A Dynamic General Equilibrium Model with Terms of Trade Shocks: A Small Open Economy Case

Ogho O. Okiti
School of Economic Studies
University of Manchester
July 2003

1 Introduction

This paper consider a dynamic general equilibrium model that is used in the discussion of the questions posed by fluctuations in terms of trade in both goods and capital in a developing economy with a single export. The model is, therefore, based on evidence that developing economies are subjected to external shocks emanating from fluctuations in terms of trade (see Agenor and Montiel, 1996), and the understanding that interest rate shock becomes especially important when the economy is a net borrower (Baxter and Crucini, 1993). The Nigerian economy has been integrated into the world economy in the last three decades by versions of these events. Thus the attention is to show how key macroeconomic variables in the economy are affected by stochastic changes in export prices, as reflected in the fluctuations in the price of oil, and the world interest rate.

The dynamic intertemporal optimisation type model that we adopt here is scarce in available studies of developing countries. Previous models on terms of trade shocks in developing countries have concentrated on the macroeconomic adjustment response of these economies to such shocks. In terms of savings and current account behaviour in Nigeria, existing literature include a study of intertemporal model of the current account in Nigeria (Adedeji, 2001a) and a similar study of examination of "the size and sustainability of Nigerian current account deficits" by the same author (2001b).

This model follows and complements many studies on terms of trade disturbances, as reflected in oil price movement. However, it is particularly in the spirit of Macklem (1993) work on Canada, and Eika and Magnussen (2000) work on Norway. In contrast to many papers on oil price changes as reflection of terms of trade movement, such as Sachs (1981), Marion and Svensson (1984a and b), these were written from the perspective of oil exporting countries. Nevertheless, these economies are quite different from Nigeria as they have wide resource and export base

while Nigeria is practically a single export economy and also a member of organisation of the petroleum exporting countries (OPEC).

In the above context, the model is different in a number of respects. We consider the implications of the changes in terms of trade on a macroeconomy with significant trade sector as reflected in the status of a single export economy. In specific terms; first, the economy is decomposed into household, firm and the government, and identifies the stochastic implications of terms of trade changes for their intertemporal optimisation objectives. Second, the model expressly addresses the effects of terms of trade on government budget deficits when government expenditure is given, by endogenising government budget deficits.[1] Third, it is the first of country study of a typical oil exporter and a member of OPEC.[2] Fourth, it is the first model to incorporate interest rate shock into analysis of terms of trade shocks, as reflected in the fluctuations in oil prices.

To enable the proper study of the dynamic adjustment of the macroeconomic variables in the model, we consider a dynamic macroeconomic framework with optimising agents in a representative agent model with both traded and nontraded sectors. By examining both the traded and nontraded sectors, we are able to study both intertemporal and intratemporal elasticities of substitution, which are crucial to analysis of developing economies (see Ostry and Reinhart, 1992). Though the model draws on many previous works on the subject of terms of trade and general equilibrium analysis, it particularly relies on Brock (1988), Gavin (1990), Mansoorian (1991), Macklem (1993), Agenor and Montiel (1996, pp. 44 – 55), and Backus and Crucini (2000). Following these studies, this model abstracts from the monetary side of the economy, therefore implicitly assuming that there are no nominal rigidities and no feedback

[1] Models of endogenous budget deficits are quite uncommon, when compared to the plethora evidence on the macroeconomic effects of budget deficits. Nevertheless, good examples include Ke – Young Chu (1989) who study the sources of fluctuation in 18 countries. Mansur and Robinson (1989) examines the structural causes of budget deficits in developing countries, and also Roubini and Sachs (1989) who study general economic and political determinants of budget deficits for OECD countries.

[2] Spatafora and Warner (1999) examined the terms of trade effects on oil exporting developing countries. However, oil exporting countries are studied as a whole, and different from a country study such as ours.

from the monetary to the real side of the economy. In the context, the model is viewed in the steady state.

The general feature of the model is the understanding of the dynamic response of the economy to exogenous disturbances emanating from the international economic environment. For clarity purpose, first we consider the domestic economy where we examine the welfare and budget deficits effects of disturbances emanating from changes in terms of trade of both goods and capital. By establishing agents' preferences for consumption, capital accumulation and the issue of foreign debt by the government, we set up the analysis and discussion of the impact of terms of trade movements on the economy.

The choice of representative agent type model is motivated by the fact that the issues we study here require understanding the time series behaviour of macroeconomic variables. It is thus helpful if the theoretical framework one uses can be mapped directly into implications for behaviour that can be compared with actual data. This mapping is more easily done with representative agent models than with OLG models (Walsh, 1998). Our approach thus follow the approach adopted in previous researches that include Obsfeld (1981), Obsfeld (1982), Lipton and Sachs (1983), Bruno and Sachs (1985), Engel and Kletzer (1989), Mendoza (1991), and Backus, Kehoe, and Kydland (1994).

The structure adopted in the chapter is to present the behavioural relationships and endogenous variables before presenting the disturbance processes emanating from the terms and trade shocks. In what follows in section 2, the main assumptions and notations of variables and parameters of the model are presented. The general assumptions are the standard small open economy assumptions. The structure of production and the economic environment of the economy is presented in section 3. The section deals with the details of the properties of household, firms and government. Then the economy is characterized, starting with the structure and type of production. The preferences of the economic agents are then looked at, followed by the international constraints and options

faced by economic agents in the economy. Section 4 is the focus of the disturbance processes. We follow Backus and Crucini (2000) in characterizing the disturbance process as a form of autoregressive process. The section also includes analysis on the motivation for characterizing oil price movement exogenous in the context of Nigeria. Section 5 concludes.

