MICROECONOMIC SHOCKS, DEPRECIATION
AND INFLATION: AN AUSTRALIAN PERSPECTIVE

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January 2002

Discussion Paper No 298

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Abstract

The general equilibrium approach demonstrates that macroeconomic shocks link the exchange rate and the inflation rate through diverse transmission channels. Therefore, the one-track focus of the partial equilibrium 'pass-through' approach that predicts that exchange rate depreciation causes inflation is flawed does not explain the exchange rate inflation dynamics of post-float australia. In this paper based on a mundell-fleming stochastic rational expectations model the theoretical priors that link exogenous shocks and macro-variables such variables real exchange rate, relative prices and relative output have been identified. Thereafter, the structural var (svar) methodology has been deployed to the identify the exogenous shocks by appealing to the long-run classical neutrality postulates. The dynamic interactions between shocks and macro-variables have been empirically reviewed using innovation accounting.

Key Words: depreciation. Inflation. Pass-through. Open economy models. Structural VAR. Australia.

1.   INTRODUCTION

The two-country stochastic rational expectations model containing features of the open economy Mundell-Fleming model is used in this paper to establish the theoretical priors in order to check the plausibility of links between exogenous shocks and macro-variables such as real exchange rate, relative prices and relative output. The structural var (SVAR) methodology is used to identify the unobserved exogenous shocks invoking long-run classical neutrality postulates. The empirics of the dynamic response of the macro-variables linking real exchange rates and relative prices to shocks are analysed in terms of forecast error variance decompositions and impulse response functions. These empirics indicate: First, that the real exchange rate depreciation observed during the post-float period has been caused by real demand shocks resulting in deflation rather than in inflation as predicted by the pass-through perspective. Second, the real exchange rate movements caused by real demand shocks appear to be explained better by the equilibrium exchange rate theories rather than the rival disequilibria theories based on sticky prices. Third, the shocks impacting the macro-economy appear to have resulted in permanent rather than a temporary changes in the equilibrium exchange rate during the post-float period.

Since the Australian dollar (AUD) was floated in December 1983 the domestic currency has steadily depreciated when measured in terms of bilateral exchange rates of major trading partners and the trade weighted exchange rate. Many studies based on the pass-through perspective have warned that the exchange rate depreciation would after a time-lag unleash inflationary pressures. However, the observed facts do not support the assertions of the pass-through perspective as episodes of depreciation have co-existed with spells of deflation rather than inflation during the post-float era. The paper is motivated by the need to explain this paradoxical behaviour of the exchange rate that contradicts the assertions of the adherents of the pass-through perspective.

The pass-through perspective is based on the law of one price and it postulates that a small open economy such as Australia would be a price-taker in the world market. According to the law of one price the domestic price (P) of homogenous traded goods would be equal to the foreign price (P*) when converted by the spot exchange rate (S). The spot exchange rate (S) is defined as the domestic currency units required to purchase one unit of foreign exchange. Therefore, according to the law of one price

P =SP* (a)

If there was a complete pass-through of an exchange rate change the domestic price of imports would change one-to-one giving unity, when the economy is a price-taker, where P* is given, thus:

dP/dS = 1 (b)

In the case of exports complete pass-through would be zero given by:

dP*/dS =0 (c)

However, in practice the pass-through has been shown to be incomplete as only about 70 per cent of the exchange rate depreciation has been transferred to import prices according to Dwyer and Lam (1995). In the case of exports the pass thorough is even much smaller and has been estimated at 40 per cent by Swift (1998). The incomplete pass-through phenomenon has been widely researched and has been attributed to many factors such as: First, imperfectly competitive market structures where oligopolistic firms strive to maintain market share by "pricing-to-market" (Hooper and Mann 1989, Krugman1987). Second, due to hysteresis effects caused by the high "sunk-costs" that retard entry and exit by firms to the market in response to exchange rate changes. Third, due to the operation intra-firm trading trading strategies by multinational corporations to insulate against the high volatility of exchange rates experienced under a floating exchange rate regime. Both Australian and cross-country studies contend that a complete pass-through of depreciation to inflation occurs eventually after a lag of two years. During this time-lag the J-curve effects get worked out assuming that Marshall-Lerner elasticity conditions are met.

