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# Exchange rate alignment and producer support estimates (PSEs) for India

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**Abstract**

This article examines the effects of exchange rate alignment during 1985–2002 on agricultural producer support estimates (PSEs) for India. Based on several time series techniques, the equilibrium exchange rate of the Indian rupee and the corresponding misalignment of the actual rate are estimated and applied to recent PSE calculations. Our results show that the exchange rate was substantially misaligned before a financial crisis and macroeconomic reform in the early 1990s, with subsequent indirect effects on the PSEs. We find a relatively high pass-through of exchange rate movements to domestic agricultural prices, so that removal of the exchange rate misalignment would have improved incentives to Indian farmers during this period. More recently, this indirect exchange rate effect is smaller than the direct effect in the PSEs, indicating the dominance of sectoral-specific policies over economy-wide policies.

*JEL classification:* F31, Q18

*Keywords:* Exchange rate; Cointegration; Pass-through; Producer Support Estimate (PSE)

## 1. Introduction

Agricultural policies in developing countries play a very important role in determining domestic commodity prices and the returns to agriculture. The nature and degree of the policy interventions differ across countries thereby producing different types of impact on producers and consumers. Various agricultural policy indicators (APIs) such as the producer support estimate (PSE) have been constructed to evaluate and monitor these policy changes (Josling and Valdes, 2004). A problem with conventional analyses based on the APIs, however, is that they usually have a sector-specific focus that can miss the important linkages between economy-wide policies and the agricultural sector. By changing the relative prices of importables, exportables, and home goods, some economy-wide policies, such as policies affecting exchange rates, can have impacts on agricultural incentives that might overwhelm those from sectoral policies. The different effects of sectoral and economy-wide policies on agriculture in the developing countries were documented in the study by Krueger et al. (1991).

The relevance of the exchange rate in calculation of PSEs has been pointed out by a number of authors including Harley (1996), Liefert et al. (1996), and Melyukhina (2002). This issue is particularly important for developing countries and economies in transition, since capital surges, macroeconomic instability, and subsequent financial crises, together with delayed or insufficient adjustments in exchange rates, have generated substantial exchange rate misalignments in some cases. Pronounced misalignments of the exchange rate potentially subsidize or tax the agricultural sector and can result in misleading estimates of the level and sometimes the direction of agricultural support as measured by the PSE.

While there is general agreement that use of misaligned exchange rates introduces a bias in PSE calculations, and that this bias can be substantial in some cases, there is much less agreement on the appropriate alternative. Previous studies (e.g., Liefert et al., 1996, for Russia) have used certain "adjusted" exchange rates such as the purchasing power parity (PPP) exchange rate as the "equilibrium" and indicated that exchange rate misalignment had significant impacts on the calculation of the PSEs. Despite plausible results, calculations based on PPP involve a degree of discretion and the results are sensitive to the selection of a base year. Other models of the equilibrium exchange rate are potentially preferred to the PPP approach in PSE estimation (Harley, 1996).

Recently an equilibrium approach that relates the real exchange rate to underlying economic fundamentals has gained

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prominence among both practitioners and policy makers to address issues of exchange rate misalignment and to test for over- or under-valued currencies. We apply this approach and analyze misalignment effects on the PSEs of India, a country where agricultural support or disprotection levels are important but exchange rate effects have received little attention. We find a long-run cointegrating relationship between the exchange rate and basic economic fundamentals over the period 1950–2002, as suggested by real exchange rate equilibrium theory. This empirical model suggests the Indian rupee was continuously misaligned in the late 1980s–early 1990s, which contributed to a financial crisis and subsequent macroeconomic reforms during 1991–1993. We also find a relatively high coefficient of pass-through from exchange rate movements to domestic agricultural prices, although less so for basic food grains such as wheat and rice than for other commodities. Applying these results to recently completed PSE estimates by Mullen et al. (2005) for 1985–2002, we find that the misalignment had a substantial effect during the prereform period. Removal of the exchange rate misalignment would have improved incentives to Indian farmers during this era. More recently, the indirect exchange rate effect has been smaller than the direct sectoral effects measured in the PSEs, indicating the dominance of sectoral-specific policies over economy-wide policies.

The article is organized as follows. Section 2 empirically estimates exchange rate equilibrium and misalignment in India. Section 3 discusses the effect of exchange rate misalignment on PSEs, evaluates exchange rate pass-through, and provides estimates of the exchange rate effects on PSEs in India for the period 1985–2002. Summary and conclusions are provided in Section 4.

## 2. Exchange rate equilibrium and misalignment in India

To address the effects of exchange rate misalignments on agriculture support levels measured by the PSE, the first task is to establish the exchange rate equilibrium. The fundamental difficulty is that the equilibrium value of the exchange rate is not observable. Assessment is further complicated because there exist a variety of models of equilibrium exchange rate determination. Common approaches range from the simple PPP to more sophisticated models such as the Fundamental Equilibrium Exchange Rate (FEER) (Williamson, 1994), the Natural Real Exchange Rate (NATREX) (Stein, 1994), the Behavioral Equilibrium Exchange Rate (BEER) (Clark and MacDonald, 1999) and the Real Equilibrium Exchange Rate (REER) (Edwards, 1989; Hinkle and Montiel, 1999).

The equilibrium exchange rate for the Indian rupee has been modeled using several approaches. Kholi (2003) calculates the equilibrium (nominal) exchange rate of the Indian rupee for postfloating years using PPP with a base rate set at the 1993 level. Results from this study show that the nominal exchange rate moved closely with the PPP rate during the sample period with slight overvaluation. Patnaik and Pauly (2001) use a variant of the BEER approach to derive the equilibrium exchange rate in India. Their results suggest that in the 1990s the equilibrium value of the rupee was essentially determined by the output market. However, due to slow adjustments in this market, the exchange rate was not always in equilibrium. There were periods when the rupee was overvalued or undervalued compared to the long-run rate, but there was a clear tendency to revert to the equilibrium level. Cerra and Saxena (2002) apply the REER approach to study whether the rupee was misaligned before the 1991 crisis through a vector error correction model (VECM). The evidence from this study indicates that the rupee was overvalued in the late 1980s and early 1990s. This overvaluation played a significant role in the macroeconomic crisis which resulted in sharp exchange rate depreciations.

Following Cerra and Saxena (2002) (and Edwards, 1989), this article adopts the REER approach in which the real exchange rate for India is determined by a set of economic fundamentals. The fundamentals identified include four categories: (1) Domestic supply-side factors and particularly the Balassa–Samuelson effect arising from faster productivity growth in the tradable relative to the nontradable good sector; (2) Fiscal policy, such as fiscal deficits as well as changes in the composition of government spending between tradable and nontradable goods; (3) International economic environment, including world interest rate, capital inflows and terms of trade; and (4) Commercial policy such as trade liberalization in terms of a reduction in import tariffs and export subsidies. Time series cointegration is used to test for a stationary long-run relationship between the exchange rate and the economic fundamentals.

