

## Review

# Reforms and terms of trade volatility in an agriculture dependent economy

Jonaki Sengupta<sup>1</sup>, Ranjanendra Narayan Nag<sup>2</sup> and Bhaskar Goswami<sup>3\*</sup>

<sup>1</sup>Department of Economics, Charuchandra College, Kolkata, India.

<sup>2</sup>Department of Economics, St. Xavier's College (Autonomous), Kolkata, India.

<sup>3</sup>Department of Economics, Burdwan University, India.

Accepted 10 February, 2011

**The issue of food crisis and agricultural price volatility were of critical importance in times of globalization. The present paper examined the potential benefits of trade in agricultural products and analyses the macroeconomic implications of commodity price volatility in the context of agricultural trade liberalization. The reference frame was an emerging market economy with a strong presence of agricultural sector.**

**Key words:** Commodity price volatility, agricultural trade liberalization.

## INTRODUCTION

The crucial variables determining macroeconomics of linkage between the agricultural sector and industrial sector has been empirically observed to be speculation, inventory behaviour of agricultural products, commodity price volatility and unemployment. Global price hikes and volatility during the last decades cannot be explained solely by underlying consumption and production trends. In recent years, speculation amplifies volatility in prices to such an extent that they no longer reflect market fundamentals. Figure 1 shows relation between inventory behaviour and commodity price volatility over the last decade.

Both short run volatility and long run trend movements in commodity prices make serious challenges for many developing countries because of their macroeconomic implications, namely effects on employment, output, inflation, balance of payment, income distribution and government budgetary positions. The change in agricultural price produces effect on internal terms of trade which in turn influences industrial employment and output. The transmission mechanism can operate either through demand or through the change in real wage and consequent change in profit maximizing employment and

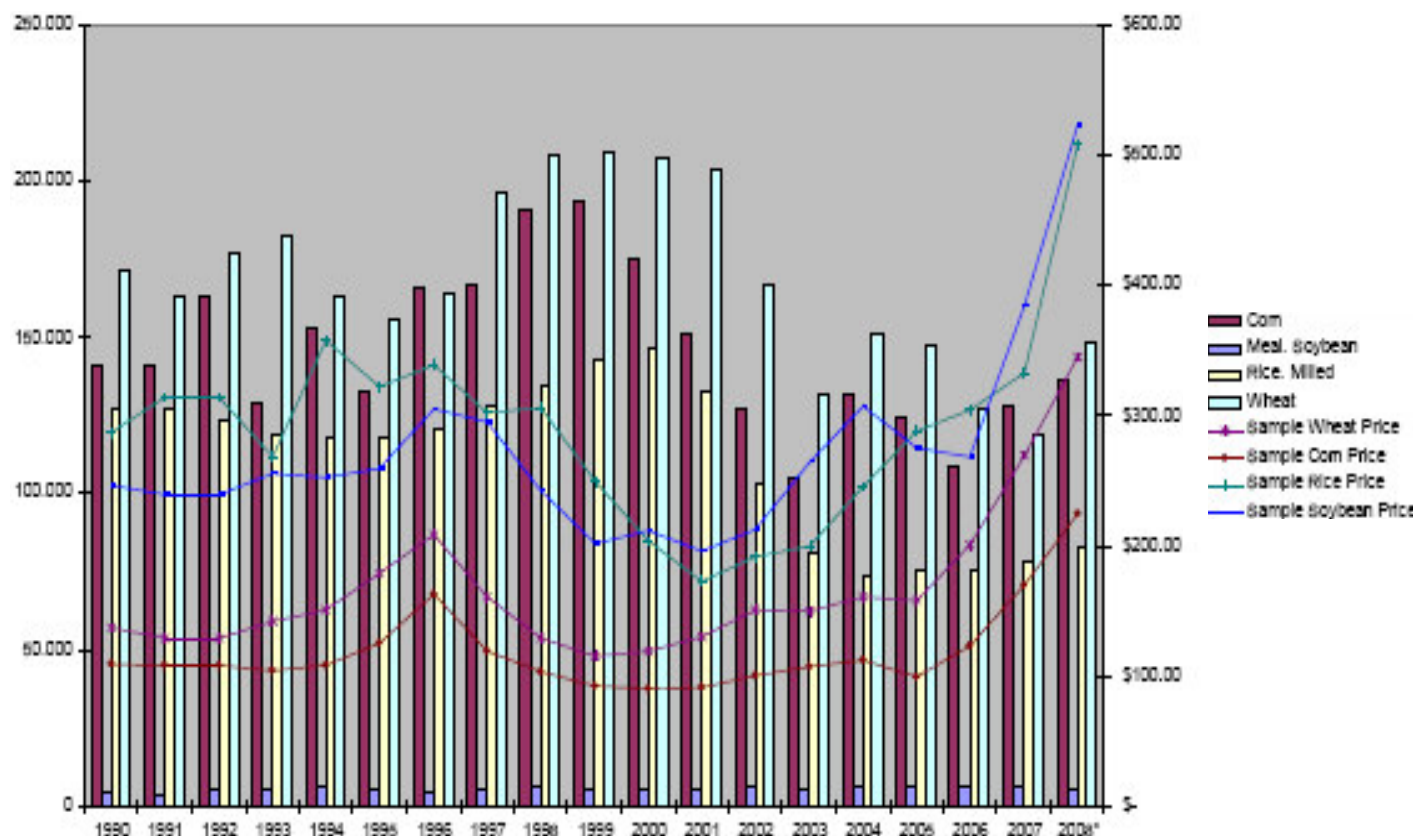
output. Moreover, the income distribution implications of price volatility are of major concern. Small farmers in developing countries, with low propensity to save and poor access to efficient saving instruments can not cope with the revenue variability resulting from fluctuations in commodity prices. The only gainers are the financial intermediaries who are able to profit from rapidly changing prices.

Food price volatility also has impact on overall inflation in a dual economy. According to the IMF's International Financial Statistics, global inflation, which peaked at 6.27% in July 2008, had come down to around 1.3% by Aug 2009. The inflation rate in emerging market economies was falling from 9 to 4.3% during 2008 to 2009. This acceleration in inflation in large part reflects the impact of higher commodity prices. The direct effects on inflation are determined by the weights of these commodities in the consumption basket. The average weight of food in the overall consumer price index is almost 20%, ranging from about 45% in the case of very low expenditure categories to 15% in the highest expenditure categories. The indirect effects operate through the expectation of future inflation and wage indexation.

However, the problem of commodity price volatility can not be studied in isolation from the current process of globalization. In particular, agricultural trade liberalization has become a key policy issue in developing countries. Contribution of agricultural sector to export earnings is shown in Table 1.

---

\*Corresponding author. E-mail: [mailbhaskar08@gmail.com](mailto:mailbhaskar08@gmail.com), [callbhaskar03@yahoo.co.in](mailto:callbhaskar03@yahoo.co.in). Tel: +919433285834.



**Figure 1.** Global inventory and prices. Source: U.S. Department of Agriculture statistical data used for inventory numbers. Price data gathered from UNCTAD for years 1990 to 2007 and FAOSTAT for 2008.

**Table 1.** Agricultural Export (As a percentage of shares of GDP).

Country	2000	2006	2007
Africa	2.1	2.8	2.6
Asia	1.4	1.3	1.3
Oceania	3.6	4.2	4.5

Source: UNCTAD secretariat calculations, based on UNCTAD Handbook of Statistics database: UNCTAD, Commodity price Statistics online; and national sources.

Commodity price volatility can pose problems for primary commodity exporters since price volatility increases cash flow variability and reduces collateral value of inventories.

The recent research shows that both short run and long run relationships exist between commodity prices and money and that the influence of commodity prices on consumer prices occurs through a money-driven overshooting of commodity prices being corrected over time. In other words, commodity prices' influence on consumer prices may not be captured simply by mechanical pass-through effects from the commodity market to the final goods market and a richer, monetary

based characterization and macroeconomic modeling of their relationship is imperative.<sup>1</sup> In this paper, we will construct a monetary model of sectoral interlinkage with specific focus on commodity price volatility and its attendant implication for employment, output and balance of payment.

