

Macroeconomics of Commodity Price Fluctuations: A Structuralist Approach

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The paper analyses the different sources of commodity price fluctuation and their attendant macroeconomic implications for developing countries in terms of the over(under)shooting hypothesis under perfect foresight. We construct a two-sector, open economy macromodel to examine the effects of different shocks on commodity price, wage and employment under the flexible exchange rate regime.

JEL Classification: E63, F41, O13, F41

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1. Introduction

Since the late 1990s, commodity prices have followed an upward trend, with the prices of metals and crude oil showing the most pronounced increases. Although booms in commodity prices could be observed previously, the magnitude of the increase, its duration and its breadth are unparalleled compared with other upswings in the past 25 years. Notably, prices for all

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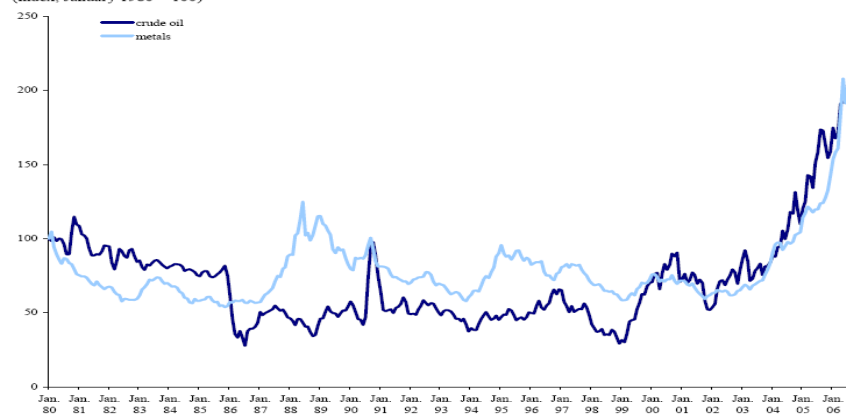
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commodities have risen simultaneously since 2002, a pattern which cannot be detected for such a prolonged period any time since 1980 (as shown in charts 1 and 2).

Of the individual commodity groups, crude oil prices have increased more than fivefold, while metal prices have more than tripled since early 1999. In both cases, this is the longest continuous rise since 1980. Although prices for agricultural raw materials, food and beverages have been following an upward trend since late 2001, it is relatively moderate compared with non-agricultural commodities. Nevertheless, the current rise is the most prolonged for food and beverages in the last two and a half decades, which have tremendous effects on farm income and the financial viability of farms. More importantly, such volatility in the commodity prices has often been correlated and attributed to agricultural trade liberalization. This is due to the fact that agricultural trade liberalization opens up the possibility of exporting a wide range of agricultural products by the developing countries provided the industrialized countries fall in line with WTO rules and regulations by removing their farm subsidies and providing market access. In fact, most of the developing countries have been attempting to promote agricultural export³. This can be represented by an autonomous increase in export demand for the primary commodities⁴.

Chart 1: Price developments of crude oil and metals, 1980-2006
(index, January 1980 = 100)

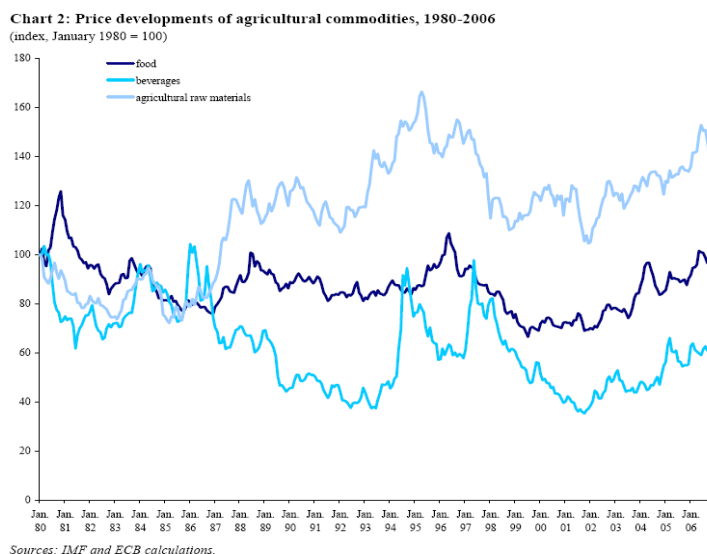


Sources: IMF and ECB calculations.

³ In the 1990s India's bulk exports conformed to traditional products. However due to some product diversification and spread of new markets, non traditional exports started growing. In 2004-05, agricultural exports of non traditional items like poultry, dairy products and fruits, vegetable seeds, registered high growth. In case of traditional agricultural commodities which are exported special mention may be made of cereals, cashew nuts, spices, rice and pulses. See Economic Survey, 1999 and 2005-06.

⁴ In a general equilibrium structure, agricultural trade liberalization can be represented by an increase in world price of agricultural commodities for a small open economy. See, for example, Marjit and Acharyya (2003).

These stylized facts have generated increasing interest in macroeconomic models of sectoral interlinkages in which commodity price fluctuations are put in the centre of all concerns. This concern is easily understandable since agricultural price fluctuations causes instability of farm incomes. These models have been seen as a way to formulate policy guidelines to reduce these fluctuations. A key element in many of these models is the overshooting of the prices of primary commodity caused by unanticipated monetary expansion. The point is obvious. If the stock of primary good is an asset and its price adjusts instantaneously while the industrial price adjusts slowly, the primary commodity price overshoots⁵ in response to monetary expansion. Seminal contributions of Frankel (1986) and Moutos and Vines (1992) to the analysis of commodity price fluctuations for a closed economy serve as a benchmark for further investigation. A similar line of research, both at the theoretical and empirical level, on agricultural price volatility in an open economy setup has been undertaken by Robertson et al. (1990), Lai, Hu and Wang (1996), Saghaian et al. (2002), Bakucs et al. (2005) and Asafa et al. (2007). These models give a clear account of commodity price fluctuations as an outcome of monetary shocks.