The empirical results presented in this paper challenge the assertions of the pass-through perspective that depreciation has caused inflation in Australia during the post-float period. The paper demonstrates that the pass-through perspective provides only one of several channels that link the exchange rate movements that occur due to exogenous shocks to and relative price changes in a small open economy such as Australia.

In this paper, we identify and analyse empirically the operation of other transmission channels besides the pass-through channel that links the depreciation of a currency to relative prices and

inflationary pressures in post-float Australia. Empirical studies that have been undertaken so far by Koya and Orden (1994) and Fisher (1996) to identify structural shocks and transmission mechanisms linking the exchange rate depreciation and inflation in Australia in a rather ad hoc manner. These previous studies have failed to check the empirical results against received theory. In this paper the empirical analysis is motivated in the context of the theoretical framework of the rational expectations open economy macro-model incorporating features of the Mundell-Fleming model as enunciated by Obstfeld (1985) and Clarida and Gali (1994). Therefore, this paper attempts to advance the frontiers empirical research on exchange rate depreciation links in Australia in at least four directions.

First, it exposes the pitfalls in pass-through perspective that links depreciation and inflation. Second, it provides the theoretical priors based on a stochastic rational expectations open macro-model to check the effects of exogenous shocks on the macroeconomy as stylised by macro-variables such as real exchange rate, relative prices and relative real outputs. Third, by empirically analysing the stochastic rational expectations open macro-economy model for Australia using the SVAR methodology this paper complements the empirical findings based on the model for USA by Clarida and Gali (1994) and for UK by Astley and Garrat (2000) . Fourth, the empirical evidence reported in this paper support the equilibrium exchange rate theories (Stockman 1987) that contend that real shocks rather than the disequilibrium theories (Dornbusch 1976, Mussa 1982) that contend that nominal shocks are important in explaining exchange rate movements under a floating exchange rate regime.

The rest of the paper is organised as follows: Section 1 presents the two-country open economy macro-model in the spirit of Mundell-Fleming that provides the theoretical framework for undertaking the empirical analysis of the transmission mechanisms that link exogenous shocks and real exchange rate behaviour. Section 2 explains the systems approach or the Blanchard-Quah (1989) structural vector autoregression (SVAR) methodology used in this paper to identify the unobserved exogenous shocks that impact on the macro-economy. Section 3 presents the empirical results of the study in terms of dynamic responses to exogenous shocks as captured by measures of forecast error variance decompositions, impulse response functions. Section 4 presents the conclusions and suggestions for improving the empirics.

In the SVAR empirics we analyse the dynamic response of macrovariables such as relative real outputs, the bilateral exchange rate and relative prices of Australia and her major trading partners to exogenous shocks. Specifically, in this study we identify three exogenous shocks: aggregate supply (AS-shock); aggregate demand i.e. real goods market (IS- shock); nominal money market (LM-shock). The identification of these various shocks are achieved by using the insights of natural rate hypothesis of classical economics which postulates that in the long-run on real shocks have permanent effects while nominal shocks have only transitory effects. SVAR modelling by Blanchard and Quah (1989) and Clarida and Gali (1994) uses such theory based restrictions to identify long-run effects of shocks on endogenous variables, whilst leaving the short-run dynamics of variables to unrestricted to be determined by the data generation process.

The SVAR empirics that illustrate the dynamic response of endogenous or the macro-variables to exogenous (real AD and nominal LM) shocks provide information to evaluate to examine the adequacy of the rival equilibrium and disequilibrium models of exchange rate behaviour. Furthermore, the empirics demonstrate whether shocks result in permanent changes or deviations from the equilibrium levels or temporary changes that result in a reversion to pre-shock equilibrium locus as has been analysed in other studies
(Lastrapes 1992).

2.   THE THEORETICAL FRAMEWORK

The stochastic rational expectations two-country open macro-economy model formulated by Obstfeld (1985) provides the theoretical framework for motivating the empirical analysis undertaken in this paper. The model contains all the features of the workhorse Mundell-Felming or IS-LM open economy models in widely used intermediate macroeconomic texts by Dornbusch *et al*. (2001) and Mankiw (2000). It has been applied for empirical analysis of the US economy by Clardia and Gali (1994) and for the UK economy by Astley and Garratt (2000). In this paper we complement those studies by performing similar empirics for the Australian economy during the post-float era.