2 Assumptions of the Model and Notations of Variables

2.1 The General Assumptions of the Model

In this section, the general assumptions relating to the model are stated. Other assumptions are made when necessary. Stating the general assumptions here help focus on the general limitations of the model. The assumptions are the following:

1. The first assumption of the model is the small country assumption. This assumption describes the economic size of the country and is based on the established facts that the economies of many developing countries are small, open and sometimes experience sporadic shocks. That is, the country is small relative to the rest of the world with respect to its terms of trade, both in goods (exports and imports) and capital and assets. By 'small', we mean the country is not able to influence its external terms of trade but must accept the prevailing world market prices for its imports and exports. Consequently, the country cannot affect the world prices of its exports and imports through its production or consumption and therefore takes the prices of such products as obtained in the international markets as given. In the same vein, the country is small with respect to capital movements in the international financial markets and therefore takes the world real interest rate, the cost of borrowing, as given. By 'open', we mean that international trade forms a substantial component of GDP.

2. Secondly, following from the first assumption, the terms of trade faced by the country is taken as exogenous. This view is reminiscent of the stylised facts that have been established in developing countries where the value of their exportable products are determined in world markets with little or no capacity to influence the prices of such goods (Agenor and Montiel, 1996). This incapability is suggested both by their small share in the world economy and by the composition of their exports, which makes them vulnerable to the fluctuations in their export prices. The typical developing country export is small and dominated by primary and homogenous commodities. That means the terms of trade do vary and it is allowed to do so in this model. Indeed, the variation of the terms of trade in developing countries represent one of the major characteristics of developing economics and a source of macroeconomic disturbances.

The view is in contrast to the analysis often followed in industrial country context. Of course, what matters for the purpose of determining the exogeneity of developing countries' terms of trade is the size of individual countries exports and imports in particular markets. The Nigeria case is a unique one. On the surface, being a member of OPEC, it seems to have control over the prices which it charges for her oil, however in a later section, this view is argued against and justification made for the view of exogenous terms of trade in this model.

3. The third assumption in this model refers to the fluctuation in the real exchange rate (RER). This assumption stems from the explicit consideration of non-traded goods in this model. This represents a clear and unambiguous departure from purchasing power parity (PPP). This assumption is necessary to be able to capture the effects of terms of trade on the RER through income adjustment. In fact, the RER represents a key relative price in the economy and central to dynamic adjustment to responses in the economy to external shocks. The domestic currency price of non-traded goods, p^N is endogenously determined by the condition of equilibrium in the non-traded goods market. The relative price between

traded and non-traded goods will be referred to as RER. An increase in p^M / p^N represents a real depreciation and vice versa.

2.2 Notation of Variables and Parameters

In what follows, we will make use of the notational convention that uppercase letters denote macroeconomy wide variables while lowercase letters denote random disturbances and variables expressed in per capita terms.

Table 1 Notation of Variables

C	Consumption
Y	Gross Domestic Product (GDP)
L	Labour
A	Productivity
X	Exportable good
M	Importable good
N	Nontraded good
R	Firms' Revenue
θ	The terms of trade shock
Γ	Interest rate shock
p	Price
w	Real wages
β	Consumers' rate of time preference
π	Profits
G^T	Government transfer to consumers and firms
T	Tax on consumers and firms
ξ	Intertemporal elasticity of substitution

3 The Domestic Economy, Economic Environment and Agent's Preferences

3.1 Production Structure

We follow the standard specification in dynamic general equilibrium models by assuming that output is produced using capital and labour according to a Cobb – Douglas constant returns to scale production function. However, in contrast to most real business cycle (RBC) literature,[3] productivity does not assume a stochastic role.
Formally, output, Y is

$$Y_t = A_t K_{t-1}^{\alpha} L_t^{1-\alpha} \qquad (1)$$

where A is productivity, K is installed capital investment, L is labour, α is the share of capital in production and $(1-\alpha)$ is the share of labour in production. It is postulated that output responds only to the initial stock of capital and current labour. The Cobb – Douglas type production technology is used in the two productive sectors in the economy for the production of two goods. These goods are the exportable (X) and the nontraded (N). The third good, the importable(M) is not produced in the economy and has to be imported. Both non-traded and importable goods are consumable, while exportable good is simply exported. In GDP terms, the production technology is described as

$$Y_t = Y_t^i \left[Y_t^X, Y_t^M, Y_t^N \right], i = \overset{+}{X}, \overset{-}{M}, \overset{+}{N}. \qquad (2)$$

[3] Real business cycle (RBC) literature concerned with explaining fluctuations in growth of output in competitive equilibrium models and with productivity shocks. Early analyses include Kydland and Prescott (1982), Long and Plosser (1983), King, Plosser and Rebelo (1988), and Christiano and Eichenbum (1992). Though the literature have been able to predict most of the fluctuation in output in closed economies in this manner, it has been necessary to extend the models to take account of some features rather than technology shocks in the explanation of the fluctuations in output. Therefore, the models have been extended to include international economic variables and explain comovements in international output (see for example Mendoza (1991), and Backus, Kehoe and Kydland (1992)).