Once we get a story of commodity price fluctuation, however, there arise some immediate questions: Is this fluctuation solely attributable to monetary shock and what are the macroeconomic implications of fluctuations in terms of employment and output? How has trade

⁵ Overshooting of prices is defined as a temporary change in its value beyond its long run equilibrium.

contributed to fluctuation and can agricultural trade liberalization lead to a collapse of food security in developing countries? How does the nature of sectoral interlinkages change in an open economy set up? The paper seeks meaningful answers to these queries. Accordingly, attention is drawn to the distinct channels so as to identify relevant parameters in assessing the importance of different sources of agricultural price fluctuation and their attendant macroeconomic implications. Since the existing literature was primarily based on a closed economy framework, we build up an open economy macro model appropriate for a transitional economy. The importance of openness is primarily attributable to the current process of globalization and the WTO agreement regarding agricultural trade liberalization.⁶ The most striking result of the paper is related to the impact agricultural trade liberalization on commodity price fluctuations. Contrary to the popular belief that agricultural trade liberalization adds to the inflationary pressure on the prices of primary commodity, the present paper argues otherwise. In fact, agricultural trade liberalization has some short run adverse impact on the prices of primary commodity, but there are potential long run benefits that can be captured in terms of improvements in the real wage rate.

The paper utilizes a standard dual economy framework. The two sectors of the economy are agriculture and industry. The industrial sector is the non-traded sector, which uses labor and an imported intermediate input⁷. Moreover, in the short run, industrial prices are sticky. The agricultural sector operates under a supply constraint, which is expressed in terms of an exogenously given production of primary commodities. At a disaggregate level, the agricultural sector can be decomposed into a traditional sector catering to domestic demand and a modern, export oriented sector. The traditional agricultural sector acts as a supplier of wage goods while the modern sector generates foreign exchange earnings. In fact, agricultural exports are necessary to finance imports of intermediate goods for industry⁸. However, in the present paper we choose an aggregative structure for the agricultural sector. We simply assume that agricultural output is sold both in the domestic and the international market. Thus, the paper can be viewed as a study of sectoral interlinkages in an open economy setting where the agricultural sector plays a twin role (provider of wage goods and supplier of foreign exchange) that creates important economic

⁶ We model agricultural trade liberalization as an autonomous rise in the export of primary commodities. In the post WTO regime and given Agreement on Agriculture, the developing countries are now more focused on exporting the primary commodities in which they have a comparative advantage. See Safadi and Sam Laird (1996) for a survey of the various estimates of the likely increases in world trade due to the Uruguay Round and the effects of the round on developing countries.

⁷ Introduction of consumption goods imports will hardly make any difference to our results.

⁸ Gibson (1985) introduces a linkage between export agriculture and industrial production in a study of Nicaragua, based on the industrial dependency of intermediate imports. His approach has motivated the formulation of sectoral balances relevant for sub-Saharan Africa, separating between export oriented traded sector and protected sector dependent on imported intermediates. (See Jorn Rattsö 1994).

linkages in the production chain. An important contribution of the paper is to explore trade-induced input linkages between industry and agriculture.⁹

We assume that the Central Bank allows the exchange rate to float freely.¹⁰ However, we completely ignore capital account transactions¹¹. Any adjustment in the foreign exchange market occurs through changes in the nominal exchange rate. Hence, any current account imbalance causes instantaneous adjustment in the nominal exchange rate such that the current account balance is always maintained.

The technique used in the paper is the rational expectation saddle path behaviour which can account for volatility in asset prices. Dornbusch (1976) did the pioneering work in the context of volatility of the nominal exchange rate¹². The basic logic of overshooting is this. A set of variable is free to jump in response to the shocks while another set of variable is slow to adjust. In such a situation, the jump variables can overshoot or undershoot the final equilibrium value. A specific context classifies the nature of these variables. In Dornbusch type framework, the jump variable is the nominal exchange rate while the predetermined variable is either the output level or the price level. In the present paper, we extend Dornbusch's model with agricultural sector and allow for international trade in the primary commodities so as to explain the volatility in the primary commodities market. Thus, in the present context, the jump variable is the price of primary commodity while the predetermined variable is primarily the industrial wage and, by implication, the industrial price level.

The paper is organized as follows. Section 2 develops the basic model along with an instantaneous run (short run) analysis and steady state analysis. Section 3 offers a comparative statics analysis. Section 4 contains some concluding remarks.

⁹ Jorn Rattsö and Ragnar Torvik (2003) have carried out a similar macroeconomic analysis that is relevant for sub-Saharan Africa. A number of country studies emphasize the role of intermediate import dependency of the industrial sector. For example, see Green and Kadhani (1986), Ndulu (1986), and Davies and Rattsö (1993). In fact, it is a general characteristic of low income developing countries as shown by the analysis of Moran (1989).

¹⁰ Analysts agree that "getting the exchange rate right" is essential for economic stability and growth in developing countries. Over the past two decades, many developing countries have shifted away from fixed exchange rates and moved toward more flexible exchange rates. During a period of rapid economic growth, driven by the twin forces of globalization and liberalization of markets and trade, this shift seems to have served a number of countries well. (Francesco Caramazza, Jahangir Aziz, 1998).

¹¹ We admit that the absence of capital account transaction undermines several important transmission channels that are relevant for addressing balance of payment issues of developing countries. Nevertheless, the absence of capital account transactions is not all together an unjustifiable assumption. In fact, many developing countries have prohibited destabilizing capital inflows/outflows by imposing a variety of capital controls (See Agenor and Montiel, 1999).

¹² Frankel (1986) used Dornbusch's overshooting technique to explain the volatility of the price of primary commodity.