## REVIEW OF LITERATURE

There have been some major attempts to construct effective demand models suitable for developing countries (Cardoso, 1981; Taylor, 1982, 1985; Rakshit, 1982). All these models incorporate the Kaleckian distinction between agriculture and industry. Despite differences in these models, the basic structure is effective demand problem for industrial sector in presence of wage goods constraint. In these models, the industrial sector has Keynesian features, so that effective demand plays a major role in determining its output, while in the agricultural sector, output is supply constrained.

<sup>1</sup> For modeling of volatility, we have to allow for varying speeds of adjustment of prices across goods market under rational expectation.

Agricultural prices are taken to be market clearing while prices of industrial goods are assumed to be relatively rigid. Cardoso (1981) constructed a structuralist macro model to explain persistence of inflation in Latin American countries. Inflation occurs due to conflict between aspiration of different classes and structural rigidity expressed in terms of binding food constraint. It is shown that the structuralist hypotheses are capable of generating disequilibria that can lead to constantly rising prices. Finally, the paper also explores the implications of foreign trade. It shows that under structuralist hypothesis, external disequilibria cannot be corrected through exchange rate devaluations alone, and it examines the stagflationary impacts of an increase in the price of imported intermediates. Taylor (1982) extended the model to include the capital accumulation process in the analysis of steady state dynamics and hence, studied the long run interactions between investments, production capacities, and real wages. Rattso (1989) extended a static dual economy framework to address medium-term adjustment through accumulation of capital in both agricultural sector and industrial sector along with wage adjustment. However, the issue of food grain stocks and the attendant macroeconomic adjustment was neglected in these models. A similar exercise had been done by Taylor (1991). Parkin (1991) embedded a core structuralist model of sectoral interlinkage within a framework that includes stocks and flows of financial assets. The model shows how financial accommodation of inflation can have an important endogenous component, particularly in an indexed economy- and also how stocks of financial assets can themselves have an impact upon inflation.<sup>2</sup> However, Parkin's work does not examine the issue of speculative holdings of food grain as a stock. Though Baland (1993) explicitly incorporated speculative aspect of food grain stocks in a non-monetary framework, the issue of commodity price volatility is not addressed. The dynamics in Baland's paper involves adjustment in the stock of food grain and accumulation of capital stock. The paper shows that exogenous increase in the investment demand for food grain stocks, by driving up agricultural prices, have a positive impact on industrial employment in the short run.

There is a parallel line of research on the issue of commodity price volatility in a dual economy framework. The role of commodity price volatility in response to monetary shock is the basic issue in an emerging literature on macroeconomics of sectoral interlinkage. The issue in this discussion is the knowledge of not only agricultural quantities produced but also stored which is essential ingredient in the derivation of time path of price which is sensitive to variety of shocks. The shocks could be occasioned either by physical effects of crop variations (that is, supply shocks) or policy induced shocks (that is, monetary shocks or fiscal shocks). In the

post reform period, the shocks could also be external, that is, trade induced. This literature represents an interface between monetary economics and agricultural economics. Frankel (1986) made seminal contribution to this literature on commodity price volatility. He developed a closed economy, monetary macro model to explain overshooting of agricultural prices following an unanticipated expansion in money supply.<sup>3</sup> He emphasized the distinction between fix price sectors (manufactures), where prices adjust slowly and flexible price sector (agriculture), where prices adjust instantaneously in response to a change in the money supply.<sup>4</sup> Lai et al. (1996) extended Frankel's (1986) model to examine effects of both anticipated and unanticipated monetary shock on commodity price volatility. Moutos and Vines (1992) also examined the role of commodity prices in the macroeconomic process of output and inflation determination. There have been econometric studies of volatility of agricultural prices in different countries. Devadoss and Meyers (1987) showed that agricultural prices respond faster than manufactured product prices in response to a change in money supply in the United States. Hence, they conclude that the non-neutral effect of positive money supply shocks on relative prices benefit farmers because farm product prices increase relatively more than non-farm product prices. Robertson and Orden (1990) found that agricultural prices respond more quickly than manufacturing prices in case of New Zealand, but no evidence was found that agricultural prices rise more than proportionately to the money supply in the short run. Zanas (1998) empirically studied the relationship between agricultural prices and the general price level in Greece. It was found that agricultural prices overshoot in the short-run.

However, the issue of price volatility has hardly been theoretically addressed in the context of emerging market economies which depend on export of primary goods as a major source of export earning<sup>5</sup>. When real sector is embedded in a simple open economy, monetary macromodel adapted to capture key institutional feature of an emerging market economy, useful framework

<sup>3</sup>From the policy perspective, an important implication of the overshooting of agricultural prices is that changes in monetary and fiscal policy and other exogenous shocks constitute an additional source of instability for agricultural producers. In fact, overshooting of agricultural price not only distorts market signals, but it redistributes income between producer group and consumers.

<sup>4</sup> Frankel considers Hicksian distinction between these two sectors. This difference lies in alternative motives behind holding of inventory stocks. Producer in the fixed price sector (industrial sector) hold inventory stocks to meet fluctuations in sales order which is a stochastic variable. However, in the flex price sector (agricultural sector), inventory stocks are traded speculatively. Moreover Frankel's (1986) model can be seen as an application of Dornbusch's (1976b) model of exchange rate dynamics. A decline in the nominal money supply is a decline in real money supply in the short run which in turn generates an expectation of future appreciation of agricultural price. The outcome is overshooting of agricultural price.

<sup>5</sup> There are some empirical works by Saghaian et al (2002), Ivanova (2003), Orden and Fackler (1989), Ghironi (2000), Asfaha and Jooste (2007) on dynamics agricultural prices in response to unanticipated monetary shocks in an open economy framework.

<sup>2</sup> Parkin's work can be regarded as an extension of Cardoso's model.

emerges for the study of terms of trade volatility and unemployment. In this paper, we shall examine the macroeconomic implications of variety of shocks in an open economy framework of sectoral interlinkage that includes explicit considerations of stock versus flow equilibrium. With perfect foresight, the short run monetary equilibrium depends on the entire future path of the economy. Over time, the rates of changes in the stocks move the system towards the steady state.

## THE MODEL

We consider two sectors: The agricultural sector and industrial sector. Agricultural sector produces goods (primary commodities) for the internal and external market while the industrial sector produces non-traded manufacturing goods by using imported capital goods<sup>6</sup>. In the spirit of structuralist models,<sup>7</sup> investment is characterized as composite goods produced by combining domestic and imported components. Exchange rate is fixed<sup>8</sup> and the paper ignores capital account transactions<sup>9</sup>. We consider that the money wage is determined by a bargaining process. This protects the real consumption wage. Profit maximization under wage indexation is the basis for supply of industrial output.<sup>10</sup> Industrial price does not adjust instantaneously to clear market for industrial goods. We have role of both inflation inertia and demand-pull factors in determining inflation of industrial price.<sup>11</sup>

The model is presented by the following set of equations:

$$F = \bar{F} \quad (1)$$

<sup>6</sup> This characteristic of the model is very much appropriate for the less developed economy. Rattso and Torvik (2003) also builds up a model for Sub Saharan economies where agricultural sector is exportable sector and industrial sector is a non-traded sector which, however, depends on imported intermediate inputs. Our model departs from their model in the sense that we consider imported capital goods instead of imported intermediate inputs.

<sup>7</sup> Buffie (1986) considers industrial sector which uses imported capital goods. A recent paper (Koichi Yashimine & Thomas .P. Barbiero, 2009) shows how cross country movements of output and trade depend on share of capital goods in total trade.

<sup>8</sup> Despite widespread adoption of floating exchange rates among industrial countries, the vast majority of developing countries have continued to maintain official parities for their currencies. In the face of frequent and severe external shocks, such parities have been subject to frequent devaluations. (Lizondo and Montiel, 1989).

<sup>9</sup> There are several contending views regarding capital account convertibility. Given the lack of some macroeconomic fundamentals like huge fiscal deficit, rising inflation etc., rapid and unplanned liberalization of the capital account can be harmful rather than beneficial to the economy. This skeptical view needs to be given serious consideration given the mixed experience in some of the East Asian and Latin American countries. The liberalization of the capital transactions can lead to capital inflow in the country but this opening also gives a way for flight of capital from the country. In an empirical study, Edwards (2001) also shows that the effect of capital account opening on growth is stronger in a developed country than in a developing country.

