector</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\theta_1$</td>
<td>Share of labor income</td>
<td>0.37</td>
</tr>
<tr>
<td>$\theta_2$</td>
<td>Share of capital income</td>
<td>0.18</td>
</tr>
<tr>
<td>$\eta_i$</td>
<td>Elasticity of marginal adjustment cost function</td>
<td>$\eta_i = -(\phi'/\phi'')(i_i/k_i)$</td>
</tr>
<tr>
<td><strong>Final Goods Sector</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\alpha$</td>
<td>Share of labor income</td>
<td>0.45</td>
</tr>
<tr>
<td>$s$</td>
<td>Share of capital income</td>
<td>0.23</td>
</tr>
<tr>
<td>$s$</td>
<td>Share of intermediate input income</td>
<td>0.32</td>
</tr>
<tr>
<td>$1/(u+1)$</td>
<td>Elasticity of substitution between intermediate and capital goods</td>
<td>0.77</td>
</tr>
<tr>
<td>$\sigma_{i,s}$</td>
<td>Allen elasticity of substitution between intermediate and capital goods</td>
<td>0.55</td>
</tr>
<tr>
<td>$\delta$</td>
<td>Depreciation rate</td>
<td>0.10</td>
</tr>
<tr>
<td>$tb/(y^r+y')$</td>
<td>Trade balance to aggregate output ratio</td>
<td>-0.088</td>
</tr>
<tr>
<td>$\eta_i$</td>
<td>Elasticity of marginal adjustment cost function</td>
<td>$\eta_i = -(\phi'/\phi'')(i_i/k_i)$</td>
</tr>
</tbody>
</table>

where $\sigma_{i,s}$ is the Allen elasticity of substitution (see Sato (1967)). The elasticity of substitution between the intermediate inputs and capital goods is equal to $1/(1+u)$.

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. We assume that the share of labor, $\theta_1$, is 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 trade balance to aggregate output ratio is equal to -0.088 that is the average value for the countries in our sample.

It is enough to specify the three parameters, which describe the cost of adjustment functions in the two sectors, to analyze the near steady state dynamics of the model. Following Baxter (1995), we assume that $\phi(i_i/k_i) = \phi(i_p/k_p) = \delta$ and $\phi'(i_i/k_i) = \phi'(i_p/k_p) = 1$ at the steady state. This specification implies that there are no adjustment costs at the steady state of the model, and capital to its replacement cost, Tobin's 'Q', is equal to 1. The elasticity of the marginal adjustment cost function, $\eta_i = -(\phi'/\phi'')(i_i/k_i)$, for each type of capital is fixed, so that the volatility of investment generated by the model is equal to the one in the data.

4.3. Exogenous shocks

4.3.1. Productivity Shocks

We estimate the total factor productivity in the nontraded goods sector, $z_i'$, by using the formula of the Solow residual in logarithms

$$\log(z_i') = \log(y_i') - \alpha \log(n_i')$$

$y_i'$ is the total real value added of industry and service output. $n_i'$ is equal to the employment index of the manufacturing sector since data on labor hours is unavailable for most of the countries in our sample. We fit a 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. The shock process for the primary sector output is estimated using the data of agricultural value added, and employment in manufacturing sector.
4.3.2. External Shocks

We determine the parameters of the processes of price disturbances by using univariate AR(1) processes. We do not have world price indices which are specifically designed for capital goods and intermediate inputs. However, this type of 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 portion of exports of African economies come from 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.

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 entire sample. The resulting specification for exogenous processes is given by

\[
\Pi = \begin{bmatrix}
0.37 & 0 & 0 & 0 \\
0 & 0.33 & 0 & 0 \\
0 & 0 & 0.54 & 0 \\
0 & 0 & 0 & 0.41
\end{bmatrix}
\]

\[
\Sigma = \begin{bmatrix}
0.11^2 & 0.71 & -0.25 & 0.02 \\
0.09^2 & 0.10^2 & -0.42 & 0.09 \\
-0.03^2 & -0.03^2 & 0.03^2 & 0.01 \\
0.01^2 & 0.02^2 & 0.03^2 & 0.05^2
\end{bmatrix}
\]

The bold values in \(\Sigma\) represent the correlations between the innovations.