2. The Model

The model is specified by the following equations (1) to (6):

$$Y = \alpha c \left[\frac{P_f F}{P_Y} + Y \right] + \bar{I} - vr + G \quad (1)$$

$$\frac{M}{P_Y} = a \left[\frac{P_f F}{P_Y} + Y \right] - lr \quad (2)$$

$$r = k + \frac{\dot{P}_f}{P_f} \quad (3)$$

$$P_Y = wh + ea_m \quad (4)$$

$$P_f X \left(\frac{e}{P_f} \right) - ea_m Y = 0 \quad (5)$$

$$\dot{w} = \partial (Y - \bar{Y}), \quad \partial > 0 \quad (6)$$

Industrial output (Y) is determined by aggregate demand, which consists of domestic private consumption expenditure, investment expenditure and government expenditure, as represented by equation (1). Private consumption expenditure on industrial goods is a constant fraction ‘ α ’ of the total consumption expenditure with $\alpha \in [0,1]$. Total consumption expenditure is equal to

$c \left[\frac{P_f F}{P_Y} + Y \right]$, where $c \in [0,1]$ is the marginal propensity to consume, P_f is the price of the primary commodity, P_Y the price of the manufactured good and F denotes the (exogenous) level of primary commodity production¹³. Therefore, $\left[\frac{P_f F}{P_Y} + Y \right]$ represents the real income in terms

¹³ As pointed out by an anonymous referee, F can depend on the price of primary commodities. This would require farmers’ profit maximization exercise which in turn involves specification regarding the production function. Such

of the industrial goods. Note that a part of investment expenditure is autonomous (that is, \bar{I}) and the other part is sensitive to nominal interest rate (r)¹⁴. Government expenditure (G) is exogenous in the model.

Equation (2) represents the conventional money market equilibrium, where ‘M’ is the nominal money supply deflated by the industrial price to obtain the real money balances. Demand for real money balances is a function of real income and interest rate. Equation (3) states that primary commodities and bond are perfect substitutes and the returns from these two assets are always brought into equality through arbitrage, where ‘k’ reflects the difference between ‘convenience yield’ and storage costs of holding primary commodities.¹⁵

Equation (4) reflects the assumption that the industrial price is equal to average cost of production, where ‘ a_m ’ denotes the imported intermediate input per unit of industrial output, ‘ e ’ denotes the nominal exchange rate and ‘ h ’ denotes a labor coefficient, that is, labor per unit of industrial output.¹⁶

Equation (5) specifies the current account balance. The demand for foreign exchange originates from the industrial sector because of its dependence on imported intermediate inputs. On the other hand, the supply of foreign exchange comes from exports of agricultural products. Since the exchange rate is flexible, the current account balance is always maintained.

Finally, the money wage is a slow-moving variable. In the short run, the wage is sticky. Over time it adjusts in response to the difference between actual output and natural level of output (\bar{Y}) in the industrial sector, as suggested by equation (6). This type of wage adjustment is very similar to the Phillip’s curve relation between wage and unemployment.¹⁷

an alternative specification will moderate the magnitude of the overshooting without any qualitative change in the results.

¹⁴ One can consider investment to be a function of real interest rate defined as $\left(r - \frac{\dot{P}_y}{P_y} \right)$. But at the steady state,

$\dot{w} = 0$ (from wage adjustment equation). Moreover, $\dot{e} = 0$ (from the trade balance equation). Hence, $\dot{P}_y = 0$ (from the pricing equation of the industrial goods). Thus, the real interest rate is the same as the nominal interest rate.

¹⁵ For a detailed discussion of the arbitrage condition between primary commodities and bonds, see Frankel and Hardouvelis (1987), Gordon and Frankel (1987).

¹⁶ Under perfect competition price is equal to average cost. If we introduce market imperfection, price is determined by a typical Kaleckian markup formula, which is inconsequential in the context of our paper.

¹⁷ See Turnovsky, 1995. One can incorporate the price setting behaviour along with output deviations in equation for \dot{w} in the following manner: $\dot{w} = \psi(Y) + f\left(\frac{W}{P}\right)$; $\psi' > 0, f' < 0$ where $\left(\frac{W}{P}\right)$ represents the target real wage and P is the

A. Instantaneous Run Analysis¹⁸

In the instantaneous run, we take the money wage (w) and the price of primary commodities (P_f) as given. Equations (1) and (2) determine industrial output (Y) and rate of interest (r). Equation (5) gives the nominal exchange rate (e), while equation (4) solves for industrial price (P_y).

Taking total differentials of equations (1), (2), (4) and (5) we get:

$$\hat{Y} + \beta \hat{P}_y + \frac{mvr}{Y} \hat{r} = \beta \hat{P}_f + \beta \hat{F} + \frac{mG}{Y} \hat{G}, \text{ where } \beta = \frac{m\alpha cpF}{Y}, p = \frac{P_f}{P_y} \quad (7)$$

$$a\hat{Y} + (\xi - \eta) \hat{P}_y - \frac{lr}{Y} \hat{r} = -\eta \hat{P}_f - \eta \hat{F} + \xi \hat{M}, \text{ where } \xi = \frac{M}{Y.P_y}, \eta = \frac{apF}{Y} \quad (8)$$

$$\hat{P}_y - \theta_2 \hat{e} = \theta_1 \hat{w}, \text{ where } \theta_1 = \frac{wh}{wh + ea_m}, \theta_2 = \frac{ea_m}{wh + ea_m} \quad (9)$$

$$\hat{Y} - (\alpha - 1) \hat{e} = -(\alpha - 1) \hat{P}_f, \text{ where } \alpha = \delta X / \delta(e/P_f) \cdot (e/P_f) X^{-1} \quad (10)$$

where, α = elasticity of export demand and hat over a variable denotes its proportional change, e.g., $\hat{z} = \frac{dz}{z}$.

Arranging (7) - (10) in matrix form, we get

$$\begin{bmatrix} 1 & \beta & \frac{mvr}{Y} & 0 \\ a & (\xi - \eta) & -\frac{lr}{Y} & 0 \\ 0 & 1 & 0 & -\theta_2 \\ 1 & 0 & 0 & -(\alpha - 1) \end{bmatrix} \begin{bmatrix} \hat{Y} \\ \hat{P}_y \\ \hat{r} \\ \hat{e} \end{bmatrix} = \begin{bmatrix} \beta \hat{P}_f + \beta \hat{F} + \frac{mG}{Y} \hat{G} \\ -\eta \hat{P}_f - \eta \hat{F} + \xi \hat{M} \\ \theta_1 \hat{w} \\ -(\alpha - 1) \hat{P}_f \end{bmatrix}$$

general price level. Such a specification would allow for unemployment to persist even in the long run. However, the results of the model will remain unchanged.

¹⁸ Instantaneous run analysis is same as short run analysis for a given value of 'w' and 'P_f'.

We consider the following determinant:

$$|D| = -\frac{r}{Y} [(\alpha - 1)(l - mva) + \theta_2 \{ \beta l + mv(\xi - \eta) \}] < 0$$

Now we examine the short run effects of a change in the price of primary commodity, money wage, export of the primary commodity and money supply on the Y , r , P_Y and e , that would prepare us for the steady state analysis.