### *2.1. Model description*

A system of variables $\mathbf{x}$ consisting of the real exchange rate and the underlying fundamentals is formulated as $\mathbf{x} = [LRER, LPRO, LGEX, WIR, LNCI, LTOT, LOPN]$ with each variable defined as follows. All variables are in logarithms, except for the world interest rate (*WIR*). When index numbers are used, the base year is 2000. Annual data are drawn from the International Financial Statistics of the IMF and supplemented by various issues of the Handbook of Statistics on Indian Economy published by the Reserve Bank of India. The sample period is 1950–2003 for all variables except *LNCI* (1975–2003).

The real exchange rate (*LRER*) is defined as the product of nominal exchange rate and the ratio of consumer price indexes: $LRER = \ln(e \cdot CPI^{US}/CPI)$, where $e$ is the nominal exchange rate and $CPI^{US}$, $CPI$ are U.S. and India's consumer price indices, respectively. While some other studies have used the multilateral real effective exchange rate, the real exchange rate defined here is a bilateral rate expressed in domestic currencies per U.S. dollar (an increase represents depreciation). This bilateral rate can be readily applied to the later PSE calculations, as world commodity prices are generally denominated in U.S. dollars.

The Balassa–Samuelson effect caused by differential productivity growth in the traded versus nontraded good sectors is approximated by the productivity change variable (*LPRO*). To be consistent with the Balassa–Samuelson theory, an increase in the productivity in the tradable sector relative to the nontradable sector would appreciate the exchange rate, because it creates excess demand for nontradable goods. Following Cerra and Saxena (2002), this variable is proxied by the log of annual growth of the industrial production index (*IPI*):

$$LPRO = \ln(IPI/IPI_{-1}).$$

Government expenditure (*GEX*) as a percentage to GDP is used to capture the effect of fiscal policies: $LGEX = \ln(GEX/GDP)$. Changes in the composition of government consumption affect the exchange rate in different ways, depending on whether the consumption is directed toward traded or nontraded goods. If an increase in government consumption is concentrated in nontraded goods, excess demand in this sector will lead to higher nontraded good price and thus real exchange rate appreciation. Depreciation will occur if expanded government consumption is concentrated in traded goods.

Three variables are defined to capture changes in the international economic environment. First the real world interest rate (*WIR*) is used, which is approximated by the U.S. real interest rate calculated by subtracting the U.S. inflation rate (measured by the $CPI^{US}$) from the one-year Treasury-Bill rate (*TBR*): $WIR = TBR - (CPI^{US} - CPI^{US}_{-1})/CPI^{US}_{-1}$. Second, the ratio of net capital inflows (*NCI*) to GDP is used: $LNCI = \ln(NCI/GDP)$. It is widely accepted that world interest rate fluctuations and capital flows into and out of the developing countries drive real exchange rate movements. A stylized effect associated with a reduction in the world interest rate or increased capital inflow is real exchange rate appreciation (Fernandez-Arias and Montiel, 1996)

A third international variable is the terms of trade (*LTOT*) defined as the ratio of export price index (export unit value *XUV*) to import price index (import unit value *MUV*): $LTOT = \ln(XUV/MUV)$. Previous studies (e.g., Goldfajn and Valdes, 1999) have shown that the effect of terms of trade on the exchange rate is ambiguous. An improvement in the terms of trade, for instance, through a decrease in the price of importables, increases national income which in turn increases demand for nontraded good leading to real exchange rate appreciation (an income effect). Simultaneously, the movement of production away from importables toward nontradables can depress the price of nontradables causing real exchange rate depreciation (a substitution effect). Therefore the net effect of terms of trade on the real exchange rate depends on the relative magnitude of the income and substitution effects.

Finally, openness of the economy (*LOPN*) is calculated as the ratio of the sum of value of imports (*VM*) plus value of exports (*VX*) to GDP: $LOPN = \ln((VM + VX)/GDP)$. Openness reflects how connected the economy is to the rest of the world and reflects the degree of trade liberalization. Its use as a proxy for trade policy is justified by the difficulty of obtaining good time series data on import tariffs and export subsidies, and also because it may account not only for explicit but also implicit trade policy, for example, quotas and exchange controls. Previous studies have shown that the improvement of a country's openness (decrease in tariff and subsidy) generates a depreciation of real exchange rate due to crowding-in and subsequent reduction in nontradable prices (Goldfajn and Valdes, 1999).

### 2.2. Long-run exchange rate determination

The Johansen maximum likelihood method (Johansen, 1991) is used to determine the long-run equilibrium exchange rate in India after augmented Dickey–Fuller (ADF) tests on the univariate series indicate that all the variables in the system are I(1) in levels and I(0) in first differences.[1] The Johansen procedure is based on the following $p$th-order VECM:

$$\begin{aligned}\mathbf{\Delta x}_t &= \mathbf{\Gamma}_1 \mathbf{\Delta x}_{t-1} + \mathbf{\Gamma}_2 \mathbf{\Delta x}_{t-2} + \cdots + \mathbf{\Gamma}_{p-1} \mathbf{\Delta x}_{t-p+1} \\ &\quad + \mathbf{\Psi} x_{t-1} + \mathbf{\Pi} D_t + \boldsymbol{\varepsilon}_t \end{aligned} \tag{1}$$

where $\mathbf{x}_t$ is a $(n \times 1)$ vector of nonstationary I(1) variables, $\mathbf{\Delta}$ is the difference-operator, $\mathbf{\Gamma}_i$, $\mathbf{\Psi}$ and $\mathbf{\Pi}$ are $(n \times n)$, $(n \times n)$ and $(n \times k)$ coefficient matrices, $\mathbf{D}_t$ is a $(k \times 1)$ vector of deterministic terms and $\boldsymbol{\varepsilon}_t$ is a vector of error terms. Suppose that $rank(\Psi) = h$, $0 < h < n$ and there are $h$ cointegrating relationships in $\mathbf{x}_t$. This implies that $\mathbf{\Psi}$ can be written in the form

$$\mathbf{\Psi} = \mathbf{AB}' \tag{2}$$

for $\mathbf{A}$ an $(n \times h)$ matrix and $\mathbf{B}'$ an $(h \times n)$ matrix. The Johansen procedure provides two tests, the trace and the maximal eigenvalue tests, for the number of linearly independent cointegrating relationships among the series in $\mathbf{x}_t$;

$$\begin{aligned}&\lambda_{\text{trace}}(h) = -T \sum_{i=h+1}^{n} \ln(1 - \hat{\lambda}_i), \quad \text{and} \\ &\lambda_{\max}(h, h+1) = -T \ln(1 - \hat{\lambda}_{h+1}),\end{aligned} \tag{3}$$

where $\hat{\lambda}_i$ are the estimated eigenvalues of matrix $\mathbf{\Psi}$.