The theoretical model that motivates our empirical analysis can be specified in terms of four equations, where the variables are defined in relative terms or in terms of domestic and foreign

country equivalents. Therefore, the log differences refer to difference between domestic and foreign equivalents and an asterisk notates the foreign variables.

$$y^d_t \quad = \quad \eta q_t - \sigma(i_t - E(p - p_{t-1})) + d_t \quad \text{(1) Open economy IS equation .}$$

$$(m_t - p_t) \quad = \quad y_t - \lambda i_t \quad \text{(2) Real money demand or LM equation}$$

$$i_t \quad = \quad \Delta s^e_t \quad \text{(3) Uncovered interest parity condition).}$$

$$p_t \quad = \quad (1-\theta)E_{t-1}p^e_t + \theta\, p^e_t \quad \text{(4) Price setting rule.}$$

Equation (1) is the open economy IS equation and it postulates that real domestic output relative to foreign output (y_t) is a positive function of the real exchange rate(q_t), a negative function of the real interest rate differential ($i_t - E(p - p_{t-1})$), and a positive function of relative domestic absorption (d_t). Equation (2), the demand for relative real money balances ($m_t - p_t$), is shown to be a positive function of relative real income (y_t) and a negative function of the nominal interest rate differential (i_t). Equation (3) defines the uncovered parity (UIP) condition which postulates that the expected change in the nominal exchange rate (Δs^e_t) is a function of the interest rate differential (i_t), assuming that risk premia are constant. Finally, equation (4) defines a price - setting rule, where relative price in period t, (p_t) is a weighted average of the expected equilibrium price in period t, (p_t ^{e}) and period (t-1), (p_{t-1} ^{e}). The parameter (θ) measures the degree of price flexibility. It ranges from perfect price flexibility when $\theta = 1$ to absolute price stickiness, when $\theta = 0$.

The long-run solution of the above theoretical model is obtained under the twin assumptions of rational expectations and perfect price flexibility. The exogenous variables relating to aggregate supply (y_t), aggregate money demand (m_t) are assumed to follow pure random walks. While aggregate real demand relating to domestic absorption (d_t) is assumed to follow a random walk with both a permanent and transitory component as shown below:

$$y_t = y_{t-1} + z_t$$
$$m_t = m_{t-1} + v_t$$
$$d_t = d_{t-1} + \delta_t + \gamma\delta_{t-1} \tag{5}$$

The long-run equilibrium solution of the model assuming the random shocks specified above can be given in terms of three endogenous variables following Clarida and Gali (1994: 26) thus:

$$y^e_t = y^s_t \tag{6}$$

$$q^e_t = (y^e_t - d_t)/\eta + \sigma\gamma\delta_t / \eta(\eta+\sigma) \tag{7}$$

$$p^e_t = (m_t - y^s_t) + \lambda\gamma\delta_t / (1+\lambda)(\eta+\sigma) \tag{8}$$

Equation (6) shows that relative output is determined by aggregate supply (AS) shocks. In the long run the AS-curve is vertical and output is at the natural rate. Only real shocks affect real output. The long run neutrality of money ensures that nominal money demand or LM shocks have zero effects on relative output. Equation (7), the long-run real exchange (q^e_t) is the solution obtained after substituting IS and AS shocks from (5) in equation (1). Equation (7) shows that the long run real exchange rate depreciates with positive aggregate supply (AS) shocks and negative real demand (IS) shocks. In the case of IS shocks only the permanent component (γ) has a long-run real exchange rate effect. Nominal money demand (LM) shocks have no long-run real exchange rate effects because the response of relative price and nominal exchange rate cancel each other out. Equation (8), relating to long-run relative price is obtained by transposing from the LM equation (2).

In the long run we consider the asymmetric effects of shocks on the domestic economy. A positive AS-shock will cause the AS-curve to shift to the right and result in a fall in relative prices (deflationary impact). A positive aggregate demand or IS-shock could cause the AD-curve to shift upwards resulting in a rise in relative prices (inflationary impact) due to effect of the temporary component ($\gamma\delta_t$). The permanent component of the IS-shock has no long-run effect on relative prices. A positive LM-shock could shift the AD-curve upwards and cause a rise in relative prices (inflationary impact) that is consistent with the predictions of the pass-through perspective.