A.1 Change in the price of the primary commodity: An increase in the primary commodity price causes real income to go up. Demand for money goes up and interest rate rises to clear money market. Effects on industrial output are ambiguous, since rise in primary commodity price causes consumption to rise but investment to fall. The similar ambiguity exists in the effects on the industrial price and the nominal exchange rate.

A.2 Change in money wage: A rise in money wages causes industrial price to increase. This in turn reduces real income in terms of manufactured goods. Consequently, industrial output decreases. On the other side, a rise in industrial price reduces real money supply and thereby leading to an increase in the rate of interest. Again, a fall in industrial production relaxes the pressure on imported intermediate inputs resulting in trade surplus and thereby appreciation of nominal exchange rate.

A.3 Change in the export of the primary commodity: We introduce an exogenous component of primary commodity export, denoted by 'T', in the current balance equation (that is equation (5)). Thus equation (5) can be rewritten as:

$$P_f \left[T + X \left(\frac{e}{P_f} \right) \right] - e a_m Y = 0 \quad (11)$$

A rise in the autonomous export of the primary commodity would lead to an incipient trade surplus and hence the nominal exchange rate appreciates. Now, greater availability of foreign exchange permits greater usage of intermediate inputs in the industrial sector. This would result in a rise in the industrial output level. It follows from the industrial pricing equation, that is equation (4), that the industrial price falls. However, the effect on the interest rate is ambiguous. It is due to the fact that on one hand, with a rise in 'Y' and a fall in 'P_y' the demand for real money balances goes up and on the other hand, real money supply also increases with a fall in 'P_y'.

A.4 Change in Money Supply: An increase in money supply causes the interest rate to fall which leads to rise in investment and industrial output. A rise in industrial production requires additional imported intermediate inputs and hence, a trade deficit ensues. Consequently, there is a depreciation of the nominal exchange rate that results in a rise of the industrial price.

B. Steady State

This section deals with how commodity prices and money wages respond as the economy experiences unanticipated shocks when money wages adjust sluggishly. Corresponding to this situation, equations (1) to (6) can be reduced to the following pair of differential equations in ‘w’ and ‘P_f’:

$$\begin{bmatrix} \dot{w} \\ \dot{P}_f \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \bar{w} - w \\ \bar{P}_f - P_f \end{bmatrix} + \begin{bmatrix} x_1 & x_2 & x_3 \\ z_1 & z_2 & z_3 \end{bmatrix} \begin{bmatrix} dG \\ dM \\ dF \end{bmatrix}$$

where, $a_{11} = \frac{d\dot{w}}{dw} = \partial \frac{dY}{dw} < 0$ ¹⁹

$$a_{12} = \frac{d\dot{w}}{dP_f} = \partial \frac{dY}{dP_f} > 0$$

$$a_{21} = \frac{d\dot{P}_f}{dw} = \frac{dr}{dw} > 0$$

$$a_{22} = \frac{d\dot{P}_f}{dP_f} = \frac{dr}{dP_f} > 0$$

$$x_1 = \frac{d\dot{w}}{dG} = \partial \frac{dY}{dG} > 0$$

$$z_1 = \frac{d\dot{P}_f}{dG} = \frac{dr}{dG} > 0$$

$$x_2 = \frac{d\dot{w}}{dM} = \partial \frac{dY}{dM} > 0$$

¹⁹ The sign restrictions are obtained from the short run analysis by applying Cramer’s rule.

$$z_2 = \frac{d\dot{P}_f}{dM} = \frac{dr}{dM} < 0$$

$$x_3 = \frac{d\dot{w}}{dF} = \partial \frac{dY}{dF} ?$$

$$z_3 = \frac{d\dot{P}_f}{dF} = \frac{dr}{dF} > 0$$

Given the values of a_{11}, a_{12}, a_{21} and a_{22} the determinant of the system is negative; that is, $\Delta = a_{11}a_{22} - a_{12}a_{21} < 0$. Thus, the two characteristic roots of the system are of opposite signs and therefore the system possesses a stable saddle path. Since the price of primary commodities is the jump variable, it adjusts instantaneously so as to place the economy on the stable saddle path.

The equation of the saddle path is given by²⁰:

$$(P_f - P_{f_2}) = \left(\frac{\lambda_1 - a_{11}}{a_{12}} \right) (w - w_2)$$

Or equivalently as,

$$(P_f - P_{f_2}) = \left(\frac{a_{21}}{\lambda_1 - a_{22}} \right) (w - w_2)$$

We note that the slope of the saddle path (SS) is given by:

$$\left. \frac{dP_f}{dw} \right|_{SS} = \left(\frac{a_{21}}{\lambda_1 - a_{22}} \right) = \left(\frac{\lambda_1 - a_{11}}{a_{12}} \right) < 0$$

For graphical presentation of the saddle point equilibrium, we consider the $\dot{w} = 0$ and the $\dot{P}_f = 0$ loci. The $\dot{w} = 0$ locus denotes the combination of the wage rate and price of primary commodity that will maintain output at its natural level. The slope of $\dot{w} = 0$ line is:

²⁰ See appendix for the derivation of the saddle path equation.

$$\left. \frac{dP_f}{dw} \right|_{\dot{w}=0} = \frac{-a_{11}}{a_{12}} > 0$$

Intuitively, the slope of $\dot{w}=0$ locus can be explained as follows: suppose that ' P_f ' increases leading to a rise in ' Y ', and therefore ' Y ' become greater than ' \bar{Y} '. Consequently ' w ' must increase such that ' Y ' tends to ' \bar{Y} '. Therefore the $\dot{w}=0$ locus is positively sloped.

Likewise, the $\dot{P}_f=0$ locus denotes the combinations of wage rate and commodity prices consistent with no change in the price of the primary commodity, that is, $r = k$. The slope of $\dot{P}_f=0$ is:

$$\left. \frac{dP_f}{dw} \right|_{\dot{P}_f=0} = \frac{-a_{21}}{a_{22}} < 0$$

Intuitively the negative slope of $\dot{P}_f=0$ locus can be explained as follows: suppose that there is a rise in ' w ' leading to a decrease in M/P_Y . Consequently there is a rise in ' r ' resulting in $\dot{P}_f > 0$. Hence, to maintain $\dot{P}_f=0$, ' P_f ' must fall.