Before proceeding with the Johansen test, we consider different model formulations. Initially, the vector $\mathbf{x}$ consists all the variables in the system ($n = 7$). However, difficulty arises because data for variable *LNCI* are only available for the period 1975–2002. The resulting loss of degrees of freedom leads to nonrobust results. *LNCI* is thus dropped from the system and the model is re-estimated using an expanded sample period from 1950 to 2003 ($n = 6$).

The model is further adjusted by taking short-run shocks into account. We follow Edwards (1989) and define an exogenous variable that captures macroeconomic policy, *LDCT*, the log of domestic credit (*DCT*) over GDP: $LDCT = \ln(DCT/GDP)$ (also I(1) in levels and I(0) in first difference by an ADF

[1] The ADF test results are not reported here but are available upon request.

Table 1
Johansen cointegration test results

| Null hypothesis | Case I | | | | Case II | | | |
|---|---|---|---|---|---|---|---|---|
| | $\lambda_{trace}$ test | $\lambda_{trace}$ (0.95) | $\lambda_{\max}$ test | $\lambda_{\max}$ (0.95) | $\lambda_{trace}$ test | $\lambda_{trace}$ (0.95) | $\lambda_{\max}$ test | $\lambda_{\max}$ (0.95) |
| $h = 0$ | 151.55* | 103.85 | 68.56* | 40.96 | 147.86* | 95.75 | 68.26* | 40.08 |
| $h \leq 1$ | 82.99* | 76.97 | 38.82* | 34.81 | 79.61* | 69.82 | 38.32* | 33.88 |
| $h \leq 2$ | 44.18 | 54.08 | 20.60 | 28.59 | 41.29 | 47.86 | 20.60 | 27.58 |
| $h \leq 3$ | 23.58 | 35.19 | 10.65 | 22.30 | 20.69 | 29.80 | 10.60 | 21.13 |
| $h \leq 4$ | 12.92 | 20.26 | 9.60 | 15.89 | 10.09 | 15.49 | 9.23 | 14.26 |
| $h \leq 5$ | 3.33 | 9.16 | 3.33 | 9.16 | 0.87 | 3.84 | 0.87 | 3.84 |
| **D** | Constant and short-run shocks | | | | Constant and short-run shocks | | | |
| Lag length | 2 | | | | 2 | | | |
| Sample | 1950–2003 | | | | 1950–2003 | | | |

*Note*:* denotes rejection at the 0.05 significance level. Case I: no intercept in the cointegrating equation or the VECM; Case II: intercept in the cointegrating equation and the VECM. $h$ is the cointegrating rank. The lag-length of two is determined by a battery of diagnostic tests on an unrestricted vector autoregression model (VARM) including a $\chi^2$ test for the hypothesis that the $i$-period lag is zero for each equation separately; a joint *LM* test for the hypothesis that there is no heteroskedasticity or serial correlation; and a joint $\chi^2$ test for the normality of the errors (not reported but available upon request).

test). Edwards argues that excess supply of domestic credit can proxy inconsistent macroeconomic policies; and when it becomes highly expansive without matching adjustment in the nominal exchange rate, the real rate appreciates in the short run causing overvaluation. The first difference of this variable, $\Delta LDCT$, is included in $\mathbf{D}_t$ to represent such effects. In addition, following Edwards and Savastano (2002), a vector of dummy variables—representing two oil price shocks in the 1970s, and the balance of payment crisis with subsequent exchange rate regime shifts in the early 1990s—is also included in $\mathbf{D}_t$.[2]

Table 1 presents the Johansen cointegration tests for the final model formation under two cases: without and with an intercept (Case I and Case II, respectively). The $\lambda_{trace}$ and $\lambda_{\max}$ statistics reject the null hypothesis of zero cointegrating rank at the 0.05 significance level for each case. However, the null hypothesis that the cointegrating rank is at most 2 is accepted indicating that there are up to two cointegrating relationships among the variables ($h = 2$).

The existence of multiple cointegrating vectors complicates the interpretation of the equilibrium exchange rates. If the exchange rate variable (*LRER*) appears in two cointegrating vectors then each vector, or any linear combinations of the two, could be treated as a long-run equilibrium exchange rate relationship. However, a likelihood ratio test (Johansen and Juselius, 1990):

$$-2\ln(\hat{L}_R/\hat{L}_U) = -2\ln(Q) = T\sum_{i=1}^{\hat{h}} \ln\left\{\frac{(1-\hat{\lambda}_i^*)}{(1-\hat{\lambda}_i)}\right\}$$

($\chi^2$ distributed with $R$ and $U$ denoting restricted and unrestricted models) shows that a joint restriction on $\mathbf{B}$ and $\mathbf{A}$ in the form:

$$\mathbf{B}' = \begin{bmatrix} * & * & * & * & * & * \\ 0 & * & * & * & * & * \end{bmatrix} \text{ and } \mathbf{A}' = \begin{bmatrix} * & * & * & 0 & * & * \\ * & * & * & 0 & * & * \end{bmatrix}$$

is not rejected at 0.05 significance level with $\chi^2(2) = 1.93$ ($P$-value $= 0.38$). In light of this joint test, the first (unrestricted) cointegrating vector, which contains the exchange rate, can be recognized as the equilibrium exchange rate relationship, while the second (restricted) cointegrating vector represents a different long-run relationship for variables excluding the exchange rate. The world interest rate (*WIR*) can be treated as weakly exogenous to the system. Table 2 presents the restricted cointegration results normalized on *LRER* and *LPRO* for the first and second vector, respectively. The two cointegrating vectors can be alternatively presented as

$$\begin{aligned} LRER &= -10.370LPRO + 0.621LGEX + 2.695WIR \\ &\quad + 0.569LTOT + 0.654LOPN + 4.037 \\ LPRO &= 0.042LGEX - 0.548WIR - 0.031LTOT \\ &\quad - 0.030LOPN + 0.250. \end{aligned} \tag{4}$$

For the first cointegrating vector, the negative sign of the variable *LPRO* for India suggests that an increase in the productivity in the traded good sector relative to the nontraded good sector is associated with real exchange rate appreciation, which is consistent with the Balassa–Samuelson theory. An increase in government expenditure (*LGEX*) causes the rupee to depreciate, suggesting that Indian government expenditures might have a higher content of traded goods, which is consistent with Cerra and Saxena (2002). The positive sign associated with *WIR* indicates that a reduction in the world interest rate appreciates India's long-run real exchange rate. The positive sign on *LTOT* suggests the possible dominance of the substitution effect over the income effect and that improvements in the terms of trade depreciate the currency. The volume of trade, or degree of openness, as measured by the variable *LOPN*, confirms previous findings that economic closedness is typically associated with overvaluation, and that external liberalization aimed at reducing tariffs and eliminating trade restrictions causes currency depreciation.