<sup>10</sup> There are aggregative models in which unemployment is primarily an outcome of real wage resistance (see Wijnbergen 1984).

<sup>11</sup> See Blejer and Liviatan, 1985-86.

$$Y = f(L, K), \quad f_L > 0, f_{LL} < 0, f_{LK} > 0 \quad (2)$$

$$L = L\left(\frac{W}{P_Y}\right), \quad L' < 0 \quad (3)$$

$$W = P_Y^\alpha P_F^{1-\alpha} \quad 0 < \alpha < 1 \quad (4)$$

$$\frac{W}{P_Y} = \theta^{1-\alpha} \quad (5)$$

Where,

$$\theta = \frac{P_F}{P_Y}, \text{ is the terms of trade.}$$

From Equations (2), (3) and (5), we get the supply function of industrial goods:

$$Y_s = Y_s(\theta) \quad \text{with} \quad Y_s' = \frac{dY_s}{d\theta} = \left(\frac{f_L}{f_{LL}}\right)(1-\alpha)\theta^{-\alpha} < 0$$

$$Z = \theta F + Y_s(\theta) \quad (6)$$

$$\frac{M}{P_Y} = L(Z, r) \quad \text{with} \quad \frac{\partial L}{\partial Z} > 0 \quad \text{and} \quad \frac{\partial L}{\partial r} < 0 \quad (7)$$

$$\frac{\dot{P}_F}{P_F} + k = r \quad (8)$$

$$\frac{\dot{P}_Y}{P_Y} = \pi_Y = \pi_1 + \delta\{\alpha C(Z) + \mathcal{I}(r - \pi_Y) + G - Y_s\},$$

$$\delta > 0$$

$$\Rightarrow \pi_Y = \pi_1 + \delta(ED_Y) \quad (9)$$

$$\dot{M} = P_f X\left(\frac{s/P_f}{P_f}\right) - (1-\gamma)sI(r - \pi_Y) \quad (10)$$

Comments on the aforementioned set of equations are in order:

Agricultural output is determined by supply side factors. In our model, we take agricultural output (F) to be fixed. Equation (1) gives the supply function of output in the agricultural sector.

The production function for industrial sector takes the form of Equation (2) where Y the industrial output and L, K are the labour and capital inputs, respectively.

Employment in the industrial sector is derived from the condition of profit-maximization, namely equality between marginal product of labour and real product wage. Thus we get the labour demand function as given by Equation (3) where  $W$  denotes money wage and  $P_Y$  is the industrial price.

Equation (4) considers the money wage determination. Instead of assuming flexible adjustment in money wage, we take money wage to be determined as an outcome of a bargaining process. Specifically, we assume that the money wage is determined by a social pact, which protects the real consumption wage. In Equation (4),  $\alpha$  and  $1 - \alpha$  are the share of expenditures on industrial and agricultural goods respectively and  $P_f$  is the price of primary commodity.

Equation (5) expresses the real wage in terms of industrial goods as a function of terms of trade  $\theta$ .

In Equation (6),  $Z$  denote aggregate output (or real income) measured in units of industrial goods.

Equation (7) denotes the conventional money market equilibrium.  $M$  is the nominal money supply deflated by the industrial price to get the real money supply. The demand for real money balance is a function of  $Z$  and rate of interest ( $r$ ) on government bonds.

We consider three types of assets, namely money, government bonds and stock of primary commodities.

The term  $\frac{\dot{P}_F}{P_F}$  represents expected change (and actual

change under the assumption of perfect foresight) in food price. The term  $k$  is the difference between the convenience yield and the storage cost of holding primary commodities. Hence, return on stocks of primary

commodities is  $(\frac{\dot{P}_F}{P_F} + k)$ . Equation (8) states that the

bonds and stock of primary commodities are perfect substitutes.

Equation (9) specifies inflation mechanism of industrial price. Aggregate demand for industrial goods consists of private consumption expenditure ( $C$ ) on manufactured goods, private investment ( $I$ ), government expenditure ( $G$ ) and also demand for imports ( $\mathcal{I}$ ). Shares of expenditure on food and industrial goods are constant, which are  $1 - \alpha$  and  $\alpha$ , respectively and total consumption is function of aggregate output ( $Z$ ). Thus, consumption expenditure on the industrial goods is  $\alpha C$  ( $Z$ ). Investment expenditure on the industrial goods depends on the real interest rate. Thus, investment function can be written as  $I = I(r - \pi_Y)$  where  $\pi_Y$  is the rate of industrial inflation. The share of imported capital goods in the industrial sector is  $(1 - \gamma)$  of the total investment<sup>12</sup>.

Therefore import demand for industrial goods is  $(1 - \gamma) I$ . Government expenditure ( $G$ ) is parametrically given. Now, the inflation rate can change in response to excess demand for the industrial goods.<sup>13</sup> Moreover, in the spirit of the "inflationary-inertia" theory, rate of industrial price inflation can be written as Equation (9). Here  $\pi_1$  represents the component associated with inflationary inertia and it may depend on all past variables, including past inflation rates, trade surplus. ED denotes current excess demand that enhances industrial price inflation.

External sector and money supply adjustment is captured by Equation (10). In particular, any difference

between value of export, that is,  $P_f X \left( \frac{s}{P_f} \right)$  and that of

import  $((1 - \gamma) s I (r - \pi_Y))$  involves quantity adjustment through change in foreign exchange reserves, stock of high powered money and money supply under fixed exchange rate regime,  $s$ .

### Steady state equilibrium

State variables in this model are real money supply and terms of trade.

### Real money supply adjustment

Equations (9) and (10) can be combined together to produce the adjustment in the real money supply ( $m = \frac{M}{P_Y}$ )

$$\frac{\dot{m}}{m} = \frac{\dot{M}}{M} - \frac{\dot{P}_Y}{P_Y}$$

$$\dot{m} = \theta X \left( \frac{s}{P_Y} \frac{1}{\theta} \right) - (1 - \gamma) \frac{s}{P_Y} I (r - \pi_Y) - \pi_Y m \quad (11)$$

In an implicit form, the real money balance dynamics can be expressed as:

$$\frac{\dot{m}}{m} = \phi(\theta, m, s, F, G); \phi_1 < 0, \phi_2 < 0, \phi_3 > 0, \phi_4 < 0, \phi_5 < 0 \quad (12)$$

<sup>12</sup> Buffie (1986) stated that most empirical estimates placed  $\gamma$  in the .04- .075 range.

<sup>13</sup> This type of inflation is basically demand-pull inflation.

$$\phi_1 = X(1 - e_x) - (1 - \gamma) \frac{s}{P_Y} I' \left( \frac{\delta r}{\delta \theta} - \frac{\delta \pi_Y}{\delta \theta} \right) - m \frac{\delta \pi_Y}{\delta \theta} < 0$$

(We assume that export elasticity is greater than one).

$$\phi_2 = (1 - \gamma) \frac{s}{P_Y} I' \left( \frac{\delta r}{\delta m} - \frac{\delta \pi_Y}{\delta m} \right) - m \frac{\delta \pi_Y}{\delta m} - \pi_Y < 0$$

$$\phi_3 = e_x - (1 - \gamma) \frac{s}{P_F} \frac{I}{X} > 0$$

(We assume that export elasticity is greater than change in value of import)

$$\phi_4 = (1 - \gamma) \frac{s}{P_Y} I' \left( \frac{\delta r}{\delta F} - \frac{\delta \pi_Y}{\delta F} \right) - m \frac{\delta \pi_Y}{\delta F} < 0$$

$$\phi_5 = -(1 - \gamma) \frac{s}{P_Y} I' \left( -\frac{\delta \pi_Y}{\delta G} \right) - \frac{\delta \pi_Y}{\delta G} < 0$$

The sign restrictions can be explained as follows: The increase in  $\theta$  leads to increase in the real income and hence, demand for money goes up. As a result, interest rate increases leading to fall in private investment. But, rise in  $\theta$  leads to fall in the industrial output. For reasonably low interest elasticity of private investment, we can assume that there is an increase in the industrial price inflation which makes  $\dot{m} < 0$ . Again, fall in private investment leads to fall in demand for imports which tends to generate trade surplus. On the other hand, rise in  $\theta$  causes physical volume of export to fall. Since elasticity of export demand is assumed to be greater than one<sup>14</sup>, real value of food export measured in units of industrial goods declines. As interest elasticity of investment is low, we assume that  $\dot{m} < 0$  as  $\theta$  goes up. Next, we consider increase in  $m$  which causes rise in interest rate and therefore, private investment goes up. Accordingly, there is an increase in industrial price inflation as well as demand for imports and hence, we get,  $\dot{m} < 0$ . Increase in nominal exchange rate raises both export demand and value of import demand of industrial goods. But, considering high elasticity of export demand, net export increases such that  $\dot{m} > 0$ . Next, rise in  $F$  raises the real income, which causes interest rate to rise. Consequently, there is a fall in investment expenditure and hence, fall in import demand. On the other hand, we have increase in consumption expenditure on the industrial output due to rise in real income. For reasonably low interest elasticity of private

investment, we can assume that there is an increase in the inflation of the industrial price. However, we assume that increase in the industrial price inflation exceeds fall in import demand leading to  $\dot{m} < 0$ . Lastly, increase in  $G$  raises the industrial price inflation and hence, it makes  $\dot{m} < 0$ .