The short-run equilibrium solution under sticky prices is derived by substituting the price adjustment rule (4) in the long-run solutions above, given $v=(1+\lambda)/(\lambda+\sigma+\eta)$ yielding:

$$y_t = y^e_t + v(\eta+\sigma)v(1-\theta)(\varepsilon_{m,t} - \eta\varepsilon_{s,t} + \alpha\gamma\delta_t),$$

$$q_t = q^e_t + v(1-\theta)(\varepsilon_{m,t} - \eta\varepsilon_{s,t} + \alpha\gamma\delta_t), \tag{9}$$

$$p_t = q^e_t - (1-\theta)(\varepsilon_{m,t} - \eta\varepsilon_{s,t} + \alpha\gamma\delta_t)$$

The response of the macro variables to shocks in the long and short-runs are summarised in Table 1. In the long-run a positive aggregate supply (+ $\varepsilon_{AS,t}$) increases relative output and causes a real depreciation and a decline in relative prices (deflation). In the short-run the same outcomes are replicated, but are markedly weaker due to sticky prices (see row 1, Table1). The model shows that real demand (IS) shocks have only temporary effects on relative prices in the long run. Only permanent IS shocks have long-run effects on the real exchange rates while temporary shocks are reversed by discounting that occurs in the foreign exchange market. Positive AS shocks leads to fall in relative prices and improvement in competitiveness and long-run real exchange rate depreciation. Table 1 summarises the long-run and short-run responses of endogenous variables to positive exogenous shocks.

Table 1 Long-run (LR) and Short-run (SR) response of macro-variables to positive shocks (+ ε_t)

Variable	y_t		q_t		p_t		s_t		S, L
+ Shock	LR	SR	LR	SR	LR	SR	LR	SR	
AS	+	(+)	+	(+)	-	(-)	+	(+)	S<L
IS temporary	0	(+)	0	(-)	+	(+)	-	(-)	S<L
IS permanent	0	(0)	-	(-)	0	(0)	-	(0)	S<L
LM	0	(+)	0	(+)	+	(+)	+	(+)	S<L

Notes: L: long-run; S: short run impacts

+: increase; -: decrease; 0: no change; < less than.

Note that the short-run shocks affect all the endogenous variables. The relative price effects on the short-run are less than their effects in the long run. The real exchange after a shock undershoots its long-run equilibrium rate. The nominal exchange rate may undershoot or overshoot the long-run equilibrium rate depending on the size of parameters in the open economy macro model.

The stochastic rational expectations two-country open macro-economy model thus provides the theoretical priors to examine empirically whether the dynamic behaviour of the macro-economy under various shocks is consistent with the predictions of the theoretical model.

3   THE SVAR IDENTIFICATION METHODOLOGY

In order to perform the empirical analysis we need to identify the unobserved exogenous shocks that impact the open macro-economy. In this paper we use the structural VAR (SVAR) methodology of Balanchard and Quah (1989) to identifying the exogenous shocks that impact the macro-economy as defined by the three endogenous variables relative output, real exchange rate and relative prices. The SVAR methodology is a general equilibrium or systems based approach that is free from simultaneity bias. The exchange rate dynamics it provides are more robust than those provided by the pass-through perspective based on a partial equilibrium approach.

The macroeconomy is first stylised in terms of a trivariate reduced from VAR (vector autoregression) which links the first difference of the three endogenous variables to unobserved structural shocks thus:

$$\Delta x_t = A(L)\, \varepsilon_t \tag{10}$$

The endogenous macro-variables are: $x_t = (\, y_t\, q_t\, p_t\,) =$ (relative output, real exchange rate, relative prices). The structural shocks are: $\varepsilon_t = (\varepsilon_{AS,t}\ \varepsilon_{IS,t}\ \varepsilon_{LM,\, t}) = (\,$ aggregate supply, aggregate demand, and nominal money). Here, $A(L)$ is a lag polynomial and $E(\varepsilon_t) = 0$ and covariance matrix $E(\varepsilon_t \varepsilon_t')$ $= \Sigma_\varepsilon,$ where, ε_t is a white-noise process such that $E(\varepsilon_t \varepsilon_{t+s}) = 0$ when $s \neq t$.