Consider first the exportable, Y^X, it is exclusively produced for export and not consumed at home. Therefore the prices are determined by market conditions in the relevant international market. This description would represent a reasonable approximation to reality in most developing countries whose exports are dominated by primary commodities. This is especially so in the case of Nigeria where only a negligible amount of the oil production that takes place in the economy is set-aside for domestic consumption. The main property of the exportable is that the price is the terms of trade. That is, the model economy abstracts from other forms of exportable, beside oil. The following denotes the value of exportable in the economy,

$$Y_t^X = Y_t^X(\theta_t) \qquad (3)$$

where $Y_t^X = \left(p_t^X \times \overline{q}_t^X\right)$ is the value of the exportable good in the economy and θ_t is the terms of trade (details of the properties are provided below). Equation 3 relates the value of the exportable good to the terms of trade. This relationship is a positive relationship. Implicit in this equation is the constant assumption of production, thus demonstrating that a change in the value of exportable is only responsive to changes in the relative prices as reflected in terms of trade. For simplicity, we assume that investment and production is unaffected by changes in the real oil prices in the short run (see Favero, Pesaran, and Sharma, 1994; Eika and Magnussen, 2000).[4]

[4] However, Favero, Pesaran, and Sharma maintain that the finite time of extraction from an oil field, say N_t is a function of real oil prices. Thus, the intuition is that actual extraction is subject to changes in real oil prices, but not decision to invest in the oil field. They present evidence in support of postponement in extraction in response to uncertainty prevailing in oil price trends. Though, this assumption is not trivial, it is a reasonable limitation to the analysis. Furthermore, there is evidence that the huge fluctuations in oil prices have followed disproportionate fluctuations in output.

On the other hand, importable good is not produced at home but does possess some interesting properties. The best way to view this is to assume that the importable is a composite tradable good that could be use either for consumption or investment. Essentially, it can be consumed, used as capital or saved as assets. In addition to these properties, the importable good is the numeraire in the economy. It is purchased by the lump sum transfers granted to both consumers and firms by the government (details later) and it is supplied inelastically by the rest of the world. Formally,

$$Y_t^M = Y_t^M\left(Y_t\right) \tag{4}$$

Basically, M consists of two types, both of which are bought by the lump sum transfer granted the two representative agents by the government

$$M = \gamma M^c + \left(1-\gamma\right) M^I \tag{5}$$

Also, it can be transformed into capital and stored till the next period and the value the next period becomes

$$M_{t+1} = M_t + \frac{1}{\left(1+r\right)}, \tag{6}$$

This links any divergence between its income and expenditure to its accumulation of claims on future units of the foreign good. The model's key structural feature is that production requires imported inputs that can only be purchased with uncertain export revenue as in Basu and McLeod (1992). In addition, by selecting the importable as the numeraire, and all variables measured at constant import prices, ensures consistency in the manner in which wealth effects, caused by variations in the purchasing power of exports, influence all endogenous variables in the model (see Frankel and Razin, 1987, pp. 171 – 182).

The non-traded goods sector in the economy is connected to the traded sector by the relationship it has with the importable sector. Though the sector consists of productive activities such as transport, agricultural production and the service industry, it imports its capital inputs from abroad but do not sell its product abroad. Also, though, the price of non-traded good are therefore determined in the domestic market, it is obvious that by linking the importable goods to nontradeable goods in this way, we implicitly link inflation with exchange rate movements.[5] The relative price of nontradeable adjusts to equate the domestic demand and supply of nontradeables. The non-traded good is also a function of real income in the following manner

$$Y_t^N = Y_t^N\left(Y_t\right) \qquad (7)$$

The determination of the different prices is peculiar to the market in which the goods are traded. The domestic currency prices of exportable, importable and non-traded goods respectively are p_t^X, p_t^M, p_t^N.

Table 2: Properties of the Production Structure

Exportable	Produced, but not consumed at home. Price is determined at the international market. Output is constant.
Importable	Consumed, but not produced at home. Homogenous composite good and serves as the numeraire.
Non-traded	Produced and consumed at home. Not traded at the international market.

[5] Note however that the model is in real terms, thus the fluctuations in exchange rate is not explicitly modeled.

3.2 Households

The representative consumer, alongside the government consumes all non-traded and importable goods. The problem of the representative household involves maximizing the present value of utility gained from the consumption of these goods. Formally,

$$\max \sum_{t=0}^{\infty} \beta^t u\left(C_t^N, C_t^M\right) \tag{8}$$

where β is a subjective rate of time discount with the property that $0<\beta<1$, and measures the household's impatience to consume. u is utility, and there is the restriction that all consumption is non - negative, $C^M, C^N > 0$, where C^N and C^M denote the consumption of non-traded and importable goods respectively. By constituting consumption into both nontraded and importable goods explains also the substitution effects induced by changes in intratemporal and intertemporal relative prices of nontraded goods, besides their wealth effects. And total utility is given by

$$U\left(C^N, C^M\right) = \frac{1}{1-\xi}\left(C^{N,\varphi}, C^{M,(1-\varphi)}\right)^{1-\xi} \tag{9}$$

The utility function is known as constant relative risk aversion (or CRRA) (see Dornbusch, 1983; Romer, 1996; Blanchard and Fischer, 1989). The reason for the name is the coefficient of relative risk aversion (defined as $-Cu''(c)/u'(c)$) for this utility function is ξ, and thus independent of C. ξ also determines the household's willingness to shift consumption between different periods: the smaller is ξ, the more slowly marginal utility falls as consumption rises, and so the more willing the household is to allow its consumption to vary overtime. If ξ is close to zero, for example, utility is almost linear in C, and so the household is willing to accept large swings

in its consumption to take advantage of small differences between its discount rate and the rate of return it gets on its savings.