### Terms of trade adjustment

Equations (8) and (9) can be combined together to produce the dynamic adjustment in the terms of trade.

Noting that  $\theta = \frac{P_F}{P_Y}$ , we get:

$$\frac{\dot{\theta}}{\theta} = \frac{\dot{P}_F}{P_F} - \frac{\dot{P}_Y}{P_Y} = r - k - [\pi_1 + \delta \{ \alpha C(Z) + \mathcal{I}(r - \pi_Y) + G - Y_S \}] \tag{13}$$

In an implicit form, the terms of trade dynamics can be expressed as:

$$\frac{\dot{\theta}}{\theta} = g(\theta, m, F, G); \quad g_1 > 0, g_2 < 0, g_3 > 0, g_4 < 0 \tag{14}$$

We begin with initial steady state value  $\theta$  such that

$\frac{\dot{\theta}}{\theta} = 0$  and examine effect on  $\dot{\theta}$  following any change in variables that appear in Equation (14).

$$g_1 = A + \theta \frac{\delta r}{\delta \theta} - \theta \left[ \delta \left( \alpha C' \frac{\delta Z}{\delta \theta} + \mathcal{I}' \frac{\delta r}{\delta \theta} - \mathcal{I}' \frac{\delta \pi_Y}{\delta \theta} - Y'_S \right) \right] > 0$$

since we assume that food price inflation is greater than industrial price inflation. (A is a constant).

$$g_2 = \theta \left[ \frac{\delta r}{\delta m} - \delta \left( \mathcal{I}' \frac{\delta r}{\delta m} - \mathcal{I}' \frac{\delta \pi_Y}{\delta m} \right) \right] < 0$$

$$g_3 = \theta \left[ \frac{\delta r}{\delta F} - \delta \left( \alpha C' \frac{\delta Z}{\delta F} + \mathcal{I}' \frac{\delta r}{\delta F} - \mathcal{I}' \frac{\delta \pi_Y}{\delta F} \right) \right] > 0$$

since we assume that food price inflation is greater than industrial price inflation.

$$g_4 = -\theta \delta + \mathcal{I}' \frac{\delta \pi_Y}{\delta G} < 0$$

<sup>14</sup> This assumption is required for saddle path stability of the steady state in our model.

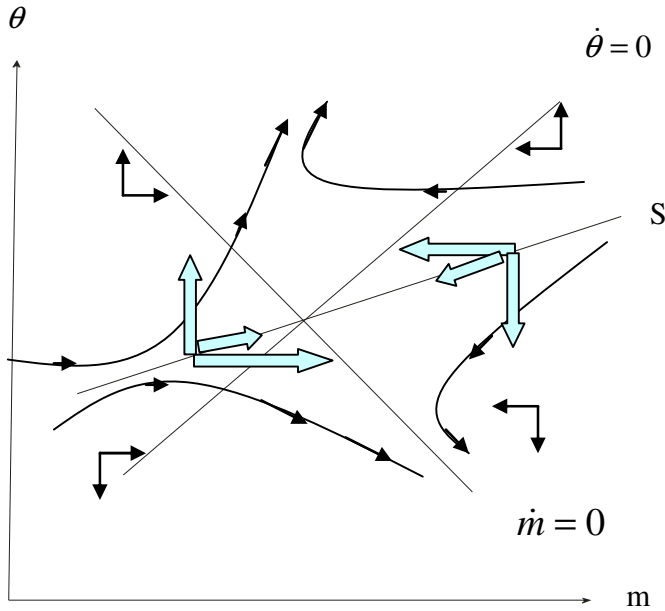


Figure 2. Saddle path stability.

The sign restrictions can be explained as follows: Rise in  $\theta$  leads to increase in the real income and hence, demand for money goes up. As a result, there will be rise in interest rate and hence, food price inflation also increases. On the demand side, private consumption expenditure on the industrial good rises, but private investment falls. Moreover, rise in  $\theta$  leads to fall in the industrial output. For reasonably low interest elasticity of private investment, we can assume that there is an increase in the inflation rate of the industrial price.

However, we assume that the increase in food price inflation exceeds that of industrial price inflation in response to rise in  $\theta$  such that  $g_1 > 0$ . Next, increase in  $m$  causes fall in interest rate and therefore, food price inflation decreases. Moreover, decrease in interest rate causes rise in private investment which pushes up the industrial price inflation. Decrease in food price inflation as well as increase in industrial price inflation make  $g_2 < 0$ . Increase in  $F$  raises real income, which causes interest rate to rise. As a result, the food price inflation increases. However, the effect on the inflation of industrial price is ambiguous. In particular, there are two opposite forces. One is increase in consumption expenditure of the industrial output and other is fall in investment expenditure. For reasonably low interest elasticity of private investment, we can assume that there is an increase in the industrial price inflation. However, we assume that the rise in food price inflation exceeds any possible increase in the industrial price inflation such that  $g_3 > 0$ . Lastly, we consider increase in  $G$  which raises the industrial price inflation and hence it makes

$\dot{\theta} < 0$ , that is,  $g_4 < 0$ .

In the steady state  $\dot{\theta} = 0$  and  $\dot{m} = 0$ ;  $\dot{\theta} = 0$  locus denotes the combination of the  $\theta$  and  $m$  such that food price inflation equals industrial price inflation.

The slope of  $\dot{\theta} = 0$  is  $\left. \frac{d\theta}{dm} \right|_{\dot{\theta}=0} = -\frac{g_2}{g_1} > 0$ .

$\dot{m} = 0$  locus denotes the combination of the  $\theta$  and  $m$  such that real money balance remains unchanged.

The slope of  $\dot{m} = 0$  is  $\left. \frac{d\theta}{dm} \right|_{\dot{m}=0} = -\frac{\phi_2}{\phi_1} < 0$ .

Equations (11) and (13) constitute a system of differential equations in the terms of trade and the real money balance. The terms of trade are a jump variable and real money balance adjusts over time. In presence of perfect foresight the existence of unique convergent saddle path requires that there must be one positive and one negative characteristic root such that the determinant  $\Delta < 0$ , where

$$\Delta = \begin{vmatrix} \phi_2 & \phi_1 \\ g_2 & g_1 \end{vmatrix}$$

Diagrammatically, we get unique convergent saddle path if the  $\dot{m} = 0$  locus is steeper than the  $\dot{\theta} = 0$  locus as shown in Figure 2. The saddle path  $SS$  is upward sloping and flatter than the  $\dot{\theta} = 0$  locus. The equation of the saddle path is given by:

$$(\theta - \bar{\theta}_2) = \left( \frac{\lambda_1 - \phi_2}{\phi_1} \right) (m - \bar{m}_2) = \left( \frac{g_2}{\lambda_1 - g_1} \right) (m - m_2)^{15}.$$

## COMPARATIVE STATIC ANALYSIS

Here, we examine macroeconomic effects of shocks, both policy induced and exogenous. The specific shocks examined are: (1) Devaluation (2) Increase in government expenditure and (3) Rise in agricultural output.

### Unanticipated devaluation

In most of the primary goods producing and exporting countries, the exchange rates are over valued. Thus, devaluation is one of the major components of IMF

<sup>15</sup> See appendix for the derivation of saddle path.