The empirical estimation of (10) is achieved by applying the Wold representation theorem and inverting it to derive the reduced form moving average representation (MAR) given below:

$$B(L)\Delta x_t = e_t \tag{11}$$

Where, $B(L) = A(L)^{-1}$ and $B(L) = B_0 - B_0 L - B_1 L^1 - \ldots - B_k L^k$, given that $B_0 = I_n$

Also $e_t = C\varepsilon_t$, that is the estimated innovations are functions of composite structural shocks. Therefore, recovery or a one-to-one mapping of e_t to structural shocks ε_t depends on the identification of C. The identification of C is achieved by imposing restrictions on the long-run

multiplier matrix A(1) which links the endogenous macro-variables to shocks thus in compact matrix form:

$$x_t = A(1)\varepsilon_t \tag{12a}$$

or alternatively in expanded form as:

$$
\begin{pmatrix}
y_t \\
q_t \\
p_t
\end{pmatrix}
=
\begin{pmatrix}
A_{11}(1) & A_{12}(1) & A_{13}(1) & \varepsilon_{t,AS} \\
A_{21}(1) & A_{22}(1) & A_{23}(1) & \varepsilon_{t,IS} \\
A_{31}(1) & A_{32}(1) & A_{33}(1) & \varepsilon_{t,LM}
\end{pmatrix}
\tag{12b}
$$

Since the VARs are estimated in first differences the impact of a shock of type i on the level form of the j-th macro-variable is the sum of the structural MA coefficients given by the elements of the long-run multiplier matrix A(1). If the i-th shock in the long-run neutral (has no effect) on the j-th macro variable, then the element should be $A_{ij}(1) = 0$.

The above system (12) comprises of n= 3 equations in n^2 =9 unknowns. Therefore, to close the system or achieve exact identification we need to impose 9 restrictions. We impose the required restrictions in three steps. First, we apply the Choleski decomposition, which postulates that macro variables are linked to contemporaneous shocks recursively. In this decomposition the assumptions orthogonality and unit variance render the elements of the long-run multiplier matrix A(1) upper triangular.

Therefore, the Choleski decomposition yields n(n+1)/2=6 restrictions. Second, the remaining n(n-1)/2=3 restrictions are imposed on the premise that the long-run aggregate supply curve is vertical at the natural rate of output. This implies that aggregate supply depends only on the real AS-shock and this implies that the two shocks, IS and LM shocks in the long-run have neutral effects on output (y_t). This means that the multipliers $A_{12}(1)=A_{13}(1)=0$, thus giving 2 restrictions. Third, the remaining restriction which incidentally allows us to distinguish between the real AS and IS shocks, is imposed using the assumption that LM shocks have no long-run effects on the real exchange rate (q_t). This implies that the multiplier $A_{23}(1)=0$. Thus, the SVAR methodology provides the 9 restrictions required for exact identification. Further details of the

SVAR long-run identification methodology are provided in the expositions by Keating (1992), Issac and Rapach (2001).

It should be noted that the SVAR methodology of Blanchard and Quah (1989) achieves identification by imposing theory consistent long run restrictions on the exogenous shocks that impact the endogenous variables. The SVAR methodology is superior to other identification methodologies. First, the Sims (1980) methodology achieves identification by imposing a Wold causal chain linking contemporaneous exogenous shocks to endogenous variables. The resulting Choleski decomposition has been chastised as mechanistic and semi-structural and bereft of economic content. Moreover the empirics are shown to be extremely sensitive to the ordering of the macro-variables in the VAR (Cooley and LeRoy, 1985). Second, Bernanke-Sims methodology due to Bernanke (1986) and Sims (1986) achieves identification by imposing direct restrictions on the short-run interactions based on theoretical insights. Third, Gali (1982) combines both short-run and long run restrictions to achieve identification. The SVAR methodology is better than the other rival identification methodologies on both theoretical and empirical grounds and therefore has been used in this paper.

4 EMPIRICAL RESULTS

The open economy model provides the theoretical priors to determine whether the application of the SVAR methodology to quarterly time-series data for the post-float period (1983:4-2000:2) yields exchange rate dynamics that have economic content.