[2] The dummy variables take the value of 1 in years 1973 (Dummy 1), 1979 (Dummy 2), and 1991, 92, 93 (Dummy 3) respectively, and 0 otherwise.

Table 2
Restricted cointegration results

| | *LRER* | *LPRO* | *LGEX* | *WIR* | *LTOT* | *LOPN* | Constant |
|---|---|---|---|---|---|---|---|
| **B′** | | | | | | | |
| | 1.000 | 10.370** | −0.621** | −2.695** | −0.569** | −0.654** | −4.037 |
| | | (1.345) | (0.078) | (1.104) | (0.184) | (0.076) | |
| | 0.000 | 1.000 | −0.042** | 0.548** | 0.031* | 0.030** | −0.250 |
| | | | (0.008) | (0.100) | (0.018) | (0.007) | |
| **A′** | | | | | | | |
| | −0.017** | −0.015** | 0.016* | 0.000 | 0.049** | 0.040** | – |
| | (0.008) | (0.006) | (0.008) | | (0.020) | (0.015) | |
| | 0.011 | 0.002 | 0.019** | 0.000 | −0.011 | −0.041* | – |
| | (0.022) | (0.010) | (0.003) | | (0.032) | (0.025) | |

*Note:* Standard errors are in parentheses. ** and * denote significance at the 0.05 and 0.10 levels, respectively.

### 2.3. Exchange rate equilibrium and misalignment

To calculate the equilibrium exchange rate based on the restricted cointegration results in Eq. (4), we filter the values of the economic fundamentals by the Hodrick–Prescott (H-P) decomposition technique (Hodrick and Prescott, 1997), as the economic fundamentals themselves may be out of long-run equilibrium. The H-P method decomposes these time series into a trend $\mu_t$ and stationary component $x_t - \mu_t$ by minimizing:

$$\sum_{t=1}^{T}(x_t - \mu_t)^2 + \lambda \sum_{t=2}^{T-1}[(\mu_{t+1} - \mu_t) - (\mu_t - \mu_{t-1})]^2,$$

where $\lambda$ is an arbitrary constant reflecting the penalty of incorporating fluctuations into the trend.[3]

Fig. 1 compares the actual with the equilibrium exchange rates for 1980–2002. The difference between the two indicates the exchange rate misalignment. The figure shows that the actual real exchange rate of the Indian rupee significantly increased (depreciated) from 1980 to 1993. Large steps of devaluations started in 1988 and continued through 1992. The actual exchange rate shows a persistent overvaluation from 1986 to 1992 compared to the equilibrium rate. Concurrent with the long period of real exchange rate overvaluation was the deterioration of the country's balance of payments, the depletion of foreign exchange reserves, and political turmoil, which triggered the macroeconomic crisis starting in 1991.

The actual real exchange rate came into line with the equilibrium in 1993 after devaluations and as a result of postcrisis adjustments featuring macroeconomic stabilization and structural reforms, especially in the direction of trade and financial liberalization. The combined effects of these measures were evident in the external sector. In the years following the crisis, rising capital inflows and shrinking trade deficits have led to continued accumulation of foreign exchange reserves by India. The actual real exchange rate of the Indian rupee has fluctuated around its equilibrium values with limited degrees of misalignment. As Fig. 1 shows, both the actual and the equilibrium real exchange rates were relatively stable during 1993–2002, with a slight initial appreciation followed by depreciation when the U.S. dollar began to appreciate globally in 1996. In cases of misalignment of the Indian rupee, the actual rate has subsequently moved in the direction of restoring the equilibrium during this period.

[3] Different $\lambda$s should be used depending on data frequency: larger when the data is monthly and smaller when it is annual. Hodrick and Prescott (1997) suggest a $\lambda$ of 1,600 for quarterly data. In this analysis of annual data, $\lambda$ is set equal to 10.

## 3. Effects of exchange rate alignment on PSEs

### 3.1. The PSE

According to the OECD, the PSE is "an indicator of the annual monetary value of gross transfer from consumers and taxpayers to agricultural producers" (Portugal, 2002). In nominal terms the PSE can be expressed as the sum of Market Price Support (*MPS*) and Budgetary Payments (*BP*). The calculation of *MPS* is shown in Eq. (5):

$$MPS = \sum MPS_j = \sum \left(P_j^d - P_j^{ar}\right) Q_j \tag{5}$$

where $j$ denotes commodity, $P_j^d$ is the domestic price, $P_j^{ar}$ is the adjusted reference price, and $Q_j$ is the quantity. The adjusted reference price $P_j^{ar}$ is the world market price (either a relevant import c.i.f. price or export f.o.b. price depending on whether the commodity is an importable or an exportable) expressed in domestic currency and adjusted by various transaction costs.[4]

[4] Byerlee and Morris (1993) and Mullen et al. (2005) point out that the selection of a relevant reference price ($P^{ar}$) depends on the relationship between the adjusted reference prices for imports ($P_m$) and exports ($P_e$) and the estimated autarky equilibrium price ($P^*$) at which the domestic market would clear without trade. It is always the case that $P_m > P_e$ because of international and domestic cost adjustments. $P_m$ is the relevant $P^{ar}$ when $P^* > P_m$, and $P_e$ is the relevant $P^{ar}$ when $P_e > P^*$. But when $P^*$ falls in the spread between the import and export world prices ($P_m > P^* > P_e$) then $P^*$ is the relevant $P^{ar}$. Mullen et al. is one of a few empirical PSE studies applying this approach to reference price determination, which requires estimation of $P^*$ as well as observation of prevailing domestic and world prices. Other studies assume either $P_m$ or $P_e$ is relevant depending on the trade position of the country for each commodity.

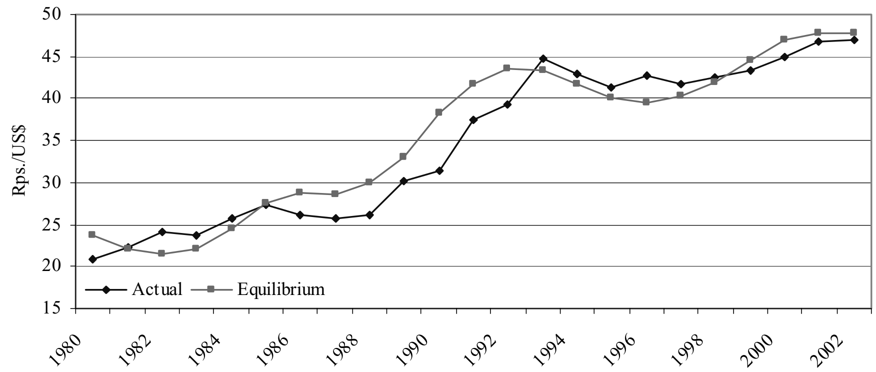


Fig. 1. The actual and equilibrium real exchange rates.