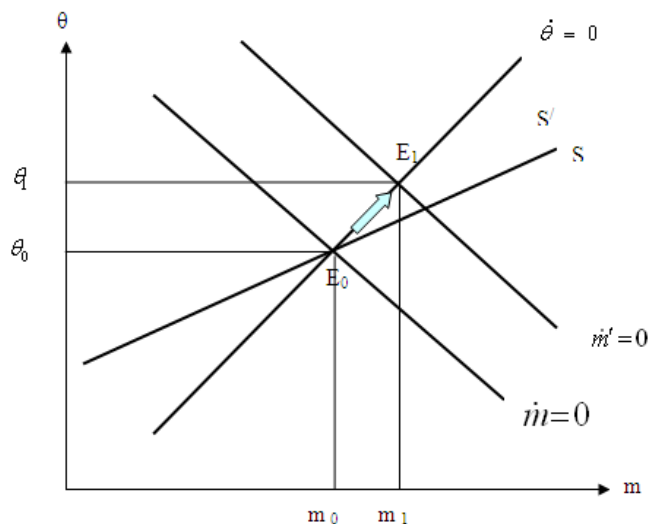


Figure 3a. Unanticipated devaluation.

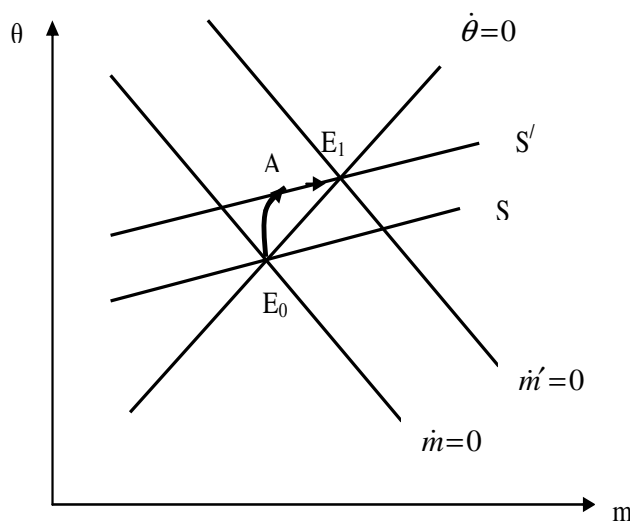


Figure 3b. Anticipated devaluation.

sponsored stabilization program. There exists very rich literature that has described the various channels by which devaluation might be contractionary in emerging and developing economies.<sup>16</sup> In this paper, devaluation might produce stagflationary effect along with an improvement of trade balance. This is definitely a discouraging trade off for policy makers. Devaluation causes an improvement in trade balance provided that:

$$e_x - (1 - \gamma) \frac{s}{P_F} \frac{I}{X} > 0$$

<sup>16</sup> See Edwards (1989), Lizondo and Montiel (1989), Van Wijnbergen (1986).

where  $e_x$  is export elasticity.

Under fixed exchange rate, trade surplus causes real balance to rise and thus  $\dot{m} = 0$  curve shifts rightward Figure 3a.

The rise in real balance reduces interest rate and in the adjustment process  $\dot{\theta} < 0$  and thus, attainment of steady state requires rise in  $\theta$ . Therefore, real wage in unit of industrial goods goes up and hence, industrial employment and output fall. Moreover, there is an increase in industrial price inflation. In particular, there are two sources of rising industrial inflation rate, one is fall in industrial output and the other one is increase in consumption and initial increase in investment. Thus, we see that in a dual economy set up, devaluation may not be a very acceptable tool of stabilization under wage indexation, imports of capital goods and supply constraint from the agricultural sector.

The economy moves from point  $E_0$  to  $E_1$  in response to devaluation with increase in  $\theta$  from  $\theta_0$  to  $\theta_1$  and increase in  $m$  from  $m_0$  to  $m_1$ .

The change in  $\theta$  and  $m$  are represented by following two equations respectively<sup>17</sup>:

$$\frac{d\theta}{ds} = \frac{g_2 \phi_3}{\Delta} > 0$$

$$\frac{dm}{ds} = \frac{-g_1 \phi_3}{\Delta} > 0$$

**Proposition**

Devaluation entails uneasy trade off for policy makers. While devaluation improves trade balance, it produces stagflationary outcomes.

Since devaluation is an important policy tool, the Central Bank announces it before actual implementation. Let at time  $t_0$ , devaluation be announced and at time  $t_1$ , devaluation actually takes place. In the interim before actual devaluation, individuals can anticipate a rise in  $\theta$  since real balance would increase in future through trade surplus. At a time before  $t_1$ , terms of trade rises which causes fall in industrial employment and output. When devaluation actually takes place at time  $t_1$ , the economy will be back on the respective saddle path and reaches the final steady state.

In Figure 3b, terms of trade increase from  $E_0$  to A in anticipation of increase in  $m$ . Over time when  $m$  actually increases, the economy gradually moves from A to  $E_1$  causing further increase in terms of trade.

<sup>17</sup> See the mathematical appendix for derivation of both steady state effects and transitional dynamics.



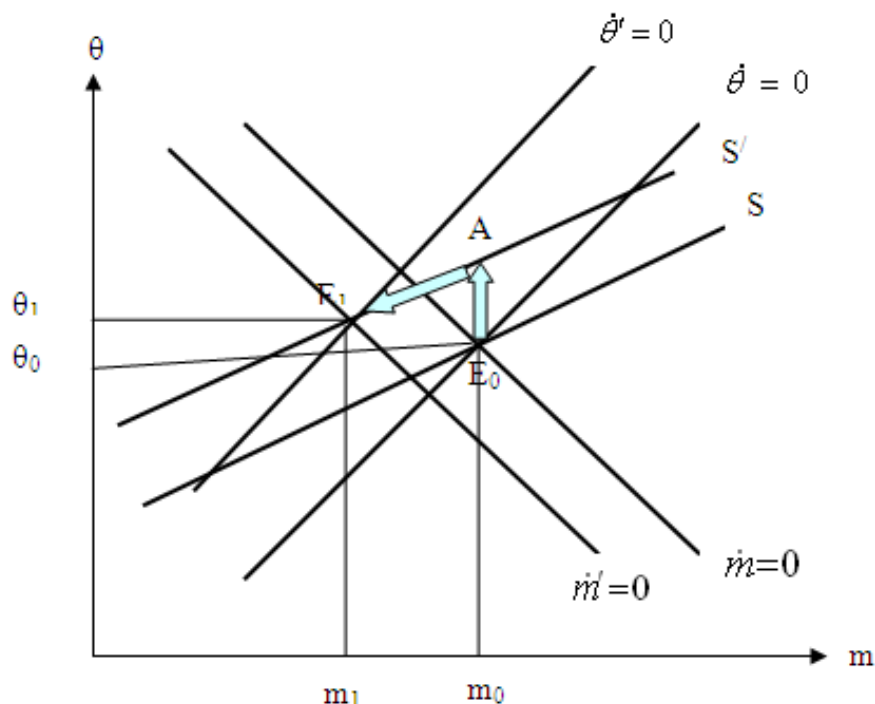


Figure 4. Increase in government expenditure.

### Increase in government expenditure

In this paper, fiscal expansion may lead to stagflationary effects along with balance of payment deficit. The intuitive explanation of this increase in government expenditure is simple.

### Long run effect

Increase in government spending on industrial goods leads to increase in industrial price inflation which makes  $\dot{\theta} < 0$ , starting from  $\dot{\theta} = 0$  and thus,  $\theta$  will increase. Diagrammatically, fiscal expansion causes an upward shift of  $\dot{\theta} = 0$  curve. Since industrial price inflation goes up, inflation tax increases leading to  $\dot{m} < 0$  and hence,  $\dot{m} = 0$  curve shifts downward. Unambiguously,  $m$  declines in the long run. However, the effect on terms of trade is ambiguous. In case of rise in terms of trade, stagflation is round the corner.