Elasticity of substitution between consumption at any two points in time is $1/\xi$. An additional feature of the utility function is that $C^{1-\xi}$ is increasing in C if $\xi \prec 1$ but decreasing if $\xi \succ 1$, dividing $C^{1-\xi}$ by $1-\xi$ thus ensures that the marginal utility of consumption is positive regardless of the value of ξ. And the marginal rate of substitution between consumption of non-traded goods and importable is given as

$$\frac{\partial u\left(C^N, C^M\right)/\partial C^N}{\partial u\left(C^M, C^N\right)/\partial C^M} = p^N \tag{10}$$

and separable in C^N and C^M as

$$u\left(C^M, C^N\right) = \varphi C^M + (1-\phi) C^N \tag{11}$$

In exchange for a competitive real wage (w), consumers give an inelastic supply of a unit of labour to the two representative firms. Labour is not internationally mobile, but is free to migrate between the non-traded and exportable sectors, though skill and information restrict the level of this movement. Labour supply in the two sectors are given by L_s^X and L_s^N.[6] Furthermore, consumers are subject to an income tax levied by the government. However, this is negligible with little or no influence on consumption patterns. Consumers also own all the firms in the economy, which entitles the consumer to the flow of dividends from profits accruing to each sector.

The consumption of importable is made possible by the transfer income granted by the government, G^{T_c}. This could be consumed immediately or saved till the next period at the prevailing world interest

[6] The labour market is not explicitly modelled.

rate or future income could be borrowed against or buy foreign assets (see the section above). We consider the behaviour of the household optimal. That is, unless there is the emergence of a stochastic process in the economy, the path of consumption will remain as planned (see Hall, 1988; and Spatafora and Warner, 1999). Household attach a zero *ex ante* subjective probability to random shocks, including terms of trade shocks and agents correctly forecast the future time paths of all variables, conditional on such shocks not occurring.

3.3 Firms

Firms carry out their production in accordance with the Cobb – Douglas production technology described earlier. There are two firms in the economy. There is the largely insulated firm that produces exclusively for export, we call this the exportable firm, and the nontraded good firm which produce only for the domestic economy. The only objective of the firms is capital accumulation, that is, accumulate capital up till the point at which their profit is maximised. The importable good form part of the capital inputs in the production of non-traded and the very capital-intensive exportable sector, but they possess different factor intensities. Labour in the two sectors are given as $l_d^X = (w_t)$ and $l_d^N = (w_t)$.

Let us specify the capital accumulation process and the relationship between the factors of production. Consistent with the timing assumption maintained before, we assume that capital must be put in place a period before it is actually used. And as before, capital can be used for production and then consumed at the end of the same period. As standard in previous researches, the assumption of perfect international capital mobility ties capital domestic rate of return to the world interest rate. If r is the world interest rate in terms of tradable, then, under perfect foresight, r must also be the marginal productivity of capital in the traded goods sector. At

the same time, r must be the value measured in tradable of capital's marginal product in the non-traded goods sector.

The firms' investment behaviour in the sectors is modelled after the analysis of Jorgenson (1963), followed by Gavin (1990), Macklem (1993), Baxter and Crucini (1993), and Backus and Crucini (2000), where capital is costly to adjust.[7] Capital depreciates at the constant rate δ, and gross investment is non – negative, $I \geq 0$. Formally, capital's law of motion is given as

$$K_{t+1} = I_t + (1-\delta)K_t + \phi K_t \qquad (12)$$

where the non-negative depreciation function δ satisfies $0 \leq \delta \leq 1$, $\delta' > 0$, $\delta'' < 0$. Gross investment is I_t, and ϕ is adjustment cost. Adjustment or installation costs capture the notion that conceiving, approving, and implementing a given investment project over a very short period of time is much more expensive than carrying it out gradually. Hence, it is in general optimal to smooth out over time any investment response to shocks. A related approach is the "gestation lag" or "time to build" formulation, which postulates it is physically impossible to complete an investment project in less than some minimum time frame. Many studies that incorporate adjustment costs have stipulated a quadratic type form in order to restrict the variability of investment and the process of capital accumulation (see Backus et al, 1990; Mendoza, 1991; Frenkel and Razin, 1992; Baxter and Crucini, 1993; Backus and Crucini, 2000).

In a developing economy context, the significance of the inclusion of capital adjustment parameter cannot be overstated. Frictions that restrict the acceleration of capital accumulation exist in many forms. However, we postulate a linear form of adjustment cost. The intuition here is that the capital adjustments carried out are necessary and sometimes cannot be

[7] Specifying adjustment costs in developing economies could be ambiguous. We could follow the intuition of BKK (1992) to specify adjustment costs as the cost of shipping. Otherwise, we could attempt to quantify adjustment via the peculiar cost of investment expenditure in the form of the indirect cost inflicted by economic uncertainty, economic instability (associated with inflation and exchange rate) or general problems of structural risks associated with expenditure.

deferred. Therefore, the linear formation signifies that adjustments cost are an addition to the cost of installing capital in developing countries. Implicitly, the level of capital accumulation has no beneficial relation with cost of adjusting capital. Since all capital is imported from abroad, and following the "time to build" analogy we assume that the cost of capital adjustment per capital is the import duties paid on imports. The value takes a positive one since we are considering values near steady state. That is, adjustment cost adds to the deviation of capital from steady state value of capital.

There is major difference between the firms, which concerns their factor intensities. The factor intensities in the sectors are denoted as follows $\varsigma y^N \neq \varsigma y^X$ and $(1-\varsigma)y^N \neq (1-\varsigma)y^X$ where ςy^N and ςy^X are labour shares of the non-traded and exportable sectors respectively. Also, $(1-\varsigma)y^N$ and $(1-\varsigma)y^X$ are the capital shares of the non-traded and exportable sectors respectively. Thus, we acknowledge that the production of exportable is very capital intensive compared to the production of nontradable goods. The firms optimally choose capital and labour so that marginal products are equal to the price per unit of input in the following manner

$$\left.\begin{aligned} r_t &= \lambda\left[\partial f(k_t, l_t)/\partial k_t\right] \\ w_t &= \lambda\left[\partial f(k_t, l_t)/\partial l_t\right] \end{aligned}\right\} \qquad (13)$$

3.4 Government

Our discussion and the preference statement of the government sector complete the characterization of the economic agents in the Nigerian economy. This is the most important economic agent in the economy for two reasons. First, the government carries out a substantial percentage of the overall trade in goods and capital because exportable is owned by the government, though the production process in contracted out to the

exportable firm. Second, in this section, our endogenous variable, which is the government budget deficit, is characterized.