The cost adjustment process differs according to the commodity's trade status (see Mullen et al., 2005, for details), but in either case, the adjusted reference price can be expressed as:

$$P_j^{ar} = P_j^w \times E + ADJ_j \tag{6}$$

where $P_j^w$ is the world market price, $E$ is the nominal exchange rate, and $ADJ_j$ is the domestic cost adjustment factor.

The PSE measure can be expressed on a percentage basis (denoted by $\%PSE$) using $(VOP + BP)$ as the denominator, where $VOP$ is the total value of agricultural production at domestic producer prices:

$$\%PSE = \frac{MPS + BP}{VOP + BP}.$$

Following the terminology of Krueger et al. (1991), we define three types of effects using the percent PSE. The "direct effect" induced by sector-specific policies is defined as the $\%PSE$ calculated using the actual nominal exchange rate $E$:

$$\begin{aligned} \text{Direct Effect} = \%PSE(E) &= \frac{MPS(E) + BP}{VOP + BP} \\ &= \frac{\sum \left(P_j^d - P_j^{ar}(E)\right) Q_j + BP}{VOP + BP}. \end{aligned} \tag{7a}$$

The "total effect" induced by both sectoral and exchange rate policies is defined as the $\%PSE$ calculated using the equilibrium exchange rate $E^*$, under the *ceteris paribus* assumption holding domestic and budgetary payments constant:

$$\begin{aligned} \text{Total Effect} = \%PSE(E^*) &= \frac{MPS(E^*) + BP}{VOP + BP} \\ &= \frac{\sum \left(P_j^d - P_j^{ar}(E^*)\right) Q_j + BP}{VOP + BP}. \end{aligned} \tag{7b}$$

The difference between the total and direct effect captures the "indirect effect" of misalignment of the exchange rate:

$$\begin{aligned} \text{Indirect Effect} &= \%PSE(E^*) - \%PSE(E) \\ &= \frac{\sum \left(P_j^{ar}(E) - P_j^{ar}(E^*)\right) Q_j}{VOP + BP}. \end{aligned} \tag{7c}$$

Ignoring domestic cost adjustment ($ADJ_j$), it can be shown that the indirect effect is $m \cdot \frac{\sum P_j^w E^* Q_j}{VOP+BP}$, where $m$ is the percentage exchange rate misalignment, $m = (E - E^*)/E^*$.[5] The indirect effect is negative if overvaluation occurs ($m < 0$), positive if undervaluation occurs ($m > 0$), and zero if no misalignment exists ($m = 0$).

### 3.2. Exchange rate pass-through

The effects of realignment of the exchange rate on PSEs depend on the degree of pass-through of appreciation or depreciation movements to domestic agricultural prices and budgetary payments. The empirical literature on exchange rate pass-through to prices is extensive but has mostly focused on the manufacturing industries of developed economies. Among those studies that examine exchange rate pass-through to agricultural commodity prices, some have shown more complete and rapid pass-through to agricultural prices than manufacturing prices (Carter et al., 1990; Xu and Orden, 2002), which is consistent with the view that agricultural commodities operate in competitive flexible-price markets. Other studies have shown incomplete pass-through for some agricultural commodities (Park and Pick, 1996). A number of reasons are offered for such incomplete pass-through from exchange rates. One explanation for this phenomenon is that importing and exporting firms choose to hold prices constant and simply reduce or increase their mark-ups when the exchange rate is changing ("pricing-to-market"). Policy interventions that affect domestic prices, or domestic prices falling between import and export parity would also affect exchange rate pass-through.

To evaluate exchange rate pass-through to domestic agricultural prices in India, we estimate a fixed effects panel regression model in first-difference logarithmic form:

$$\Delta p_{it} = \alpha_i + \theta_t + \sum_{k=0}^{n} \left(\beta_k \Delta e_{t-k} + \gamma_k \Delta p_{it-k}^*\right) + \varepsilon_{it} \tag{8}$$

[5] Ignoring domestic cost adjustment ($ADJ_j$) simplifies the expressions for the indirect effect. However, in the PSE calculations reported below, $ADJ_j$ is taken into account.

where $\Delta$ is difference-operator, $p_i$ and $p_i{}^*$ are domestic and world prices, respectively, $e$ is the exchange rate, $\alpha_i$ and $\theta_t$ represent cross-commodity and time-specific effects, $n$ represents the number of lagged terms, $\beta_k$ and $\gamma_k$ are coefficients measuring the contemporaneous or lagged pass-through of exchange rates and foreign prices to domestic prices, and $\varepsilon_{it}$ is the idiosyncratic error term distributed with mean zero and variance $\sigma_\varepsilon^2$. This specification is a variant of the panel regression model proposed by Knetter (1993) to study pricing-to-market behaviour of exporting firms for a particular commodity.[6] If $\sum_{k=0}^n \beta$ or $\sum_{k=0}^n \gamma$ is not significantly different from one (zero), then there is complete (no) exchange rate or world price pass-through to commodity prices.

The estimation of Eq. (8) is based on a panel dataset that includes 11 commodities covered in a recent PSE study for India by Mullen et al. (2005) for the period of 1985–2002. The commodities include wheat, rice, corn, sorghum, groundnuts, sugar, rapeseed, soybeans, sunflower, chickpeas and cotton, accounting for approximately 50% of total agricultural production in India. Annual data series are used due to the fact that short-run exchange rate changes (monthly or quarterly) may not be fully passed through to prices as they can be treated as temporary. Another reason for using the annual data is that for India higher-frequency data are not available. The exchange rate data are obtained from the previous analysis. Domestic prices and world prices, which are c.i.f. India prices, are taken from Mullen et al. (2005).

Table 3 shows the estimated exchange rate pass-through coefficients ($\beta$ or $\sum\beta$). Model 1 is a simple pooled regression that does not include either commodity or time effects. Model 2 includes the commodity effect that captures unobserved heterogeneity across commodities (e.g., consumer demands). In addition to the commodity effect, Model 3 also takes into account the time effect that captures common impacts in each time period across all commodities (e.g., national income). Two different lag structures are considered ($n = 0$ or 1).[7] Student-$t$ statistics are provided for the tests that the contemporaneous or aggregated pass-through coefficient is zero, implying no pass-through. Tests are also reported for the contemporaneous or aggregate pass-through coefficient summing to one, which is consistent with complete pass through.

The results in Table 3 show that aggregate exchange rate pass-through to domestic agricultural prices is fairly high for India.[8] Point estimates only differ slightly across the models.