### Transitional dynamics

We assume that in the long run terms of trade will increase. But the crucial fact is that the initial behaviour of the terms of trade depends on the long run adjustment of real money supply. In the short run (that is, at given  $m$ )

terms of trade increases from  $E_0$  to  $A$  as shown in Figure 4. Over time as  $m$  decreases,  $\theta$  begins to fall. Thus, the decrease in  $\theta$  generates overshooting of terms of trade. It is also interesting to note that when terms of trade overshoot, trade surplus must undershoot. As shown in Figure 4, initial increase in terms of trade from  $E_0$  to  $A$  reduces the export demand. Since, we assume export elasticity is greater than one, trade surplus deteriorates. But, over time, as  $m$  decreases gradually, trade surplus starts to improve and thus, value of trade surplus at point  $E_1$  must be greater than at point  $A$ . In other words, trade surplus undershoots in the long run.

In Figure 4, the equilibrium initially jumps from point  $E_0$  to point  $A$  along the new saddle path. Since,  $m$  cannot jump instantaneously; point  $A$  is the only transitional position. The transition towards the new steady state is characterized by the path between  $A$  and  $E_1$ , along which both  $m$  and  $\theta$  decline. In fact, decrease in real money supply causes fall in terms of trade causing overshooting of terms of trade. Thus, the model shows overshooting of the terms of trade following fiscal expansion. The final and initial change in  $\theta$  are represented by following two equations respectively<sup>18</sup>

$$\frac{d\theta}{dG} = \frac{-g_4\phi_2 + g_2\phi_5}{\Delta}$$

<sup>18</sup> See the mathematical appendix for derivation of both steady state effects and transitional dynamics.

$$\theta(0) - \bar{\theta}_1 = \left( \alpha_1 - \alpha_2 \left( \frac{\lambda_1 - \phi_2}{\phi_1} \right) \right) d\bar{G}$$

Subtracting the second equation from the first equation, we obtain the value of overshooting of  $\theta$  and this is given by:

$$\bar{\theta}(2) - \bar{\theta}(0) = \alpha_2 \left( \frac{\lambda_1 - \phi_2}{\phi_1} \right) dG$$

Since  $\alpha_2 < 0$ , that is, real money supply decreases, the terms of trade overshoots.

### Proposition

Increase in  $G$  generates terms of trade improvement which leads to industrial contraction. Moreover, trade balance also deteriorates along with increase in industrial price inflation.

### Increase in agricultural output

There must be an explicit recognition of the basic right to sustain food production and promote food sovereignty in developing countries. Thus, for the primary commodity dependent developing economies, this entails an increase in agricultural production.

### Long run effect

Rise in agricultural output leads to increase in aggregate income and hence, demand for money rises. It follows from the money market equilibrium that interest rate

rises, leading to  $\frac{\dot{P}_F}{P_F} > 0$ . But, effect on the industrial price

inflation is ambiguous. On the one hand, we have increase in consumption expenditure on the industrial output and on the other hand, we have fall in investment expenditure. For reasonably low interest elasticity of private investment, we can assume that there is an increase in the inflation rate of the industrial price. Moreover, we also assume that the rise in food price inflation exceeds any possible increase in the industrial price inflation such that  $\dot{\theta} > 0$ . Hence, the  $\dot{\theta} = 0$  curve shifts downwards.

Again, increase in industrial price inflation makes  $\dot{m} < 0$ . Thus,  $\dot{m} = 0$  curve shifts leftwards. In the long run, unambiguously, the terms of trade decline on impact, leading to expansion of industrial output. But effect on  $m$

is ambiguous. Increase in  $F$  directly decreases real money balance. But, there is indirect unfavourable effect through decrease in terms of trade. In particular, as terms of trade decreases, real money balance increases. This increase in  $m$  reduces the initial favourable effect.

### Transitional dynamics

In the short run, real money supply remains unchanged. But, over time change in real money supply shapes the dynamics of terms of trade.

If  $m$  decreases, the initial favorable effect on the industrial output is reinforced, that is,  $\theta$  decreases further leading to undershooting of  $\theta$ . On the other hand, if  $m$  increases,  $\theta$  increases leading to overshooting of  $\theta$ . It is also observed that either terms of trade or trade surplus overshoots. As shown in Figure 5a, the short run decrease in terms of trade raises export demand and assuming that export elasticity is greater than one, trade surplus improves. But, over time, as  $m$  decreases, the initial improvement of trade surplus is offset. Thus, trade surplus is greater at point A than at point  $E_1$ . Hence, trade surplus overshoots in the long run. In contrast, in Figure 5b, terms of trade overshoots and trade surplus undershoot in the long run.

The final and initial changes in  $\theta$  are given by following two equations, respectively:

$$d\theta = \frac{-g_3\phi_2 + g_2\phi_4}{\Delta} dF < 0$$

$$\theta(0) - \bar{\theta}_1 = \left( \alpha_3 - \alpha_4 \left( \frac{\lambda_1 - \phi_2}{\phi_1} \right) \right) d\bar{F}$$

Subtracting the second equation from the first equation, we obtain the value of overshooting or undershooting of  $\theta$  and this is given by:

$$\bar{\theta}(2) - \bar{\theta}(0) = \alpha_4 \left( \frac{\lambda_1 - \phi_2}{\phi_1} \right) d\bar{F}$$

Since  $\alpha_4 < 0$ , that is, real money supply decreases, the terms of trade undershoots. On the other hand, if  $\alpha_4 > 0$ , that is, real money supply increases, the terms of trade overshoots.<sup>19</sup>

The equilibrium initially jumps from point  $E_0$  ( $E_0'$ ) to point A (A') along the new saddle path in Figure 5a (5b) respectively. Since  $m$  cannot jump instantaneously, point

<sup>19</sup> Long run and transitional dynamics of expansion of agricultural output can be calculated very easily by similar methods as in expansionary fiscal policy.

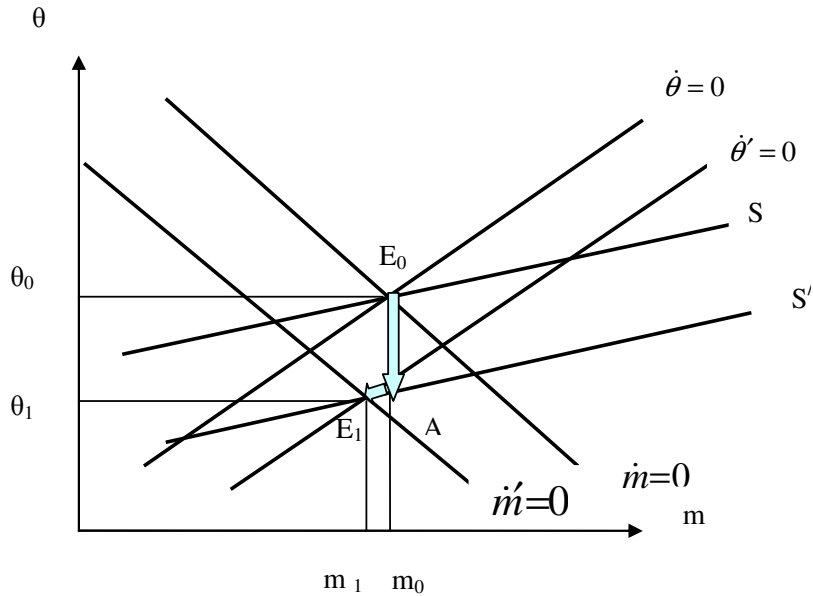


Figure 5a. Undershooting of  $\theta$ .

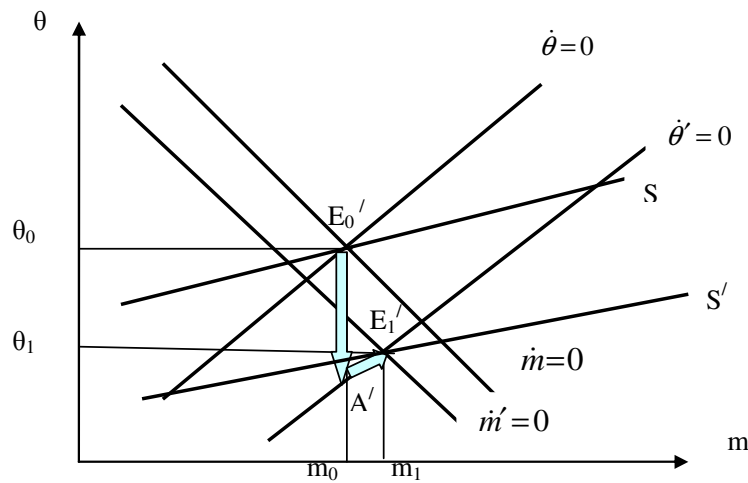


Figure 5b. Overshooting of  $\theta$ .