5. Results of the simulations

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 employing variance decompositions. Following this, we provide a brief discussion about the sensitivity of these results to presence of different types of shocks in the model. Next, the propagation of exogenous shocks in the model economy is analyzed by using impulse responses.

5.1. Aggregate fluctuations in the model economy

We simulate the theoretical model with the specification described in the previous section. We evaluate the ability of it in terms of matching the main characteristics of aggregate macroeconomic fluctuations observed in African economies. The relevant moments of actual data refer to those moments calculated for the representative African country and are presented in Table 4. For the representative economy, primary goods sector output is more volatile than the final goods output and the aggregate output. Investment and trade balance series display high variability. Consumption and employment are both procyclical while trade balance is countercyclical. We concentrate on the predictions of the model related to volatilities of main macroeconomic aggregates and their contemporaneous correlations with aggregate output. Table 5 summarizes our findings about the sample second order moments of the simulated data produced by the model. Each statistic is the sample average of across 1000 simulations of the same length as the data (23 years). The simulated data is also detrended with the HP(100) filter to make the results comparable to the data analysis in section 2.

In terms of matching volatility properties of macro aggregates, the model is quite successful. Qualitatively, it replicates most of the features of actual data: both the trade balance and investment are more volatile than aggregate output. The volatility ordering of outputs in two sectors is also captured by the model: the primary sector output has the largest variability and the aggregate output is the least volatile series. From a quantitative perspective, the model is able to reproduce some of the key 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 lower than the actual one.
Table 4
Properties of Macroeconomic Fluctuations *
(African Average)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Volatility</th>
<th>Relative Volatility</th>
<th>Comovement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>4.06</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Primary</td>
<td>7.28</td>
<td>1.79</td>
<td>0.56</td>
</tr>
<tr>
<td>Final</td>
<td>4.90</td>
<td>1.21</td>
<td>0.82</td>
</tr>
<tr>
<td>Consumption</td>
<td>9.44</td>
<td>2.33</td>
<td>0.40</td>
</tr>
<tr>
<td>Investment</td>
<td>16.43</td>
<td>4.05</td>
<td>0.44</td>
</tr>
<tr>
<td>Employment</td>
<td>7.95</td>
<td>1.96</td>
<td>0.31</td>
</tr>
<tr>
<td>Trade Balance</td>
<td>16.36</td>
<td>4.03</td>
<td>0.16</td>
</tr>
</tbody>
</table>

* The data is in terms of real domestic prices, constructed for per capita quantities, logged and filtered using HP(100) filter. 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 contemporaneous correlation with the output. All moments are averages over the moments of 15 African countries. The sample standard errors of the averages are given in parenthesis. The data, for the period 1970-1992, comes from the World Bank World Tables (1994).

The volatilities of consumption and employment relative to output are seemingly low in the model economy. This is not a surprising result and should not be interpreted as a weakness of the model. The only available data on consumption, which we have access to, includes both non-durable and durable consumption expenditures. Unlike the data, our model does not take into account durable consumption goods. It is known that the volatility of durable goods consumption is two to four times higher than that of non-durables (See Backus, Kehoe and Kydland (1995).) Considering this empirical regularity, we conclude that the model's prediction concerning the variability of consumption is quite reasonable. The problem with the employment fluctuations is also about a measurement issue: the labor supply variation in the model is captured only along the intensive margin, i.e. changes in hours per worker. Conversely, we have employment data, which measures the labor supply fluctuations only along the extensive margin, i.e. changes in employment. Earlier empirical studies suggest that the volatility of employment