The key macro-variables are relative output (y_t), real exchange rate (q_t), and relative prices (p_t) and in the empirical analysis they are in log difference form. The time-series properties of these variables were tested to check their stationarity and avoid spurious statistical inferences. The augmented unit root tests or ADF tests based on Dickey and Fuller (1979) indicated that the variables were nonstationary and needed to be first differenced to induce stationarity. The results of the unit root tests on the levels and first differences of the variables of interest are reported in Tables 2 and 3 below. Furthermore, the Johansen (1988) cointegration tests reported in Table 4 reveal the absence of cointegration amongst the variables justifying the use of an unrestricted VAR rather than vector error correction model (VECM). The lag lengths for the ADF unit root test were determined using the AIC and SBC criteria. The optimal lag length for the unrestricted

VAR modelling was determined by the application of the Sim's sequential likelihood ratio test (Sims 1980).

Table 2   ADF unit root test on levels of variables

Variable	Relative output	Real exchange rate	Relative prices
ADF(4)		Q	P
Australia-US	-2.31	-2.50	-3.76
Australia-Japan	-0.71	-3.66	-2.34
Australia-GB	-1.70	-3.42	-0.98
Australia-NZ	-1.98	-1.23	-4.54
95% critical value	For ADF with trend	--3.48	

Table 3   ADF unit root test on first differences of variables ADF(4) unless indicated otherwise

Variable	Relative output	Real exchange rate	Relative prices
ADF(4)		Q	P
Australia-US	-5.02	-3.71	-3.81
Australia-Japan	-4.85	-5.09	-5.23
Australia-GB	--3.24	-3.36	ADF(1)=--4.09
Australia-NZ	-4.67	-4.54	DF= -4.54
95% critical value	ADF no trend	-2.91	

Table 4 Johansen Cointegration tests

(Cointegration tests are based on unrestricted intercepts and trends. Test on null hypothesis: H0: r=0 cointegrating vectors)

Variable	$\lambda-$max	95% CV	$\lambda-$trace	95% CV
Australia-US	17.02	24.35	34.34	39.33
Australia-Japan	17.15	24.35	24.60	39.33
Australia-GB	21.76	24.35	31.85	39.33
Australia-NZ	22.77	22.04	39.66	34.87

The dynamic response of the macro-economic variables when impacted by exogenous shocks

Table 5   Forecast Error Variance Decompositions (FEVDs)

Australia – US Real Exchange Rate (q)							Australia – Japan Real Exchange Rate (q)							Australia – TWI Real Exchange Rate (q)						
Qtr	AS	se	IS	se	LM	se	Qtr	AS	se	IS	se	LM	se	Qtr	AS	se	IS	se	LM	se
1	44	29	24	27	31	26	1	10	25	81	26	9	14	1	5	9	87	17	8	17
4	22	24	56	26	23	21	4	8	23	81	23	11	12	4	3	8	91	12	5	10
8	9	21	80	22	10	12	8	6	23	88	22	6	7	8	2	9	95	10	3	6
12	9	22	83	22	7	8	12	3	23	93	22	4	5	12	2	9	96	10	2	4
16	13	23	82	23	5	7	16	2	23	95	22	3	4	16	2	10	97	10	2	3
20	14	24	81	23	5	7	20	2	23	96	22	2	3	20	2	10	97	10	1	3

Australia – US Relative Price (p)							Australia – Japan Relative Price (p)							Australia – TWI Relative Price (p)						
Qtr	AS	se	IS	se	LM	se	Qtr	AS	se	IS	se	LM	se	Qtr	AS	se	IS	se	LM	se
1	11	24	12	24	77	28	1	32	22	1	13	66	22	1	8	16	1	12	91	19
4	7	23	20	24	73	26	4	38	22	1	12	62	22	4	7	16	0	11	93	17
8	8	22	15	21	77	23	8	48	24	7	13	45	21	8	6	17	0	11	93	18
12	11	22	14	21	76	22	12	47	25	15	17	38	21	12	6	17	0	12	94	19
16	20	22	13	19	67	20	16	46	26	20	18	34	20	16	6	17	1	12	94	19
20	21	22	14	18	65	20	20	44	26	24	19	32	20	20	6	18	1	12	94	19