A ( $A'$ ) is only a transitional position. The transition towards the new steady state is characterized by the path between A ( $A'$ ) and  $E_1$  ( $E_1'$ ), along which  $\theta$  declines and  $m$  decreases (increases). In fact, decrease (increase) in  $m$  causes fall (increase) in  $\theta$  causing undershooting (overshooting) of  $\theta$ .

**Proposition**

Increase in agricultural output entails industrial expansion through fall in terms of trade. On the other hand, trade balance also improves in the short run due to decrease in

investment.

**Conclusions**

The present paper incorporates open economy dimensions of sectoral interlinkage with specific focus on trade in agricultural products. The industrial sector is a non traded sector that uses imported capital goods. Investment is characterized as composite output produced by combining domestic and imported components. Exchange rate is fixed and the paper ignores the capital account transactions. The adjustment variables in this paper are terms of trade (which is jump variable)

and real money balance. The paper leads to the following results:

1. Unanticipated devaluation entails uneasy trade off for policy makers. On the one hand, it improves trade balance, and while on the other hand, it has stagflationary implications.
2. Increase in government expenditure generates terms of trade improvement in favour of agricultural sector which leads to industrial contraction. Moreover, trade balance also deteriorates along with increase in industrial inflation. Thus, fiscal expansion produces contractionary effect on industrial output.
3. Increase in agricultural output entails industrial expansion through fall in terms of trade. On the other hand, trade balance also improves due to decrease in investment.

We can undertake our future research in many possible directions:

Firstly, there is an emerging issue of agricultural dualism in transitional economies. As suggested by the World Development Report, 2008, there is a modern agriculture which produces processed goods for exports and is definitely a major source of foreign exchange. However, this so-called modern agriculture co-exists with a traditional agricultural sector which is, by and large, non-traded. Given land constraint, any substantial expansion of modern agricultural sector can affect food security by reducing availability of land for traditional agriculture. This issue of development with disparity can be investigated within a broad framework of development macroeconomics.

Secondly, another emerging issue in agricultural marketing is contract farming. The problems for agricultural marketing network in developing countries are multifarious. Therefore, the government has initiated legal or administrative action for contract farming arrangements. Coverage area of the contract farming, involving the direct linkage between a private company specializing in marketing activities and the farmers, is expanding in recent period. According to the contract, the farmer is required to plant the contractor's crop on his land, and to harvest and deliver to the contractor a quantum of produce, based on anticipated yield and contracted acreage and this could be at a pre-agreed price. In particular, the agribusiness sector has witnessed the entry of a number of corporate houses, which has fuelled a debate on their effectiveness in meeting the credit and technology crunch of the economy on one hand and potential exploitation of farmers on the other. This particular issue requires further investigation in a macroeconomic framework.

## ACKNOWLEDGEMENT

The authors are grateful to two anonymous referee of this

journal for their constructive comments. However, the usual disclaimer applies.

## REFERENCES

- Asfaha Ta, Jooste A (2007). The Effect of Monetary changes on Relative Agricultural Prices: *Agrekons*, 46(4): 460-473.
- Baland (1993). Foodgrain Stocks and Macrodynamic Adjustment Mechanisms in a Dual Semi-Industrialized Economy. *J. Dev. Econ.*, 40: 171-185.
- Blezer MI, Liviatan N (1985-86). Fighting Hyperinflation: IMF Staff Papers, p. 409-438.
- Buffie F (1986). Devaluation, Investment and Growth in LDCs. *J. Dev. Econ.*, 20: 361-379.
- Cardoso EA (1981). Food supply and Inflation. *J. Dev. Econ.*, 8(3): 269-284.
- Devadoss S, Meyers WH (1987). Relative Prices and Money: Further Results for the United States: *Am. J. Agric. Econ.*, 69(4): 838-842.
- Dornbusch R (1976b). Expectations and Exchange Rate Dynamics. *J. Pol. Econ.*, 84: 76-1161.
- Edwards S (1989). Real Exchange Rates, Devaluation, and Adjustment: Exchange Rate Policy in Developing Countries, Cambridge, MA: MIT.
- Edwards S (2001). Capital Mobility and Economic Performance: Are Emerging Economies Different? : Working Paper, 8076, National Bureau of Economic Research.
- Lizondo S, Montiel P (1989). Contractionary Devaluation in Developing Countries, IMF Staff Papers, 36: 182-227.
- Frankel JA (1986). Expectations and Commodity Price Dynamics: The Overshooting Mode. *Am. J. Agric. Econ.*, 68(2): 344-348.
- Ghironi F (2000). Alternative Monetary Rules for a Small Open Economy: The case of Canada: Working Paper, p. 466.
- Ivanova N, Dawson P, Lingard J (2003). Macroeconomic Impacts on Bulgarian Agriculture during Transition. *Appl. Econ.*, 35: 817-823.
- Lai C, Hu S, Wang V (1996). Commodity Price Dynamics and Anticipated Shocks: *Ame. J. Agric. Econ.*, 78(4): 982-990.
- Moutos T, Vines D (1992). Output, Inflation and Commodity Prices, *Oxford economic papers*, 44: 355-372.
- Orden D, Fackler PL (1989). Identifying Monetary Impacts on Agricultural prices in Var Models: *Am. J. Agric. Econ.*, 71(2): 495-502.
- Parkin V (1991). Chronic Inflation in an Industrializing Economy: The Brazilian Experience, Cambridge University Press.
- Rakshit M (1982). The Labour Surplus Economy, Macmillan, Delhi.
- Rattso J (1989). Macroeconomic adjustment mechanisms in a dual semi-industrialized economy. *J. Dev. Econ.*, p. 44.
- Rattso, Torvik (2003). Interactions between Agriculture and Industry: Theoretical Analysis of the Consequences of Discriminating Agriculture in Sub-Saharan Africa. *Rev. Dev. Econ.*, 7(1): 138-151.
- Robertson JC, Orden D (1990). Monetary Impacts on Prices in the Short and long Run: Some evidence from New Zeland. *Am. J. Agric. Econ.*, 72(1): 160-171.
- Saghaian SH, Reed MR, Marchant MA (2002). Overshooting of Agricultural prices in four Asian Economies. *Am. J. Agric. Econ.*, 34(1): 95-109.
- Taylor L (1983). Structural Macroeconomics, Applicable Macromodels for the Third World, New York Basic Books,
- Taylor L (1991). Income Distribution, Growth and Inflation, Cambridge MMA, MIT press.
- Wijnbergen S (1986). Exchange rate Management and Stabilization Policies in Developing countries. *J. Dev. Econ.*, 23: 227-47.
- Zanias GP (1998). Inflation, agricultural prices and economic convergence in Greece. *Eur. Rev. Agric. Econ.*, 25: 19-29.

## APPENDIX

### Derivation of saddle path

From Equations (12) and (14) we can write:

$$\dot{m} = \phi(\theta, m) \quad (15)$$

$$\dot{\theta} = g(\theta, m) \quad (16)$$

Taking linear form, the aforementioned two equations around the initial steady state values  $(\bar{\theta}_1, \bar{m}_1)$  we get:

$$\begin{bmatrix} \dot{m} \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} \phi_2 & \phi_1 \\ g_2 & g_1 \end{bmatrix} \begin{bmatrix} m - \bar{m}_1 \\ \theta - \bar{\theta}_1 \end{bmatrix} \quad (17)$$

Now suppose that at time 0 it is announced that a parameter (for example G, M, F) are to increase, at time  $T \geq 0$ <sup>20</sup>. Therefore the new steady state after the shifts have occurred are specified by:

$$\begin{bmatrix} \dot{m} \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} \phi_2 & \phi_1 \\ g_2 & g_1 \end{bmatrix} \begin{bmatrix} m - \bar{m}_2 \\ \theta - \bar{\theta}_2 \end{bmatrix} \quad (18)$$

As long as the shifts are additive, so that the coefficients  $a_{ij}$  remain unchanged between two regimes, the eigen values  $\lambda_1, \lambda_2$  say of Equation 3 and 4 are identical. We assume that  $\lambda_1 < 0, \lambda_2 > 0$  such that  $\lambda_1 \lambda_2 = \Delta = (\phi_2 g_1 - g_2 \phi_1) < 0$ .