The government sector in this model has exogenously given spending requirements divided between non-traded and importable goods. (On budgetary terms, this expenditure consists of both recurrent and capital expenditures). Government's spending requirements are met through the sale of exportable goods, taxes, and foreign borrowing. The government budget constraint, including deficit finance equates government expenditure outlays and its revenue stream. Let T be the total lump-sum tax generated in the economy, which includes income tax, corporation tax, and value added tax (VAT), g is government exogenous expenditure flow that covers both capital and recurrent expenditures, G is governments' transfer to household and firms, and B is a combination of government stock and flow of debt, b is budget deficits, and r is the interest rate paid on past debts. Y^X is as defined above, that is the value of exportable good.

$$g + G + rB_t = T + \mathrm{Y}^{\mathrm{X}} + b_t \qquad (14)$$

The equation abstracts from the existence of non-tax revenue and foreign grants, although these components may be sizeable in some developing countries but not the case in Nigeria. And government shares of expenditure on non-traded and importable goods is given as

$$g = \phi g^M + (1-\phi) g^N \qquad (15)$$

We rule out government borrowing indefinitely (Ponzi Scheme) to finance its consumption and current debt service payments, the usual intertemporal budget constraint is imposed so that any time t, the intertemporal budget constraint, which is the present value of taxes be equal to the present value of government spending plus the value of the

initial government debt, B_0 (that is the usual the stock of the economy's net foreign assets plus the present value of future trade balances must be equal to zero). Accordingly,

$$B_0 + \int_0^{\infty} G_t r_t dt = \int_0^{\infty} \mathsf{T}_t P_t^X dt \qquad (16)$$

Now, we characterize the properties of government budget deficit.[8] The government uses income from the sale of exportable, tax revenue and bond issues to finance investment subsidies, lump sum transfers and interest payments on outstanding debt. However, budget deficits would emerge when government expenditure is not covered by the income from all sources. The deficit that emerge could be financed by three means, characterised in the following manner

$$\hat{b}_0 = \phi_0 \hat{b}_0 / \dot{B} \qquad (17)$$

$$\hat{b}_1 = \phi_1 \hat{b}_1 / \dot{B} \qquad (18)$$

$$\hat{b}_2 = (1 - \phi_0 - \phi_1) \hat{b}_2 / \dot{B} \qquad (19)$$

where $\hat{b}_0$ is foreign borrowings, $\hat{b}_1$ is domestic borrowings and $\hat{b}_2$ is money creation or seignorage. Therefore, the government budget constraint thus indicates that the fiscal deficit is financed by an increase in interest bearing domestic and external debt, or credit from the central bank.

[8] We follow the World Bank (1988), Blejer and Cheasty (1989) and Blanchard and Fischer (1989) to define budget deficits as the excess of government outlays, consisting of its purchases of goods and services and interest payments, over its tax receipts. The flow constraint says only that the government has to borrow when its outlays exceed its tax receipts, or that it repays debt or lends to the private sector when tax receipts exceed outlays. According to the World Bank (1988, p. 56), deficits determining components are: expenditure includes wages of public employees, spending on goods and fixed capital formation, interest on debt, transfers and subsidies. Revenues include taxes, user charges, interest on public assets, transfers, operating surpluses of public companies, and sales of public assets. If the government spending exceeds its revenues, then it is borrowing. If both private and public sectors of a nation are in deficit, the nation as a whole is borrowing, meaning that the current account is also in deficit. If this is the case, the rest of the world is running a surplus with that nation. Alternatively, a government deficit could be offset entirely by net private savings, leaving the current account unaffected.

4 Oil Prices, Terms of Trade and the Disturbance Process

In this section, the shock processes and the properties are described. In the above section, we regarded the value of exportable as positively related to the terms of trade, and rightly so. However, we did not mention how the terms of trade is determined. We take the view of exogenous terms of trade, subject to variations and thus the source of external disturbances in the economy. There are many reasons why oil (as terms of trade) enters the model as an exogenous variable. First, the changes in the price of oil impacts significantly on the Nigerian economy because the economic environment exhibits little or no opportunity to substitute oil for other exports. Following the standard open macroeconomic description, the terms of trade is denoted by

$$\theta_t = \frac{p^M}{p^X} \qquad (20)$$

And an appreciation, deterioration, or a constant terms of trade in period t in nominal prices fulfils the following terminology respectively,

$e_t dp_t^X > 0$

$e_t dp_t^X < 0$

$e_t dp_t^X = 0$

e is the exchange rate and p^X is the price of exportable good.

4.1 Oil Prices and Terms of Trade as Exogenous Shocks

The exogeneity of terms of trade for developing countries is subjected both by their small share in the world economy and by the composition of their exports (Agenor and Montiel, 1996). Developing countries typically export homogenous commodities, the prices of which are set in international markets. Moreover, careful studies of this issue confirm that, with limited exceptions for particular goods, those countries have little individual influence over the prices at which they buy and sell (Goldstein, 1986). In this context, what is the relationship between oil prices, based on international market conditions and the terms of trade in the Nigerian economy? The relationship is underlined by the prevailing uncertainty in the oil price trend. Generally, therefore, oil price increases and decreases are associated with positive and negative terms of trade for exporters respectively, given other considerations.