Table 3
Pass-through coefficient by fixed effect panel estimation

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| No lag ($n = 0$) | | | |
| $\beta$ | 0.82 | 0.80 | 0.81 |
| $t$-stat for $H_0 : \beta = 0$ | (2.29)* | (2.16)* | (2.45)* |
| $t$-stat for $H_0 : \beta = 1$ | (3.54)* | (3.71)* | (4.42)* |
| 1 lag ($n = 1$) | | | |
| $\sum\beta$ | 0.78 | 0.77 | 0.77 |
| $t$-stat for $H_0 : \sum\beta = 0$ | (5.62)* | (5.83)* | (5.82)* |
| $t$-stat for $H_0 : \sum\beta = 1$ | (4.21)* | (3.13)* | (3.20)* |
| Commodity dummies | No | Yes | Yes |
| Time dummies | No | No | Yes |

*Note:* Calculated $t$-statistics are in parentheses.
*denotes significance at 0.05 level.

When there is no lag, the contemporaneous exchange rate pass-through coefficient ranges from 0.80 to 0.82. Adding one lag of the exchange rate (and the world price) to the estimation only slightly changes the pass-through. For all model specifications, the pass-through coefficient is significant, indicating that the hypothesis of no exchange rate pass-through is rejected. However, despite high pass-though coefficients, the null hypotheses that they are equal to one, i.e., complete exchange rate pass-through, are also rejected.

### 3.3. Counterfactual PSEs

A counterfactual measure of the PSE ($\%PSE^{CF}$, where $CF$ denotes "counterfactual") can also be computed under the assumption that the exchange rate ($E$) moves to its equilibrium ($E^*$) in a given period. In place of the *ceteris paribus* assumption of Eq. (7b), the exchange rate changes can affect not only the reference prices but also the domestic prices due to exchange rate pass-through. Domestic prices change to $\frac{P_j^d}{1+\beta m}$ when incomplete pass-through (IPT, $0 < \beta < 1$) occurs, where $\beta$ is the exchange rate pass-through coefficient. Domestic prices remain at $P_j^d$ with no pass-through (NPT, $\beta = 0$), but change to $\frac{P_j^d}{1+m}$ with complete pass-through (CPT, $\beta = 1$).

When there is exchange rate pass-through to domestic prices (complete or incomplete) one may expect that there is also exchange rate pass-through to budgetary payments, even though the magnitude of the these two pass-throughs may differ. In this analysis we consider two cases: Eq. (1) the effect of exchange rate pass-through to budgetary payments is the same as the one to domestic agricultural prices; and Eq. (2) there is no exchange rate pass-through to budgetary payments even though there is pass-through to domestic prices (complete or incomplete). In the first scenario, budgetary payments become $\frac{BP}{1+\beta m}$ with IPT and $\frac{BP}{1+m}$ with CPT, while in the second scenario budgetary payments remain at $BP$.

A comparison between the direct PSE (based on the actual exchange rate) and the counterfactual PSE (based on equilibrium

[6] A panel cointegration method is not used as the hypothesis of a panel unit root is rejected.

[7] Results of aggregate pass-through tests using longer time lags are similar to those with 1 lag.

[8] The panel regression estimation used in this analysis provides a common pass-through coefficient for the 11 covered commodities. Similar estimation methods are used in Mundlak and Larson (1992) who also found a relatively high pass-through coefficient (0.74). In terms of individual commodities, Sharma (2003) reported small exchange rate pass-through coefficients for rice and wheat in India while much higher coefficients were found in Tyers and Anderson (1992) for the same two commodities.

Table 4
A comparison between counterfactual and direct PSE

| Pass-through | Counterfactual | Direct effect | Transfer | Nontransfer |
|---|---|---|---|---|
| NPT | $\dfrac{\sum\left(P_j^d - P_j^w E^*\right) Q_j + BP}{VOP + BP}$ | $\dfrac{\sum\left(P_j^d - P_j^w E\right) Q_j + BP}{VOP + BP}$ | $m\dfrac{\sum P_j^w E^* Q_j}{VOP + BP}$ | 0 |
| CPT 1 | $\dfrac{\sum\left(\frac{P_j^d}{1+m} - P_j^w E^*\right) Q_j + \frac{BP}{1+m}}{\frac{VOP}{1+m} + \frac{BP}{1+m}}$ | Same as above | 0 | $m\dfrac{\sum P_j^w E^* Q_j}{VOP + BP}$ |
| CPT 2 | $\dfrac{\sum\left(\frac{P_j^d}{1+m} - P_j^w E^*\right) Q_j + BP}{\frac{VOP}{1+m} + BP}$ | Same as above | $\dfrac{\sum\left(\frac{P_j^d}{1+m} - P_j^w E^*\right) Q_j + BP}{\frac{VOP}{1+m} + BP} - \dfrac{\sum\left(P_j^d - P_j^w E\right) Q_j + BP}{VOP + BP}$ | $m\dfrac{\sum P_j^w E^* Q_j}{VOP + BP} - \dfrac{\sum\left(\frac{P_j^d}{1+m} - P_j^w E^*\right) Q_j + BP}{\frac{VOP}{1+m} + BP} + \dfrac{\sum\left(P_j^d - P_j^w E\right) Q_j + BP}{VOP + BP}$ |
| IPT 1 | $\dfrac{\sum\left(\frac{P_j^d}{1+\beta m} - P_j^w E^*\right) Q_j + \frac{BP}{1+\beta m}}{\frac{VOP}{1+\beta m} + \frac{BP}{1+\beta m}}$ | Same as above | $(1-\beta)\, m\dfrac{\sum P_j^w E^* Q_j}{VOP + BP}$ | $\beta m\dfrac{\sum P_j^w E^* Q_j}{VOP + BP}$ |
| IPT 2 | $\dfrac{\sum\left(\frac{P_j^d}{1+\beta m} - P_j^w E^*\right) Q_j + BP}{\frac{VOP}{1+\beta m} + BP}$ | Same as above | $\dfrac{\sum\left(\frac{P_j^d}{1+\beta m} - P_j^w E^*\right) Q_j + BP}{\frac{VOP}{1+\beta m} + BP} - \dfrac{\sum\left(P_j^d - P_j^w E\right) Q_j + BP}{VOP + BP}$ | $m\dfrac{\sum P_j^w E^* Q_j}{VOP + BP} - \dfrac{\sum\left(\frac{P_j^d}{1+\beta m} - P_j^w E^*\right) Q_j + BP}{\frac{VOP}{1+\beta m} + BP} + \dfrac{\sum\left(P_j^d - P_j^w E\right) Q_j + BP}{VOP + BP}$ |

*Note:* For simplicity, the formulae shown ignore domestic cost adjustment ($ADJ_j$) but these adjustments are incorporated in our empirical analysis. NPT: No pass-through; CPT (IPT) 1: Complete (incomplete) pass-through to domestic prices and budgetary payments; CPT (IPT) 2: Complete (incomplete) pass-through to domestic prices, but no pass-through to budgetary payments.

exchange rate) for different exchange rate pass-through scenarios is summarized in Table 4. The difference between the initial direct and new counterfactual measures is denoted as a "transfer" of the indirect effect to the counterfactual measure.