Table 5
Properties of Macroeconomic Fluctuations *
(Model)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Volatility</th>
<th>Relative Volatility</th>
<th>Comovement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>4.60</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Primary</td>
<td>7.27</td>
<td>1.58</td>
<td>0.33</td>
</tr>
<tr>
<td>Final</td>
<td>5.23</td>
<td>1.14</td>
<td>0.96</td>
</tr>
<tr>
<td>Consumption</td>
<td>2.85</td>
<td>0.62</td>
<td>0.91</td>
</tr>
<tr>
<td>Investment</td>
<td>16.42</td>
<td>3.57</td>
<td>0.83</td>
</tr>
<tr>
<td>Labor Hours</td>
<td>2.58</td>
<td>0.56</td>
<td>0.91</td>
</tr>
<tr>
<td>Trade Balance</td>
<td>16.04</td>
<td>3.49</td>
<td>0.27</td>
</tr>
</tbody>
</table>

* All moments are averages over the 1000 simulations of the model each with 23 observations (the sample of the actual data has also 23 observations (1970-1992)). The simulated data is filtered by HP(100). 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 contemporaneous correlation with the output. The asymptotic standard deviations of the statistics are given in parenthesis.

is two to three times higher than that of labor hours (see Fiorito and Kollintzas (1994).) Interestingly, the prediction of the model concerning employment fluctuations is consistent with this empirical regularity: the volatility of labor hours in the model is approximately three times as large as the one of employment series in the data.

We also examine the performance of the model in replicating comovement properties of the data. The model slightly 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. These observations are explained with the following intuitive argument: in the model, the representative household cannot intratemporally substitute consumption goods in response to the relative price fluctuations, since she derives utility by consuming only nontraded goods.
The output-labor hours correlation in the model is higher than the output-employment correlation in the data. This is also an expected result since the form of the utility function we employ implies that the number of hours worked at time t is determined by aggregate output. The representative household allocates her labor hours between primary and final goods sectors in the model. Hence, the correlation between total labor hours and aggregate output is not a perfect one as reported in Correia, Neves and Rebelo (1995).

The model is also able to generate countercyclical behavior of the trade balance series. Interestingly, there is a relatively high negative correlation between the trade balance and aggregate output in the model. This result might be due to the existence of relatively more persistent price shocks which are negatively correlated with sectoral productivity shocks. We conclude this section with the observation that our model successfully captures several characteristics of macroeconomic fluctuations in African countries, such as the volatility ordering and comovement properties of sectoral outputs which earlier small open economy models have been unable to explore.

5.2. Sources of macroeconomic fluctuations

Our main objective is to determine the relative contribution of the different types of shocks to aggregate economic fluctuations in African economies. We apply the variance decomposition method, which is widely used in the vector autoregression (VAR) literature, to determine the relative importance of shocks in explaining aggregate economic fluctuations in our model. In other words, we decompose the variances of macroeconomic variables into fractions explained by exogenous shocks. Our VAR model is derived from the solution of the model. Since the 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 external prices. This implies that domestic shocks do not have any impact on the external price fluctuations, i.e. the price shocks precede sectoral productivity shocks in our specification.

The results of the variance decompositions, which are obtained by using the information ordering in (9), are reported in Table 6. Strikingly, a significant fraction of economic fluctuations is explained by the external shocks. They account for more than 45 percent of the variation in aggregate output. Approximately 11 percent of the business cycle movements in the primary sector output is explained by shocks to the relative price of capital goods. More than 20 percent of the variance of nontraded final output is attributable to fluctuations in capital good prices. The domestic productivity disturbances also play an equally important role in generating economic fluctuations: more than 54 percent of the output variation is due to the domestic productivity disturbances. In our model, external price shocks have a direct impact on aggregate output fluctuations, since both sectors of the economy use imported goods as factors of production. Interestingly, the price disturbances explain a larger fraction of consumption variability than aggregate output variations. While the productivity shocks play a relatively modest role in explaining the fluctuations in aggregate labor hours, the external shocks account for more than 67 percent of the variation.

Our results also show that the shocks to prices have a large impact on economic fluctuations in productive factors: more than 78 percent of the volatility of aggregate investment is explained by the price disturbances. In particular, shocks to the relative prices of primary investment goods account for approximately 98 percent of the variation in primary investment. Roughly 42 percent of the variation in intermediate inputs is explained by disturbances to the relative prices of intermediate goods. While the productivity shocks play a relatively modest role in explaining the fluctuations in aggregate labor hours, the external shocks account for more than 67 percent of the variation.