The saddle point equilibrium is shown in the following diagram. The saddle path is negatively sloped and flatter than $\dot{P}_f=0$ curve.²¹

3. Comparative Static Analysis

The present paper deals with the effects of unanticipated shocks²², namely a rise in government expenditure, increase in money supply, an increase in production of primary commodities (that is, a favourable supply shock) and an autonomous increase in primary commodity export arising out of agricultural trade liberalization. In what follows we shall explore the adjustment details and steady state effects of such unanticipated shocks in terms of the over(under)-shooting

²¹ Note that $\left. \frac{dP_f}{dw} \right|_{SS} = \left[\left(\frac{a_{21}}{\lambda_1 - a_{22}} \right) \right] < \left. \frac{dP_f}{dw} \right|_{\dot{P}_f=0} = \left| \frac{a_{21}}{a_{22}} \right|$

²² One can easily analyze effects of anticipated shocks in this type of rational expectation framework.

hypothesis. To save space, we only illustrate the impact of an autonomous increase in export of primary commodities and a monetary shock²³.

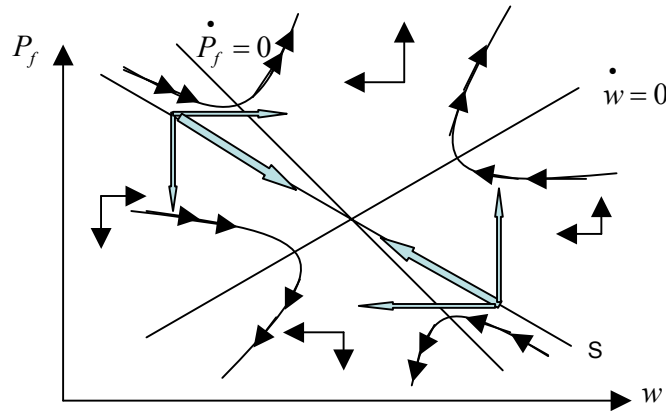


Figure 1: Phase diagram showing saddle path stability

1) Agricultural Trade Liberalization: Critics of agricultural trade liberalization argue that this would have serious inflationary consequences and will affect food security in developing country. The paper shows that this criticism is not really justified.

We represent agricultural trade liberalization as a sudden spurt in the export of primary commodities. A rise in autonomous exports leads to a fall in nominal exchange rate, thereby causing industrial price to fall. As a result, real money supply in terms of industrial output increases which in turn leads to a fall in interest rate. Consequently, $\dot{P}_f < 0$ and thus P_f has to rise (this accounts for the short run inflationary effect on commodity price). On the other hand, AD increases leading to a rise in Y in the short run. Hence, $\dot{w} > 0$ and thus w increases. The ultimate effect is that ‘ Y ’ and ‘ r ’ remains unchanged. Thus, from the money market P_y remains unchanged while P_f remains unaltered from the industrial goods market equilibrium. Thus, over

²³ Interested readers can easily work out the effects of positive supply shock (that is, an increase in the production of primary commodity) and the effects of expansionary fiscal policy. The long run expansionary effect of rise in government expenditure is less compared to its short run effect due to crowding out through fall in the primary commodity price. Identical conclusion holds for rise in the production of primary commodity. In both the cases, we have undershooting of the commodity price and the transmission channels of the effects are identical.

time as money wage starts responding and output settles down at the natural level, both P_y and P_f remain unchanged.

Hence, the clear policy message is that agricultural trade liberalization has some adverse short run effects in terms of an inflationary pressure on commodity price. But such adverse effects completely disappear once the economy sees through its transitional phase. In the long run, agricultural commodity price comes back to its original value. Now, with an increase in money wage in the long run, this clearly suggests a favourable movement in real wage rate. This is, in fact, the beneficial effect of agricultural trade liberalization.

Figure 2 represents the overshooting of commodity price (that is, the short run fluctuations in commodity price) along with the long run beneficial outcome of real wage improvement.²⁴

2) Increase in Money supply: In the short run a rise in money supply leads to output expansion. Consequently interest rate decreases to maintain the money market equilibrium. This in turn leads to $P_f < 0$ and hence, the $P_f = 0$ line shifts in the upward direction. Output expansion leads to higher wage rate such that $w > 0$. Hence, $w = 0$ line shifts downward, as depicted in figure 3. The initial equilibrium is at point 'E₀' and final equilibrium is at point 'E₁'. Both the nominal wage rate and the commodity price increases and we encounter overshooting of commodity price.

In terms of the above figure, the initial jump in the primary commodity price (that is, movement from E₀ to E') can be captured by the following expression:

$$\Rightarrow P_f(0) - P_{f_1} = \left(\Phi \left\{ 1 - \left(\frac{\lambda_1 - a_{22}}{a_{21}} \right) \right\} \right) dM^{-\lambda_2 T} \quad (12)$$

This, in fact, is the magnitude of price fluctuations measured in terms of overshooting of commodity prices resulting from a monetary expansion. The final change in the commodity price and wage rate (that is, from point E' to E₁) after the implementation of expansionary monetary policy is given by:

²⁴ The magnitude of initial jump in commodity price along the final change in commodity price and money wage can be easily worked out following the same methodology used in the appendix for the case of monetary expansion.