For non-OPEC oil exporters, the terms of trade are best seen as exogenous. Even for OPEC members, terms of trade shock is mainly reflected in two factors, according to Spatafora and Warner (1999). First is the strengthening and weakening of the OPEC cartel. Second, changes in foreign demand for their oil, stemming from the emergence of new oil producers, the development and exploitation of alternative energy sources, and business cycles abroad.

The supply side effects of changes in terms of trade centres on the sectoral changes that is brought about by a positive terms of trade in a single sector. In Nigeria, this sector has been the oil sector and the fortunes have followed the fortunes of oil export in the world. The other exportable sector and the sector most affected by these fortunes is the agricultural sector. Indeed, the growth in importance of the oil sector to the Nigerian economy has been associated with declines in agricultural productivity, output and exports. Consider the following equation,

$$Y_t^X = \gamma O_t^X + (1-\gamma) n O_t^X \qquad (4.21)$$

where O_t^X and nO_t^X are oil and non-oil export respectively and the share values are γ and $1-\gamma$ accordingly. Since the 1970s, $1-\gamma$ has continuously declined to the point that it can be safely ignored in our influence on the terms of trade in Nigeria. There are two major reasons responsible for the decline in the value of exportable of non-oil exports. The first is the general increase in the relative price of oil to non-oil exports since the 1970s, which has increased substantially the value of oil in Y_t^X. The second and associate reason is the marked decline in agricultural productivity, output and exports.

Regarding the assumption of exogeneity of terms of trade. Firstly, let us consider the world total oil output, which is given by

$$W_y = Opec_y + n - Opec_y \tag{22}$$

and the share of Nigeria's oil in world output is given as

$$\frac{N_y}{W_y} = \left(W_y - \frac{R_y}{Opec_y} - n - Opec_y \right) \tag{23}$$

where W_y is the total oil production in the world, N_y is the fraction of Nigeria's production, $Opec_y$ is the total of OPEC oil production and $n - Opec_y$ is the total oil production of non-OPEC members. As mentioned above, it is the size of the share of the country's production that should determine if the terms of trade should be exogenous. The share of Nigeria's oil in total world production is less than 5 percent even though she is the tenth largest producer in the world and the sixth within OPEC. Moreover, in the last three decades, the wide swings in the price of oil have been shaped by many events, some quite difficult to measure and quantify the exact market effect and the consequent price effect.

Nevertheless, none of the problems have emanated from Nigeria and none could the country influence the outcome.

In market terms, crude oil prices behave as much as any other commodity with price swings in times of shortage or oversupply. The result is the disproportionate correlation between changes in output and prices. In economic terms, prices tend to be extremely elastic in response to output changes and sometimes could extend over several years. Before the oil embargo in 1973 (what is being termed the pre-embargo period in the industry), crude oil prices fluctuated between 2.50 US dollars and 3.00 US dollars from 1948 through the end of the 1960s. However, when adjusted for 1996 US dollars, crude oil prices fluctuated between 14.00 US dollars and 16.00 US dollars and apparently, price increases in the 1ater decades were just keeping up with inflation. Between 1973 and now, sharp movement in oil prices have often followed significant output changes and disruptions. For instance, the 400% rise in the price of oil between 1972 and 1974 followed the Arab embargo that led to 7% drop in oil output of the free world production. From 1974 to 1978 crude oil prices increased at a moderate pace from 12.00 US dollars to 14.00 US dollars. When adjusted for inflation, the prices were constant over this period of time. Events in Iran and Iraq led to another round of crude oil price increases in 1979 and 1980. The Iranian revolution resulted in the loss of 2 to 2.5 million barrels of oil per day between November 1978 and June 1979. In 1980 Iraq's crude oil production fell 2.7 millions barrels per day and Iran's production by 600000 barrels per day during the Iran/Iraq war. The combination of these two events resulted in crude prices more than doubling from 14.00 US dollars in 1978 to 35.00 US dollars.

In the 1980s however, oil prices crumbled. In response to this negative price signals, OPEC attempted to set production quotas low enough to stabilise prices. These attempts met with repeated failure, as various members of OPEC would produce beyond their quotas. During most of this period Saudi Arabia acted as the sing producer cutting oil production to stem the free falling prices. In August of 1985, the Saudis

tired of this roll. They linked their oil prices to the spot market for crude and by early 1986 increased production from 2mmbpd to 5mmbpd. Crude oil prices plummeted below 10.00 US dollars per barrel mid year. A December 1986 OPEC price accord set to target 18.00 US dollars was already breaking down by January of 1987. Prices remained weak. The price of crude oil spiked in 1990 with the uncertainty associated with Iraqi invasion of Kuwait and the ensuing Gulf war, but following the war crude oil prices entered a steady decline until in 1994 inflation adjusted prices attained their lowest level since 1973.

From the above stories, it is easy to deduce that the fluctuations in oil prices are motivated by a combination of different reasons, both political and economic. All these make it imperative for the adoption of exogenous terms of trade in this model.

4.2 The Shocks Processes

The terms of trade shocks in both goods and capital, as reflected in the fluctuation in the price of oil and the cost of borrowing respectively, are assumed to follow an autoregressive type form in the following manner

$$\theta_t = \rho_\theta \theta_{t-1} + e_t \qquad (24)$$

$$\Gamma_t = \rho_r \Gamma_{t-1} + e_t \qquad (25)$$

where e is a serially uncorrelated mean zero process and $|\rho| < 1$.