Concerning external balances, almost 48 (35) percent of aggregate fluctuations in asset holdings (trade balance) is explained by the external shocks. The disturbances associated with the prices of capital goods play a more important role in explaining the variations in external balances than those in the prices of intermediate inputs. Almost half of the trade balance movements is attributable to the domestic productivity shocks. This is an intuitively appealing result considering that in our model, the households export all the primary goods they produce.

We next analyze the individual impact of productivity and price disturbances in our model. In Table 7, the results of the simulations when only price shocks are present are reported. Lacking technology shocks, the model is not able to match the volatilities of aggregate output and its components. In particular, the primary sector output in the model is substantially less volatile than the actual one. The correlation between the trade balance and output is around -0.19. We also simulate the model with only domestic productivity disturbances. The model successfully predicts the volatility of primary sector output. However, it matches neither the variation of aggregate output nor the one of final sector output. Further, the model is not able to replicate consumption, investment and labor dynamics when the price shocks are absent. These results show the importance of external shocks in replicating business cycle regularities in a small open economy model designed for a representative African economy.
Table 6
Variance Decomposition
(in percent)

<table>
<thead>
<tr>
<th>Variable</th>
<th>External Shocks</th>
<th></th>
<th>Productivity Shocks</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capital Goods</td>
<td>Intermediate</td>
<td>Total</td>
<td>Final Goods</td>
</tr>
<tr>
<td>Output</td>
<td>21.77</td>
<td>23.39</td>
<td>45.17</td>
<td>48.71</td>
</tr>
<tr>
<td>Primary</td>
<td>11.08</td>
<td>3.20</td>
<td>14.28</td>
<td>5.70</td>
</tr>
<tr>
<td>Final</td>
<td>20.78</td>
<td>25.42</td>
<td>46.19</td>
<td>48.74</td>
</tr>
<tr>
<td>Consumption</td>
<td>30.50</td>
<td>29.04</td>
<td>59.54</td>
<td>26.52</td>
</tr>
<tr>
<td>Investment</td>
<td>41.64</td>
<td>36.28</td>
<td>77.92</td>
<td>21.10</td>
</tr>
<tr>
<td>Primary</td>
<td>98.07</td>
<td>0.51</td>
<td>98.59</td>
<td>0.60</td>
</tr>
<tr>
<td>Final</td>
<td>35.07</td>
<td>40.26</td>
<td>75.32</td>
<td>23.21</td>
</tr>
<tr>
<td>Intermediate Goods</td>
<td>43.97</td>
<td>41.46</td>
<td>84.43</td>
<td>6.55</td>
</tr>
<tr>
<td>Labor Hours</td>
<td>32.97</td>
<td>34.43</td>
<td>67.39</td>
<td>26.59</td>
</tr>
<tr>
<td>Primary</td>
<td>22.31</td>
<td>13.44</td>
<td>35.75</td>
<td>17.23</td>
</tr>
<tr>
<td>Final</td>
<td>31.48</td>
<td>33.35</td>
<td>64.83</td>
<td>23.80</td>
</tr>
<tr>
<td>Trade Balance</td>
<td>21.57</td>
<td>13.58</td>
<td>35.15</td>
<td>15.08</td>
</tr>
<tr>
<td>Asset Holdings</td>
<td>27.72</td>
<td>19.77</td>
<td>47.49</td>
<td>22.51</td>
</tr>
</tbody>
</table>

*The ordering of shocks is $p^k_t, p^f_t, z^f_t, z^p_t$ so price shocks drive the domestic technoh shocks. A recursive information ordering is employed to factor the variance covariance matrix of shocks. In each cell, the volatility of the respective variable explained by a particular shock reported. For example, in the first row, shocks to the prices of capital goods explain 21.77 percent the output volatility, and 45.17 percent of the output variation is explained by the external shocks.