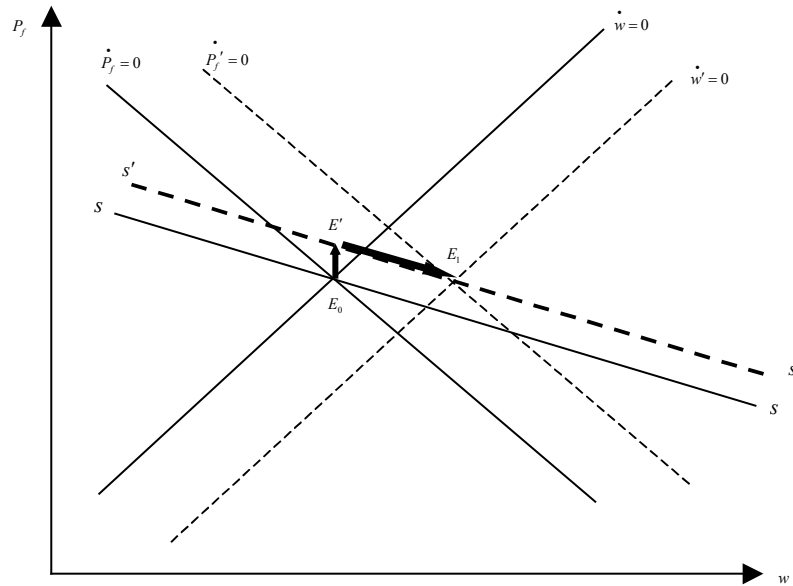


Figure 2: Overshooting of

$$P_{f_2} - P_f(0) = \chi - \left(\frac{\lambda_1 - a_{22}}{a_{21}} \right) A'_1 e^{\lambda_1 t} \quad (13)$$

$$w_2 - w(0) = (w(T) - w_1) - A'_1 e^{\lambda_1 t} \quad (14)$$

In the long run the effect of an increase in money supply disappears completely. A rise in money supply leads to equiproportionate increase in the price of primary commodity, the nominal exchange rate and the industrial price level. The explanation is this. In the long run, the interest rate is fixed at 'k' and the output level is fixed at its natural level, that is, at \bar{Y} . It follows from the industrial balance equation that the ratio $\frac{P_f}{P_Y}$ does not change. Hence, money market equilibrium suggests an equiproportionate rise in the industrial price which in turn implies an equiproportionate increase in the price of the primary commodity. Since the output level does not change in the long run, the physical volume of intermediate import remains unchanged and hence, real exchange rate retains its initial steady state value. Thus, the nominal exchange rate depreciates equiproportionately. It follows from the industrial pricing equation, that is, equation (4), that the nominal exchange rate increases in the same proportion. Thus, we have the long run neutrality of money. This is shown in figure (3). Specifically, we note that the shifts of both

$\dot{w} = 0$ and $\dot{P}_f = 0$ loci must reflect the long run equiproportionate increase in the nominal wage rate and primary commodity price.

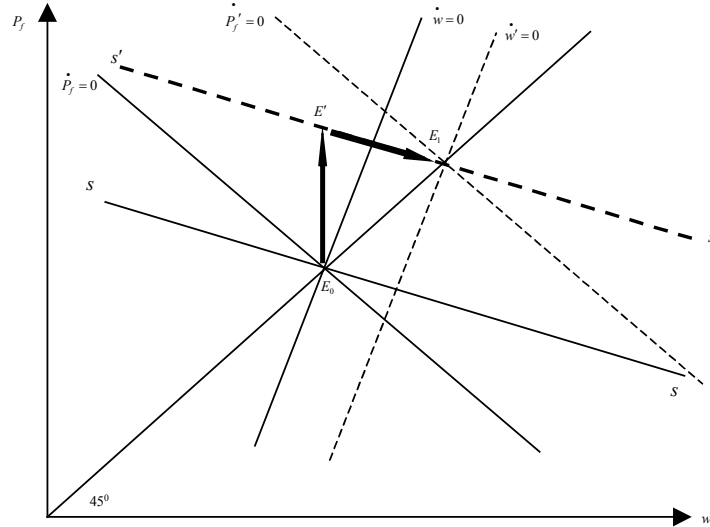


Figure 3: Overshooting of

The effects are given by the following equation²⁵:

$$\frac{\hat{w}}{\hat{M}} = \frac{\hat{P}_f}{\hat{M}} = \frac{\hat{P}_Y}{\hat{M}} = 1 \tag{15}$$

Thus, the standard long run money neutrality is valid; that is, in the long run, the industrial and the commodity price increases equiproportionately with monetary expansion²⁶. Even though money is neutral in the long run, the commodity price overshooting has tremendous effect on short run farm income and financial viability of farms. Thus, it is recommended that agricultural policy makers and monetary authorities work closely in designing and implementing policy because monetary policies meant to stabilize the economy have less desirable impacts on farmers, especially in the short run.

²⁵ See appendix.

²⁶ This is consistent not only with the theoretical conclusion by Frankel (1986), but also with the empirical evidence found by Taylor and Spriggs and Robertson and Orden.

4. Conclusion

The paper emphasizes the twin role of agricultural sector in an emerging market economy. The traditional role of the agricultural sector as a provider of wage goods is extensively studied in the existing literature. In addition to this, we consider agriculture sector to be a supplier of foreign exchange for the industrial sector. Given this specific nature of sectoral interlinkage, this paper is an attempt to identify the possible sources of commodity price fluctuations in an open economy set up.

The different comparative static exercises attempted in this paper indicate that short run and long run effects of different policy prescriptions are significantly different. The short run expansionary effect of rise in money supply does not persist in the long run through an equiproportionate rise in the price of primary commodity, the nominal exchange rate and the industrial price level. The striking result of the paper arises in the context of agricultural trade liberalization. The paper clearly shows that short run inflationary outcome is purely a temporary phenomenon. The short run adverse effect on commodity price completely disappears once the economy sees off its transitional phase. In fact, in the long run, commodity price come back to its initial level signifying an improvement in the real wage rate. Hence, the clear policy message is that the short run effect is not a reliable guide to the design of macroeconomic policy.

Appendix

Derivation of Saddle path

The initial steady-state equilibrium solutions for w , P_f , denoted by w_1 , P_{f_1} , say are obtained by solving

$$\begin{bmatrix} \dot{w} \\ \dot{P}_f \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \bar{w} - w_1 \\ \bar{P}_f - P_{f_1} \end{bmatrix} \quad (\text{A.1})$$

Now suppose that at time 0 it is announced that a parameter (For example, G , or F or M or growth in export of primary commodity, denoted as T) are to increase, at time $T \geq 0$. The new steady states after the shifts have occurred are specified by

$$\begin{bmatrix} \dot{w} \\ \dot{P}_f \end{bmatrix} = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} \bar{w} - w_2 \\ \bar{P}_f - P_{f_2} \end{bmatrix} \quad (\text{A.2})$$

As long as the shifts are additive, so that the coefficients a_{ij} remain unchanged between the two regimes, the eigen values λ_1, λ_2 say of (A.1) and (A.2) are identical. For simplicity and without loss of generality, we shall assume that they are real²⁷. The fact that the dynamics are described by a saddle point means that the product

$$\lambda_1 \lambda_2 = a_{11} a_{22} - a_{12} a_{21} < 0$$

We shall assume $\lambda_1 < 0, \lambda_2 > 0$. In order to ensure stability, one of variables say P_f , must be a jump variable, while the other w , is assumed to evolve continuously at all times.