5 Equilibrium and Terms of Trade Shocks

It is possible to show through the agents preferences and optimisation properties how terms of trade shocks might affect consumers firm and the government. Indeed, having studied the behavioural relationships of households, firms and the government within the limitations of an

intertemporal maximisation situation, and stipulated the autoregressive process of the terms of trade shocks, it is possible to argue that the way terms of trade shocks will affect the intertemporal plans and objectives of economic depends on the nature of the shock and the expectations of economic agents.

Specifically, however, consider the consumer's budget constraint, which reflects the pressure on consumer welfare is given as

$$w_t + G_t^c + \pi_t + rB^c = \left(C^N + C^M\right)^c + T \qquad (26)$$

where all the characters are as defined earlier. The representative household in the economy is affected by terms of trade through different avenues. Take wages, w, for instance, the effect here would come from the pressures faced by firms, which might result in downsizing. This does not affect only the traded sector but also the nontraded sector. This is the case because the nontraded sector relies on the traded sector, through government transfer for the foreign exchange necessary for capital accumulation. therefore, as capital accumulation declines, capacity utilisation falls and employment falls. Also, as capacity utilisation falls, firms profit and income for household declines.

The same argument applies for the dynamic effect of terms of trade movement on the firms in the economy. Consider the combined budget constraint of the two firms in the economy as follows

$$w\left(l^X + l^N\right) + T + rB^f + \pi^{(X+N)} = q\left(p^X + p^N\right) + G^f \qquad (27)$$

From our earlier analysis, it is obvious that the variable necessary for capital accumulation is the government transfer to firms, G^f. Indeed, in the face of any deterioration in terms of trade, the effect is more pronounced because the objective of the firms is seriously jeopardised or improved depending on the directions of terms of trade. In addition, capital accumulation will be slowed down in the expectations of declining terms of trade.

In contrast to consumer welfare and firms capital accumulation objective, the relationship between fluctuations in terms of trade and government budget deficits is much more complicated and ambiguous. Though positive economic theory is pretty clear on the direction it should follow. For instance, in the theoretical expectations model of Corden (1984), an open economy with a single major export is expected to run budget deficits before and after the boom, but run a budget surplus during the boom (or at least run a budget balance or increase foreign reserves). Running budget deficits might be necessary before the boom because the economy might be foreign exchange constrained and it might be necessary to run budget deficits after the boom because trade gaps that have emerged are covered by borrowings. In the face of a boom, the economy is expected to pay up its debt and build up reserves in order to smoothen consumption in the event of a slump in export prices.

However, Corden's analysis precludes uncertainty. We postulate here that the government suffers from a permanent-transitory confusion. The permanent – transitory phenomenon we are looking at here is based on the gestation lags it takes government expenditure to adjust to government revenue as reflected in changes in oil prices. assuming that already planned government expenditure cannot be altered as the it will be politically unacceptable to do so.[9] The intuition here is that there exist both permanent and transitory shocks but the confusion makes the government unable to detect which of the shocks is present. Therefore, the government has to learn whether changes are permanent or transitory by observing which has occurred. Perceptions about permanent shocks change gradually, and differences between expected and actual permanent shocks can persist for a while. The government knows the realisations of the shocks but never observe any of those shocks separately. This is what is responsible for the inaccurate prediction and expectations of terms of trade.

[9] Tornell and Lane (1998) have already pursued this line of argument.

The persistent government budget deficits suggest a permanent – transitory expectation confusion on the part of the government. Government makes implicit judgement about the persistence or otherwise of current terms of trade movements. The permanent – transitory confusion ensures that when there exist positive terms of trade, it is perceived as permanent; budget deficits escalate in the expectation of further positive terms of trade and when terms of trade is negative, budget deficits also escalate because it is expected to be transitory. Consequently, emerged income gaps are covered by foreign borrowings. Another way of separating permanent from transitory components is to imagine that government authorities are quick to recognise positive terms of trade (which they regard as permanent) and slow to adjust when the economy experiences negative terms of trade (which they regard as temporary). Therefore, the inability to accurately observe permanent and transitory changes makes the adjustment to any shock a mixture of the responses to permanent and transitory changes.

Because government expenditures are exogenous, budget deficits must now adjust endogenously to changes in government commitments and subsequently increase government stock of debt. This stems from the fact the economic downturn precipitated by terms of trade deterioration can be expected to reduce government revenues, and without a corresponding reduction in expenditure, will result in the escalation of budget deficit. Nevertheless, the finance of budget deficits requires both economic and practical considerations. The combination of the different forms of budget deficits, therefore depends on government's perspective regarding effects of the different combinations on the economy and different macroeconomic variables such as inflation and the realities of obtaining the finance. However, by taking government spending as exogenous, government budget deficits are a measure of government revenue. With a huge share value from the sale of resources, any movement in the terms of trade will undoubtedly generate repercussion on

government finance. In addition, any deterioration in government finance may affect the current account balance.

One obvious consequences of reduction in oil prices is that without any compensatory reduction in the level of government expenditure, public sector borrowing must necessarily increase following the oil price reduction, to meet the shortfall in total tax revenue. Whether this borrowing takes the form of increased overseas indebtedness, the cost of servicing the additional debt will obviously appear in the subsequent periods as a deterioration of the service account of the balance of payments, compounding the balance of payments difficulties (Afolabi and Bladden-Hovell, 1990).

6 Conclusions

We have shown in this paper through a general equilibrium intertemporal model how terms of trade shocks in both goods and capital affects the Nigerian economy. It is shown that the likely effects of terms of terms of trade shocks is not possible to tell the direction and magnitude due to complexities of the process and the shocks. Therefore, in general, this chapter only represent an attempt at demonstrating the links and avenues through which fluctuations in oil prices and world interest rate affect the economy.