Table 7
Properties of Macroeconomic Fluctuations
(Model)

<table>
<thead>
<tr>
<th>Variable</th>
<th>With Productivity Shocks</th>
<th></th>
<th>With Price Shocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Volatility</td>
<td>Comovement</td>
<td>Volatility</td>
</tr>
<tr>
<td>Output</td>
<td>3.88</td>
<td>1.00</td>
<td>1.43</td>
</tr>
<tr>
<td>Primary</td>
<td>(0.02)</td>
<td>(0.01)</td>
<td>(0.01)</td>
</tr>
<tr>
<td>Final</td>
<td>4.34</td>
<td>0.94</td>
<td>1.60</td>
</tr>
<tr>
<td>Consumption</td>
<td>1.58</td>
<td>0.97</td>
<td>1.83</td>
</tr>
<tr>
<td>Investment</td>
<td>7.82</td>
<td>0.93</td>
<td>11.62</td>
</tr>
<tr>
<td>Labor Hours</td>
<td>1.40</td>
<td>0.99</td>
<td>1.70</td>
</tr>
<tr>
<td>Trade Balance</td>
<td>15.70</td>
<td>-0.32</td>
<td>3.73</td>
</tr>
<tr>
<td>Asset Holdings</td>
<td>(0.08)</td>
<td>(0.01)</td>
<td>(0.02)</td>
</tr>
</tbody>
</table>

All moments are averages over the 1000 simulations of the model each with 23 observations (the sample of the actual data has also 23 observations (1970-1992)). The simulated data is filtered by HP(100) filter. 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 contemporaneous correlation with the output. The asymptotic standard deviations of the statistic are given in parenthesis.

5.3. The dynamic effects of shocks

We study the dynamic effects of productivity and relative price shocks by using impulse response analysis. This investigation provides information about the differences between the propagation mechanisms of productivity and price shocks. We analyze the impulse responses of model variables to a 1 percent temporary shock. The results, presented in Figures 2-4 (pages 32-37), are plotted as percentage deviations from the initial steady state.

We present the impulse responses of model variables to a temporary 1 percent increase in productivity of both sectors in Figure 2. The 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 her consumption. Qualitatively, the sectoral productivity shocks lead to more pronounced impact in investment and the trade balance compared to the ones in output and consumption.

Figure 3 shows the time paths of model variables in response to a 1 percent temporary increase in the relative price of capital goods, which are used in the primary goods sector. This type of adverse price shock pushes the economy into a prolonged recession. Investment in primary goods sector 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 representative household momentarily increases her labor supply in the primary goods sector. She faces a major decline in her export revenues and has to deal with the problem of deteriorating trade balance. There is a permanent, though not substantial, fall in consumption. Aggregate production also decreases due to a shortage of productive inputs. These impulse response plots clearly show the typical transmission mechanisms of economic fluctuations in a number of African countries which are often subjected to the price fluctuations in their export markets: contraction in the exports sector, following a fall in the relative price of exports, causes a substantial decline in the imports of productive inputs which is followed by a permanent decrease in consumption. The economy starts borrowing from world financial markets.

We present the impulse responses of the model variables to a 1 percent temporary increase in the relative price of intermediate inputs in Figure 4. The economy-wide impact of this shock is clearly bigger than the one of the price shock of capital goods, since it hits the nontraded final good sector in a direct manner: the fall in nontraded final good production is more than 0.15 percent. The decrease in the relative price of exports reflects itself in the primary sector and production in this sector contracts more than 0.05 percent. Consequently, trade deficit gets worse with a more than 0.30 percent increase. The contraction in production spreads to the demand for productive inputs: total investment and demand for intermediate inputs go down by more than 1.2 percent. The household decreases her labor supply in both sectors and allocates more time to non-market activities. The trade balance deteriorates as households accumulate foreign debt.

The overall effect of external shocks in our model is the opposite of that of domestic technology shocks since price shocks act as negative technology shocks. While productivity shocks stimulate the economy and result in short lived expansions, relative price disturbances have adverse implications: they cause negative income effects which are followed by a fall in consumption, and a contraction in demand for productive inputs. Furthermore, relative price shocks lead to prolonged recessions by having a detrimental impact on capital accumulation dynamics.