Over the period $0 < t \leq T$, before the shifts have occurred, the solutions for w, P_f are of the form

$$w = w_1 + A_1 e^{\lambda_1 t} + A_2 e^{\lambda_2 t} \quad (A.3)$$

$$P_f = P_{f_1} + \left(\frac{\lambda_1 - a_{11}}{a_{12}} \right) A_1 e^{\lambda_1 t} + \left(\frac{\lambda_2 - a_{11}}{a_{12}} \right) A_2 e^{\lambda_2 t} \quad (A.4)$$

Note that because λ_i are eigen values

$$\frac{\lambda_i - a_{11}}{a_{12}} = \frac{a_{21}}{\lambda_i - a_{22}}, \quad i = 1, 2$$

in which case (A.4) can be rewritten equivalently as

$$P_f = P_{f_1} + \left(\frac{a_{21}}{\lambda_1 - a_{22}} \right) A_1 e^{\lambda_1 t} + \left(\frac{a_{21}}{\lambda_2 - a_{22}} \right) A_2 e^{\lambda_2 t}$$

Likewise, for the period $t \geq T$, after the shifts have occurred, the solutions for w, P_f are

$$w = w_2 + A'_1 e^{\lambda_1 t} + A'_2 e^{\lambda_2 t} \quad (A.5)$$

²⁷ The coefficients a_{ij} involve the impacts of the steady state variables (that is, w and P_f) on Y and r . Transition from one steady state to another leaves the coefficients unchanged. Hence, the eigen values are real and repeated.

$$P_f = P_{f_2} + \left(\frac{\lambda_1 - a_{11}}{a_{12}} \right) A_1' e^{\lambda_1 t} + \left(\frac{\lambda_2 - a_{11}}{a_{12}} \right) A_2' e^{\lambda_2 t} \quad (\text{A.6})$$

Now convergence requires that as $t \rightarrow \infty$, $A_2' = 0$, so that

$$w = w_2 + A_1' e^{\lambda_1 t} \quad (\text{A.7})$$

$$P_f = P_{f_2} + \left(\frac{\lambda_1 - a_{11}}{a_{12}} \right) A_1' e^{\lambda_1 t} \quad (\text{A.8})$$

The remaining constants A_1, A_2, A_1' are obtained by solving the equations.

$$A_1 + A_2 = 0 \quad (\text{A.9})$$

$$(A_1 - A_1') e^{\lambda_1 T} + A_2 e^{\lambda_2 T} = dw \quad (\text{A.10})$$

$$\left(\frac{\lambda_1 - a_{11}}{a_{12}} \right) (A_1 - A_1') e^{\lambda_1 T} + \left(\frac{\lambda_2 - a_{11}}{a_{12}} \right) A_2 e^{\lambda_2 T} = dP_f \quad (\text{A.11})$$

where dw and dP_f are shifts of steady state in w and P_f respectively.

Now the stable saddle paths after time T are described by equation (A.5) and (A.6). Eliminating $A_1' e^{\lambda_1 t}$ from these equations we get,

$$(P_f - P_{f_2}) = \left(\frac{\lambda_1 - a_{11}}{a_{12}} \right) (w - w_2) \quad (\text{A.12})$$

Or equivalently as,

$$(P_f - P_{f_2}) = \left(\frac{a_{21}}{\lambda_1 - a_{22}} \right) (w - w_2) \quad (\text{A.13})$$

Equation (A.12) or (A.13) describes the equation of saddle path.

Long run analysis

In the long run $Y=\bar{Y}$ and $r=k$. Hence the basic equation in the long run becomes:

$$\bar{Y}=m[\alpha cpF+\bar{I}-vk+G], \text{ where } m=\frac{1}{1-\alpha c} \text{ and } p=\frac{P_f}{P_Y} \quad (\text{A.14})$$

$$\frac{M}{P_Y}=a[pF+\bar{Y}]-lk \quad (\text{A.15})$$

$$P_Y=wh+ea_m \quad (\text{A.16})$$

$$P_f X \left(\frac{e}{P_f} \right) = ea_m \bar{Y} \quad (\text{A.17})$$

Differentiating equations (A.14) to (A.17), we get,

$$m\alpha cpF\hat{P}_f - m\alpha cpF\hat{P}_Y = dG - m\alpha cpF\hat{F} \quad (\text{A.18})$$

$$apF\hat{P}_f + \left(\frac{M}{P_Y} - apF \right) \hat{P}_Y = \frac{dM}{P_Y} - apF\hat{F} \quad (\text{A.19})$$

$$\hat{P}_Y = \theta_1 \hat{w} + \theta_2 \hat{e} \quad (\text{A.20})$$

$$\hat{P}_f = \hat{e} \quad (\text{A.21})$$

where $\theta_1 = \frac{wh}{wh+ea_m}$ and $\theta_2 = \frac{ea_m}{wh+ea_m}$; $\theta_1 + \theta_2 = 1$.