Now, over the period  $0 < t \leq T$ , the solutions for  $m, \theta$  are given by:

$$m(t) = \bar{m}_1 + A_1 e^{\lambda_1 t} + A_2 e^{\lambda_2 t} \quad (19)$$

$$\theta(t) = \bar{\theta}_1 + \left( \frac{\lambda_1 - \phi_2}{\phi_1} \right) A_1 e^{\lambda_1 t} + A_2 \left( \frac{\lambda_2 - \phi_2}{\phi_1} \right) e^{\lambda_2 t} \quad (20)$$

Again, for the period solutions  $t \geq T$ , the solutions for  $m$  and  $\theta$  are:

$$m(t) = \bar{m}_2 + A'_1 e^{\lambda_1 t} + A'_2 e^{\lambda_2 t} \quad (21)$$

$$\theta(t) = \bar{\theta}_2 + \left( \frac{\lambda_1 - \phi_2}{\phi_1} \right) A'_1 e^{\lambda_1 t} + A'_2 \left( \frac{\lambda_2 - \phi_2}{\phi_1} \right) e^{\lambda_2 t} \quad (22)$$

It is noted that  $\theta(t)$  and  $m(t)$  do not diverge as  $t \rightarrow \infty$  when  $A'_2 = 0$  and hence:

$$m(t) = \bar{m}_2 + A'_1 e^{\lambda_1 t} \quad (23)$$

$$= \theta(t) = \bar{\theta}_2 + \left( \frac{\lambda_1 - \phi_2}{\phi_1} \right) A'_1 e^{\lambda_1 t} \quad (24)$$

The remaining constants  $A_1, A_2, A'_1$  are obtained by solving the equations:

$$A_1 + A_2 = 0 \quad (25)$$

$$(A_1 - A'_1) e^{\lambda_1 T} + A_2 e^{\lambda_2 T} = d\bar{m} \quad (26)$$

$$\left( \frac{\lambda_1 - \phi_2}{\phi_1} \right) (A_1 - A'_1) e^{\lambda_1 T} + \left( \frac{\lambda_1 - \phi_2}{\phi_1} \right) A_2 e^{\lambda_2 T} = d\bar{\theta} \quad (27)$$

where  $d\bar{m}$  and  $d\bar{\theta}$  are shifts of steady state in  $m$  and  $\theta$ , respectively.

Now the stable saddle paths after time  $T$  are described by Equations (21) and (22). Eliminating  $A'_1 e^{\lambda_1 t}$  from these equations we get:

$$(\theta - \bar{\theta}_2) = \left( \frac{\lambda_1 - \phi_2}{\phi_1} \right) (m - \bar{m}_2) = \left( \frac{g_2}{\lambda_1 - g_1} \right) (m - \bar{m}_2) \quad (28)$$

### Comparative statics

#### Effect of devaluation

**Long run effects:** From Equations (12) and (14) we get:

$$\dot{m} = \phi(\theta, m, s); \phi_1 < 0; \phi_2 < 0; \phi_3 > 0 \quad (12a)$$

$$\dot{\theta} = g(\theta, m); g_1 > 0, g_2 < 0 \quad (14a)$$

Differentiating Equation (11a) with respect to  $e$  and setting  $\dot{m} = 0$  we get:

<sup>20</sup> Here  $T$  denotes the time period at which a change in exogenous variable occurs and here  $t \geq T$ , denotes the time period after a change in exogenous variable takes place.

$$\phi_1 \frac{d\theta}{ds} + \phi_2 \frac{dm}{ds} + \phi_3 = 0 \quad (29)$$

Differentiating Equation (13a) with respect to s and setting  $\dot{\theta} = 0$  we get:

$$g_1 \frac{d\theta}{ds} + g_2 \frac{dm}{ds} = 0 \quad (30)$$

Arranging Equations (29) and (30) in matrix form we get:

$$\begin{bmatrix} \phi_2 & \phi_1 \\ g_2 & g_1 \end{bmatrix} \begin{bmatrix} \frac{dm}{ds} \\ \frac{d\theta}{ds} \end{bmatrix} = \begin{bmatrix} -\phi_3 \\ 0 \end{bmatrix} \quad (31)$$

Applying Cramer's rule we get:

$$\frac{d\theta}{ds} = \frac{g_2 \phi_3}{\Delta} > 0 \quad (32)$$

$$\frac{dm}{ds} = \frac{-g_1 \phi_3}{\Delta} > 0 \quad (33)$$

**Increase in government expenditure**

**Long run effects:** From Equations (12) and (14) we get:

$$\dot{m} = g(\theta, m, G); \phi_1 < 0, \phi_2 < 0, \phi_3 < 0 \quad (12b)$$

$$\dot{\theta} = g(\theta, m, G); g_1 > 0, g_2 < 0, g_4 < 0 \quad (14b)$$

Differentiating Equation (12b) with respect to G and setting  $\dot{m} = 0$  we get:

$$\phi_1 \frac{d\theta}{dG} + \phi_2 \frac{dm}{dG} + \phi_5 = 0 \quad (34)$$

Differentiating Equation (14b) with respect to G and setting  $\dot{\theta} = 0$  we get:

$$g_1 \frac{d\theta}{dG} + g_2 \frac{dm}{dG} + g_4 = 0 \quad (35)$$

Arranging Equations (25) and (26) in matrix form we get:

$$\begin{bmatrix} \phi_2 & \phi_1 \\ g_2 & g_1 \end{bmatrix} \begin{bmatrix} \frac{dm}{dG} \\ \frac{d\theta}{dG} \end{bmatrix} = \begin{bmatrix} -\phi_5 \\ -g_4 \end{bmatrix} \quad (36)$$

Applying Cramer's rule we get:

$$\frac{d\theta}{dG} = \alpha_1 = \frac{-g_4 \phi_2 + g_2 \phi_5}{\Delta} > 0 \text{ if } -\frac{g_4}{g_2} > \frac{\phi_5}{\phi_2} \quad (37)$$

<0 otherwise

$$\frac{dm}{dG} = \alpha_2 = \frac{-g_1 \phi_5 + g_4 \phi_1}{\Delta} < 0 \quad (38)$$

**Transitional details**

To obtain the initial jump in  $\theta$  after increase in G, we set  $t = 0$  and using  $A_1 = -A_2$  in Equation 20 we get:

$$\theta(0) = \bar{\theta}_1 + \left( \frac{\lambda_2 - \lambda_1}{\phi_1} \right) A_2 \quad (39)$$

Solving Equations (26) and (27) we get:

$$A_2 = \frac{\left( \alpha_1 - \alpha_2 \left( \frac{\lambda_1 - \phi_2}{\phi_1} \right) \right)}{\frac{\lambda_2 - \lambda_1}{\phi_1}} d\bar{G} \quad (40)$$

Substituting the value of  $A_2$  in Equation (34) we get:

$$\theta(0) = \bar{\theta}_1 + \left( \alpha_1 - \alpha_2 \left( \frac{\lambda_1 - \phi_2}{\phi_1} \right) \right) d\bar{G} \quad (41)$$

Equation (41) represents initial jump in  $\theta$ .

The value of overshooting or undershooting of  $\theta$  we subtracting Equation 41 from Equation 37 and this is given by  $\bar{\theta}(2) - \theta(0)$  [ $\bar{\theta}(2)$  is the final steady state value of  $\theta$ ]

$$= \alpha_1 dG - \left( \alpha_1 - \alpha_2 \left( \frac{\lambda_1 - \phi_2}{\phi_1} \right) \right) d\bar{G}$$

$$= \alpha_2 \left( \frac{\lambda_1 - \phi_2}{\phi_1} \right) d\bar{G}$$

Since  $\frac{\lambda_1 - \phi_2}{\phi_1} > 0$  from the slope saddle path, we get

clearly overshooting of  $\theta$  when real money supply decreases, that is,  $\alpha_2 < 0$ .

Similarly, the effects of an increase in agricultural output can be obtained.