6. Conclusions

We examine the effects of external shocks, namely fluctuations in the prices of capital goods, intermediate inputs and primary goods on economic dynamics of African countries using a dynamic, stochastic, multi-sector small open economy model. Our model successfully reproduces business cycle statistics of several macro aggregates. The results of our study suggest that the external shocks have a significant role in driving macroeconomic fluctuations in African economies. In particular, more than 45 percent of the variations in aggregate output is explained by the external shocks. Investment and consumption dynamics are also largely affected by fluctuations in the relative prices of capital and intermediate inputs. We also find that the propagation of business cycles generated by the external shocks is different than the ones caused by domestic productivity shocks.

Since a number of African economies are heavily indebted, sudden movements in the world interest rate might potentially cause significant economic fluctuations in these economies. We plan to extend our model by introducing world interest rate shocks to examine their influence in generating economic fluctuations. Understanding the impact of different types of government policies implemented in response to the external shocks is another important research subject. With the introduction of a government sector, our model provides a natural setting to assess the relative merits of different types of policies.
Figure 2: Impulse Response of 1% Shock to the Productivity of Both Sectors
Figure 3: Impulse Response of a 1% Shock to the Price of Capital Good

Output

Investment

Consumption

Trade Balance
Figure 4: Impulse Response of a 1% Shock to the Price of Intermediate Input

Output

Investment

Consumption

Trade Balance
Endnotes

1Ramey and Ramey (1995) find that countries with highly volatile macroeconomic environment have relatively lower growth using the data of developing and developed economies. See also Aizenman and Marion (1993), and Basu and McLeod (1992).

2See Easterly and Levine (1996) for an excellent review of the literature on this issue.

3We examine the data of 15 non-oil exporting African countries: Burundi, Gambia, Ghana, Guinea Bissau, Kenya, Liberia, Madagascar, Malawi, Mauritania, Mauritius, Sierra Leone, Swaziland, Tanzania, Zambia, and Zimbabwe.

4The long-run features of the representative African economy are determined using the average values of the macroeconomic aggregates of the 15 African countries in the sample.

5See Baxter (1995), and Backus, Kehoe and Kydland (1995) for surveys on dynamic general equilibrium business cycle models of open economies and their use in analyzing different issues related to the sources and transmission of international business cycles. Obstfeld and Rogoff (1995) provides a review of the early dynamic open economy literature which have mainly focused on the movements of current account balances in response to a variety of shocks in small open economy models.

6See Kydland and Zareaga (1997) for a review of the recent literature on the application of these models to the issues associated with economic fluctuations in developing economies. See Kydland and Prescott (1996) for merits of this modeling approach.

7Reinhart and Vickham (1994) provide an extensive analysis of the empirical regularities associated with commodity prices. See also Ghosh and Ostry (1994), who examine the optimal policy response of a typical developing country to fluctuations in its export earnings, and Varangis, Akiyama and Mitchell (1995) and Maizels (1995), who discuss the potential implications of different policies practiced by developing economies in response to sharp fluctuations in commodity prices.

8Detailed information about the data sources and definitions is available upon request.

9A number of African economies have recently increased the share of the manufactured exports in their total exports. However, the share of the manufactured exports is still a minor fraction of the total exports.

10For an extensive discussion of this index, see Michaeily (1984).

11To find the trend path of the time series, this method solves a constrained optimization problem that involves minimizing the sum of squared deviations from the time series subject to the constraint that the sum of squared second differences not be too large. See Hodrick and Prescott (9177) for more information about this filter.

12The price data is taken from the Citibase and the Commodity Marketer and the Developing Countries of the World Bank.

13See Ingram (1995) for a brief explanation of this method and several other issues related to the solution and estimation of stochastic dynamic general equilibrium models.

14McGratten (1994) uses the same method to investigate the effects of disturbances in labor and capital tax rates and government consumption on output fluctuations. Ingram, Kechlerkota, and Savin (1994) implement a similar variance decomposition method to evaluate the importance of the technology shocks in driving output fluctuations in a multi-shock business cycle model.

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