Combining equations (A.20) and (A.21) and then substituting it in equations (A.18) and (A.19), we get

$$m\alpha cpF\theta_1 \hat{w} - m\alpha cpF\theta_1 \hat{P}_f = dG - m\alpha cpF\hat{F} \quad (\text{A.22})$$

$$\left(\frac{M}{P_Y} - apF\right)\theta_1\hat{w} + \left(apF\theta_1 + \frac{M}{P_Y}\theta_2\right)\hat{P}_f = \frac{dM}{P_Y} - apF\hat{F} \quad (\text{A.23})$$

Arranging (A.22) and (A.23) in matrix form we get,

$$\begin{bmatrix} m\alpha cpF\theta_1 & -m\alpha cpF\theta_1 \\ \left(\frac{M}{P_Y} - apF\right)\theta_1 & \left(apF\theta_1 + \frac{M}{P_Y}\theta_2\right) \end{bmatrix} \begin{bmatrix} \hat{w} \\ \hat{P}_f \end{bmatrix} = \begin{bmatrix} dG - m\alpha cpF\hat{F} \\ \frac{dM}{P_Y} - apF\hat{F} \end{bmatrix} \quad (\text{A.24})$$

The sign of the above determinant is:

$$\Omega = m\alpha cpF\theta_1 \left(\frac{M}{P_Y}\right) > 0$$

Increase in Money Supply

Setting $dG = \hat{F} = 0$ in expression (A.24) we get,

$$\begin{aligned} \frac{\hat{w}}{dM} &= \frac{m\alpha cpF\theta_1}{P_Y \cdot \Omega} = \frac{1}{M} \\ \Rightarrow \frac{\hat{w}}{\hat{M}} &= 1 \\ \Rightarrow dw &= \Phi dM \end{aligned} \quad (\text{A.25})$$

where $\Phi = \frac{w}{M} > 0$

$$\text{and } \frac{\hat{P}_f}{\hat{M}} = 1 \Rightarrow dP_f = \Phi dM \quad (\text{A.26})$$

Therefore, $\frac{\hat{w}}{\hat{M}} = \frac{\hat{P}_f}{\hat{M}} = \frac{\hat{P}_Y}{\hat{M}} = 1$.

Transitional Details:

To obtain the initial jump in P_f after increase in M , we set $t = 0$ & using $A_1 = -A_2$ in equation (A.4) we get,

$$P_f(0) = P_{f_1} + \left(\frac{\lambda_2 - \lambda_1}{a_{21}} \right) A_2 \tag{A.27}$$

Solving equation (A.7) and (A.8) and using expression (A.25) and (A.26), we get

$$A_2 = \frac{\left(\Phi - \Phi \left(\frac{\lambda_1 - a_{22}}{a_{21}} \right) \right)}{\frac{\lambda_2 - \lambda_1}{a_{21}}} dM e^{-\lambda_2 T} \tag{A.28}$$

Substituting the value of A_2 in equation (A.27) we get,

$$P_f(0) = P_{f_1} + \left(\Phi - \Phi \left(\frac{\lambda_1 - a_{22}}{a_{21}} \right) \right) dM^{-\lambda_2 T}$$

Therefore, the initial jump in the commodity price (from point E_0 to E' as shown in figure 3) is:

$$\Rightarrow P_f(0) - P_{f_1} = \left(\Phi \left\{ 1 - \left(\frac{\lambda_1 - a_{22}}{a_{21}} \right) \right\} \right) dM^{-\lambda_2 T}$$

Again at time T , we get from equation (A.7)

$$\begin{aligned} w(T) &= w_2 + A'_1 e^{\lambda_1 t} \\ \Rightarrow w(T) - w_2 &= A'_1 e^{\lambda_1 t} \end{aligned}$$

Now we know that 'w' remains unchanged in the short run, that is, $w(0) = w_1$. Thus we get,

$$\begin{aligned}
 w_2 - w(0) &= w_2 - w_1 \\
 &= w(T) - A'_1 e^{\lambda_1 t} - w_1 \\
 &= (w(T) - w_1) - A'_1 e^{\lambda_1 t}
 \end{aligned} \tag{A.29}$$

From equation (A.25) it is seen that w increases in the long run if $A'_1 < 0$ (assuming $(w(T) - w_1) > 0$).

Now, substituting value of $A_1 = -A_2$ in equation (A.7) we get the value of A'_1 as

$$A'_1 = \left[\left(\frac{\left\{ 1 - \left(\frac{\lambda_1 - a_{22}}{a_{21}} \right) \right\}}{\frac{\lambda_2 - \lambda_1}{a_{21}}} \right) (e^{\lambda_2 T} - e^{\lambda_1 T}) (e^{-\lambda_2 T}) - 1 \right] \Phi e^{-\lambda_1 T} dM \tag{A.30}$$

$$= (\Delta - 1) \Phi e^{-\lambda_1 T} dM \tag{A.31}$$

$$\text{where } \Delta = \left(\frac{\left\{ 1 - \left(\frac{\lambda_1 - a_{22}}{a_{21}} \right) \right\}}{\frac{\lambda_2 - \lambda_1}{a_{21}}} \right) (e^{\lambda_2 T} - e^{\lambda_1 T}) (e^{-\lambda_2 T})$$

Again in period T, we get from equation (A.5.2)

$$\begin{aligned}
 P_f(T) - P_{f_2} &= \left(\frac{\lambda_1 - a_{22}}{a_{21}} \right) A'_1 e^{\lambda_1 t} \\
 \Rightarrow P_{f_2} &= P_f(T) - \left(\frac{\lambda_1 - a_{22}}{a_{21}} \right) A'_1 e^{\lambda_1 t}
 \end{aligned} \tag{A.32}$$

Now subtracting equation (A.27) from equation (A.32), we get,

$$P_{f_2} - P_f(0) = P_f(T) - \left(\frac{\lambda_1 - a_{22}}{a_{21}} \right) A'_1 e^{\lambda_1 t} - P_{f_1} - \left(\frac{\lambda_2 - \lambda_1}{a_{21}} \right) A_2$$

$$P_{f_2} - P_f(0) = P_f(T) - P_{f_1} - \left(\frac{\lambda_2 - \lambda_1}{a_{21}} \right) A_2 - \left(\frac{\lambda_1 - a_{22}}{a_{21}} \right) A_1' e^{\lambda_1 t}$$

$$P_{f_2} - P_f(0) = \chi - \left(\frac{\lambda_1 - a_{22}}{a_{21}} \right) A_1' e^{\lambda_1 t} \quad (\text{A.33})$$

where $\chi = P_f(T) - P_{f_1} - \left(\frac{\lambda_2 - \lambda_1}{a_{21}} \right) A_2$

Equation (A.33) determines the overshooting of P_f . This overshooting is an indicator of the commodity price volatility. We note that equation (A.33) is negative as $A_1' < 0$. This in turn implies that the initial jump of P_f is more than the long run increase in P_f . Thus, P_f overshoots corresponding to an increase in 'M'. Equations (A.33) and (A.29) determine the final change in the commodity price and wage rate (that is, the movement from point E' to E_1 as in figure (3)) respectively.

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