In the case of no exchange rate pass-through (NPT), the difference between $\%PSE^{CF}$ and the initial direct $\%PSE$ is equal to the indirect exchange rate effect shown earlier. This represents a full transfer of the exchange rate effect into the new measure of the PSE, with no change in actual incentives conveyed to producers through the domestic output prices or budgetary payments. The magnitude of the indirect effect, and thus the transfer, is determined by the initial exchange rate misalignment ($m$).

In contrast, when there is complete exchange rate pass-through to domestic agricultural prices and to budgetary payments (CPT 1), the transfer of the initial indirect effect into the counterfactual PSE measure is zero no matter how much the exchange rate was misaligned. Removing the exchange rate misalignment in this case affects the price incentives producers face but leaves the protection coefficient measured by the initial direct $\%PSE$ unchanged. However, if there is complete pass-through to domestic agricultural prices but no pass-through to budgetary payments (CPT 2), there still exits some degree of transfer even though the pass-through to domestic prices is complete.[9] In the case of incomplete exchange rate pass-through to domestic prices (IPT 1 and IPT 2), no matter whether there is incomplete or no pass-through to budgetary payments, the degree of transfer of the initial indirect effect into the counterfactual direct effect is determined by a combination of the initial exchange rate misalignment ($m$) and the degree of pass-through ($\beta$).

### 3.4. Direct, indirect, and total PSE effects and counterfactual results

To evaluate the direct, total and indirect effects on PSEs for India we again draw upon the recent analysis of direct PSEs by Mullen et al. (2005) and our analysis of exchange rate equilibrium and misalignment. The actual nominal exchange rates in the analysis are the annual average official rates and the nominal equilibrium exchange rates are derived from the corresponding real equilibrium rates from Section 2.[10] The PSE calculations are based on the 11 covered commodities.[11]

[9] It can be shown that $\%PSE^{CF}$ in Table 4 is a monotonic increasing function of the nominal value of budgetary payments. For the case of complete exchange rate pass-through (CPT), when there is overvaluation ($m < 0$), $\%PSE^{CF}$(CPT 1) is greater than $\%PSE^{CF}$(CPT 2); when there is undervaluation ($m > 0$), $\%PSE^{CF}$(CPT 1) is less than $\%PSE^{CF}$(CPT 2). That is, with either overvaluation or undervaluation, the absolute value of transfer in CPT 2 is greater than that in CPT 1. The same set of arguments can be made for the case of incomplete exchange rate pass-through (IPT).

[10] Specifically, the nominal equilibrium exchange rate is obtained by multiplying the real equilibrium exchange rate by the ratio of India's CPI to U.S. CPI.

[11] Following Mullen et al., the MPS component of PSEs for six commodities (wheat, rice corn, sorghum, groundnuts, and sugar) for which India's trade is small and sometimes switches from imports to exports is calculated using the Byerlee and Morris (1993) procedure to determine the reference prices (see footnote 4). Rapeseed, soybeans, sunflower, chickpeas, and cotton are assumed to be importable in all years. With this approach, the estimated autarky equilibrium price rather than a world price for imports or exports is selected as the relevant reference price in several years for one or more commodities. For example, Mullen et al. estimate that the autarky equilibrium price was

Table 5
Direct, indirect, and total effect by PSE

| Period (% misalignment) | I:1985–88 (−8.6%) | II:1989–92 (−11.8%) | III:1993–98 (3.6%) | IV:1999–02 (−2.8%) |
|---|---|---|---|---|
| Direct | 7.7 | 0.8 | −2.9 | 9.0 |
| Indirect | −3.2 | −8.2 | 1.4 | −1.3 |
| Total | 4.5 | −7.4 | −1.5 | 7.7 |
| Counterfactual (IPT) | | | | |
| IPT 1 | 7.0 | −1.1 | −2.6 | 8.7 |
| Transfer | −0.7 | −1.9 | 0.3 | −0.3 |
| Nontransfer | −2.5 | −6.3 | 1.1 | −1.0 |
| IPT 2 | 6.3 | −3.2 | −1.9 | 8.1 |
| Transfer | −1.4 | −2.4 | 1.0 | −0.9 |
| Nontransfer | −1.8 | −5.8 | 0.4 | −0.4 |

*Note:* IPT 1: Incomplete pass-through to domestic prices and budgetary payments; IPT 2: Incomplete pass-through to domestic prices but no pass-through to budgetary payments.

Table 5 shows the direct, indirect and total effects measured by the PSE for the period 1985–2002. The sample period is divided into four distinct subperiods. Period one (I) covers 1985–1988 when the exchange rate started to overvalue with an average overvaluation of −8.6%. Period two (II) represents a sustained overvaluation period from 1989 to 1992 during which the macroeconomic crisis occurred and the exchange rate was under active adjustment. The overvaluation in this period was −11.8%. Period three (III) is postreform from 1993 to 1998, with a slight undervaluation of 3.6%. The last period (IV) is the stable exchange rate period from 1999 to 2002 when the actual exchange rate is close to the equilibrium rate with a slight overvaluation of −2.8%. Fig. 2 illustrates the direct and indirect PSE results on an annual basis.

The direct effects shown in Table 5 and Fig. 2 indicate that the aggregate agricultural protection or disprotection in India follows a counter-cyclical pattern against world prices, which were low in the late 1980s, strengthened in the mid-to-late 1990s, and fell afterwards. Specifically, the direct effect was positive when world commodity prices were low during the first Period (I) but fell and then turned to disprotection when the world prices rose in Periods II and III. In Period IV, the direct effect shows an increase in support as world prices again declined. A similar pattern is observed for the total effect.

The indirect effect caused by exchange rate misalignments has had quite different impacts on India's agriculture than that of the direct effect. On average India's agricultural sector was indirectly penalized by exchange rate overvaluation in Periods I, II, and IV, but subsidized by exchange rate undervaluation in Period III. The indirect effect was greater in the years before and during the macroeconomic crisis when the exchange rate was continuously misaligned, averaging −8.2% in Period II. In the postcrisis years, as a result of decreased exchange rate misalignment following macroeconomic reforms, the indirect effect dampens to less than 2% in absolute value.

Noticeably, the indirect effect of the exchange rate is smaller in absolute value than the direct effect in Periods I, III, and IV, indicating the dominance of sectoral-specific policies over the economy-wide policies reflected in the exchange rate. The opposite happened in Period II, when substantial overvaluation had a large negative effect on incentives facing agricultural producers. This latter result is consistent with the study by Krueger et al. (1991), who found that economy-wide policies such as the exchange rate played a dominant role across a range of developing countries (not including India) in an earlier period to the mid-1980s. More recently India has not experienced sustained periods of significant exchange rate misalignment nor subsequent effects on agriculture as measured by the PSEs.