The important departure from other models of this nature include the assumption that productivity do not have stochastic implications, as we consider just terms of trade shocks on the economy. In addition, we postulate a linear adjustment costs to capital and show the importance of government transfer in the economy.

References

Adedeji, O. S. (2001a). The Size and Sustainability of Nigerian Current Account Deficits. *IMF Working Paper* (June), IMF Institute.

Adedeji, O. S. (2001b). Consumption-Based Interest Rate and the Present Value Model of the Current Account – Evidence from Nigeria. *IMF Working Paper* (July), IMF Institute.

Agenor, Pierre-Richard and Montiel, Peter J. *Development Macroeconomics*, Princeton University Press (1996), Princeton, New Jersey.

Backus, David K. and Crucini, Mario J. (2000), Oil Prices and the Terms of Trade, *Journal of International Economics*, 50 (2000), pp. 185 – 213.

Backus, David K., Patrick J. Kehoe and Finn E. Kydland. (1992). International Real Business Cycles. Journal of Political Economy 100 (4): 745 – 775.

Backus, David K., Patrick J. Kehoe and Finn E. Kydland. (1994). Dynamics of the Trade Balance and the Terms of Trade: The J Curve? *The American Economic Review*, 84 (1), March: 84 – 103.

Basu, P. and D. McLeod. (1992). Terms of Trade fluctuations and Economic Growth in Developing Economies. Journal of Development Economics 37: 89 – 110.

Baxter, Marianne and Mario J. Crucini (1993). Explaining saving investment correlations. *American Economic Review*, June, 83 (3): 416 436.

Blanchard, O. and S. Fischer. Lectures on Macroeconomics. The MIT Press, Cambridge Massachusetts. (1989)

Brock, Phillip L. (1988). Investment, the Current Account and the relative price of a non-traded goods in a small open economy. Journal of International Economics 24 (3/4): 235 – 253.

Bruno, Michael and Jeffery Sachs. (1985). *The Economics of World Stagflation*. Cambridge, MA: Cambridge University Press.

Christiano, L. J. and M. Eichenbaum. (1992). Current Real Business Cycle Theories and Aggregate Labour Market fluctuations. American Economic Review 82: 430 – 450.

Dornbusch, Rudiger. (1983). Real Interest Rates, Home Goods and Optimal External Borrowing. *Journal of Political Economy* 91: 141 – 153.

Engel, Charles M. and Kenneth M. Kletzer. (1989). Savings and investment in an open Economy with nontraded goods. International Economic Review 4: 735 – 752.

Frankel, J. and A. Razin. (1987). Fiscal Policies and the World Economy: An Intertemporal Approach. MIT Press, Cambridge MA.

Gavin, Michael. (1990). Structural Adjustment to a terms of trade disturbance: the role of relative prices. *Journal of International Economics* 28 (314), 217 – 243.

Hall, Robert E. (1988). Intertemporal Substitution in Consumption. Journal of Political Economy 96: 339 – 357.

King, R. G., Plosser, C. I., and Rebelo, S. T. (1988). Production, growth, and business cycles: I. The basic neoclassical model. *Journal of Monetary Economics*, 21: 195 – 232.

Kydland, F. and E. C. Prescott. (1982). Time to build and aggregate fluctuations. Econometrica 50: 1345 – 1370.

Lipton, D. and J. Sachs. (1983). Accumulation and Growth in a two country world: A simulation approach. Journal of International Economics 15 (1/2): 135 – 160.

Long, J. B. and C. I. Plosser. (1983). Real Business Cycles. Journal of Political Economy 91: 39 – 59.

Macklem, R. Tiff (1993), Terms of Trade Disturbances and Fiscal Policy in a small Open Economy, *The Economic Journal*, 103, Issue 419 (July, 1993), pp. 916 – 936.

Mansoorian, Arman (1991), Resource Discoveries and Excessive External Borrowing, *The Economic Journal*, Volume 101, Issue 409 (Nov. 1991), pp.1497 – 1509.

Marion, Nancy P. and Svensson, Lars E. O. (1984a). Adjustment to Expected and Unexpected Oil Price Increases. *Canadian Journal of Economics*, XV11: 15 – 31.

Marion, Nancy P. and Svensson, Lars E. O. (1984b). World Equilibrium with Oil Price Increases: An Intertemporal analysis. *Oxford Economic Papers*, XXXV1: 86 – 102.

Mendoza. (1991). Real Business Cycles in a Small Open Economy. *American Economic Review* 81 (Sept.), 797 – 818.

Obsfeld, Maurice. (1981). Macroeconomic Policy, Exchange Rate Dynamics, and Optimal Asset Accumulation. *Journal of Political Economy* 89 (Dec.), 1142 – 1161.

Obsfeld, Maurice. (1982). Aggregate Spending and the Terms of Trade: Is there a Laursen – Metzler Effect? *Quarterly Journal Of Economics*, 97 (May): 251 – 270.

Ostry, J. D. and C. M. Reinhart. (1992). Private Saving and Terms of Trade Shocks: Evidence from developing countries. *IMF Staff Papers* 39, 495 – 517.

Sachs, Jeffrey D. (1981). The Current Account and Macroeconomic Adjustment in the 1970s. *Brookings Papers on Economic Activity*, 1: 201 – 268.

Sachs, Jeffrey D. (1981). Macroeconomic policy, exchange rate dynamics, and optimal asset accumulation. *Journal of Political Economy* 89, 1142 – 1161.

Walsh, C. E. *Monetary Theory and Policy*. The MIT Press, 1998. Cambridge, Massachusetts.