Estimates of counterfactual PSEs are also shown in Table 5 and Fig. 2 under the assumption of incomplete exchange rate pass-through with a contemporaneous pass-through coefficient of 0.81 obtained from Table 4 (Model 3 with no time lag). The cases of no pass-through (NPT) and complete pass-through (CPT) are not reported explicitly, but they can be inferred from the reported total and direct PSE results under observed exchange rates, as described above.

Since the contemporaneous pass-through of exchange rate movements is relatively high in India, only a small portion of the exchange rate effect remains in the counterfactual PSE under the assumption of incomplete exchange rate pass-through to domestic prices and budgetary payments (IPT 1). For instance, despite a large indirect effect in Period II, only −1.9% out of −8.2% transfers to the counterfactual PSE, with −6.3% disappearing as a result of the exchange rate pass-through. Counterfactually, had this period of misalignment been corrected Indian farmers would have faced better production incentives, with disprotection of only −1.1% instead of −7.4% measured by the total %PSE. The pattern of transfer relative to the nontransfer is somewhat different when there is no exchange rate pass-through to budgetary payments (IPT 2). The magnitude of transfer increases in absolute value in each period but it remains smaller than the nontransfer in Periods I and II while becoming greater in Periods III and IV.

Two additional points help to place the empirical results into context. First, a country's aggregate PSE is widely used in policy discussions and we have presented results for this PSE measure for India. Percentage PSEs can also be computed on a commodity-specific basis, using the MPS computed for that commodity individually and replacing *VOP* and *BP* with the value of production of the single commodity at domestic prices and its share of total budgetary payments. Space limitations preclude a full exposition of these disaggregated results, but the estimates for two basic foodgrains, wheat and rice, are illustrative. For both wheat and rice, similar to the aggregate results, we find a countercyclical policy for India that stabilizes domestic producer prices relative to world price fluctuations. Wheat was

between the import and export adjusted reference prices during the period when world prices fell from 1999–2002, implying no trade would have occurred without policy interventions (see Mullen et al., 2005, for details). Use of these adjustments does not affect the main conclusions we draw about direct and indirect effects on PSEs.

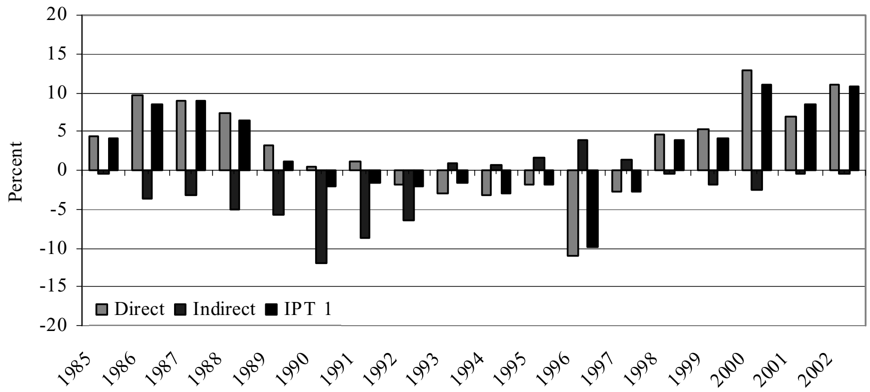


Fig. 2. Direct, indirect, and counterfactual (IPT 1) PSEs

protected in most years during 1985–2002 when the budgetary components of the PSE is taken into account (despite some price disprotection), while rice suffered disprotection throughout the 1990s. Estimates of the exchange rate pass-through for these individual commodities (based on Eq. (8) modified for a single time series) yield smaller coefficients than our aggregate estimate (0.45 and 0.48 for wheat and rice, respectively). Thus, more of the indirect effect on the PSE would be transferred to the counterfactual PSE for these commodities than in the aggregate analysis shown in Table 5. A devaluation, for example, would provide less improvement in price incentive for wheat or rice producers.

The second point of context concerns our approach to aggregation, not dissaggregation. The direct PSEs we report include only the MPS derived for the 11 covered commodities. This approach implicitly assumes that the commodities not covered (in our case, primarily livestock and fruits and vegetables) on average have been neither price-protected nor disprotected. In contrast, the MPS results for the covered commodities are often "scaled up" in PSE studies by dividing the calculated MPS value by the proportion of the value of agricultural output these commodities represent. This latter approach implicitly assumes that commodities not included in the analysis have received, on average, the same level of price protection or disprotection as the covered commodities, which we conclude is not realistic for India. The latter approach magnifies the reported MPS component, and thus our direct PSEs shown in Table 5 and Fig. 2 are smaller than would be reported had the scaling up procedure been invoked.

## 4. Summary and conclusions

The alignment of exchange rates can have significant impacts on the agricultural sector. In this analysis, a real equilibrium approach to determining exchange rates is applied and effects of exchange rate misalignment on PSEs are evaluated for India for the period 1985–2002. A long-run cointegrating relationship is found between the exchange rate and economic fundamentals. This model suggests that the Indian rupee was continuously overvalued in the mid 1980s to early 1990s. Direct, total and indirect effects on PSEs are compared and three scenarios of exchange rate pass-through are considered: no pass-through, complete pass-through, and incomplete pass-through. Counterfactual PSEs, assuming the exchange rate is in equilibrium in a given year, indicate that the indirect effect is fully transferred to the counterfactual measure when there is no exchange rate pass-through, but that part or all of the indirect effect disappears when exchange rate realignment is partially or fully passed through to domestic agricultural prices and budgetary payments.

The main empirical findings from the PSE calculations indicate that the indirect exchange rate effects counteract the direct effect of sectoral policies for all the sub-sample periods. The indirect effect of exchange rate overvaluation taxed the agricultural sector in India during the periods 1985–1992 and 1999–2002. We estimate a relatively high pass-through coefficient for India based on a fixed effect panel regression model using disaggregate prices of 11 commodities covered in the PSE assessment. Thus, Indian farmers would have faced improved production incentives in the late 1980s and early 1990s had the exchange rate misalignment during this period been corrected. The magnitude of the indirect effects becomes smaller in later periods when the actual exchange rate moves closer to its equilibrium value. Thus, unlike its neighbor China, for which concerns about substantial exchange rate undervaluation remain pervasive, exchange rate misalignment has not recently been a pressing issue for India with respect to either domestic agricultural production incentives or to broader trade and macroeconomic policy. Since the macroeconomic reforms of the early 1990s, Indian farmers have not experienced sharp policy shocks from exchange rate adjustments, nor are they likely to in the near future.

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