Australia – US Relative Output (y)							Australia – Japan Relative Output (y)							Australia – TWI Relative Output (y)						
Qtr	AS	se	IS	se	LM	se	Qtr	AS	se	IS	se	LM	se	Qtr	AS	se	IS	se	LM	se
1	43	30	40	28	16	22	1	90	21	3	19	7	12	1	87	17	1	6	11	16
4	76	19	15	15	9	10	4	90	19	6	17	4	8	4	92	10	2	4	6	9
8	85	16	9	13	6	8	8	85	19	12	18	3	5	8	97	5	1	2	3	4
12	85	16	20	13	5	7	12	90	15	8	14	2	4	12	98	3	1	1	2	3
16	89	15	8	11	4	7	16	93	12	5	11	2	3	16	98	2	0	1	1	2
20	89	15	7	11	4	7	20	93	9	4	9	1	2	20	99	2	0	1	1	1

Notes:
AS: Refers to positive real aggregate supply shocks.
IS: Refers to positive real aggregate demand shocks.
LM: Refers to positive nominal monetary shocks.
TWI: Trade weighted index.

relating to aggregate supply (AS), real aggregate demand (IS) and nominal monetary shocks (LM) have been analysed empirically using forecast error variance decompositions (FEVDs) for Australia and her major OECD trading partners (USA and Japan) and others as proxied by the real trade weighted index (TWI). The forecast error variance decompositions (FEVDs) indicate what percentage of the variation of the real exchange rate (q_t), relative prices (y_t) and relative output (y_t) are explained by each shocks. These shocks relate to real aggregate supply (AS), real demand (IS) and nominal money supply (LM) and have been reported at forecast horizons ranging from 1 to 20 quarters. The standard error (se) associated with each estimate of FEVD is also reported in the adjacent column (See Table 5).

Real exchange rates

The FEVDs results indicate that most of the variation in the real exchange rate (q_t) for all trading partners and the TWI index are explained mostly by the real demand (IS) shock for at all forecast horizons ranging from 1 to 20 quarters. In the long run at 20 quarters more than 80% of the variation in the real exchange rate (q_t) for USA, Japan and the TWI are explained by the real demand (IS) shock. Aggregate supply (AS) shock appear to be next in order in importance, where FEDVs explain 14% of the variation of real exchange rate in USA and 2% of its variation in the case of Japan and TWI after 20 quarters. The nominal money (LM) shock appears to be the least important in explaining real exchange rate variation accounting for only 5% of the FEVDs in USA, and 2% and 1% for Japan and TWI respectively, after 20 quarters. Thus, FEVDs reveal that real aggregate demand (IS) shocks predominantly explain the real exchange rate movements in Australia over the long run (See Table 5).

Relative prices

The FEVDs for relative prices (p_t) indicated that nominal monetary (LM) shock accounted for more than 65% of its variation after 20 quarters for USA, and more 94% for the TWI and about 32% for Japan. The nominal monetary (LM) shock emerged as the most important source of relative price movements for the trading partners of Australia during the post-float period. The supply (AS) shock was next in order of importance in explaining relative price movements, while the demand (IS) shock was the least important. AS shocks appeared to be more important in the case of Japan when compared to USA. The FEVDs indicate that for Australia the relative price movements were mainly explained by nominal monetary shocks and these results are consistent with those observed for USA and UK in other empirical studies (See Table 5).

Relative output

Aggregate supply (AS) shocks appeared to account for more than 89% of the movements in relative output (y_t) in the long-run or at forecast horizon of 20 quarters for all trading partners as indicated by the TWI. Next in order of importance in explaining variation of relative output at long forecast horizons were the IS shock and then the LM shock (See Table 5).

The FEVD empirics for Australia and her major trading partners are consistent with similar findings for the bilateral exchange rates for other countries such as the USA and her major trading partners (Clarida and Gali 1994) and for the UK and her major trading partners (Astley and Garratt 2000). It is noteworthy that during the post-float period in Australia, the real demand (IS) shocks emerged as the major cause of real exchange rate movements (q_t), while nominal monetary (LM) shocks were the dominant cause of relative price movements (p_t) and aggregate supply (AS) shocks were the dominant cause of relative output movements (y_t).

Real demand (IS) shocks accounted for a major component of the movements in the real exchange rate (q_t), while nominal monetary (LM) shocks emerged as the least important in explaining real exchange rate movements. In the case of relative price movements (p_t) nominal monetary (LM) shocks were the dominant source of its movements. This warrants the deduction that price movements may have been important in nominal exchange rate fluctuations as they do not appear to be unimportant in explaining the real exchange rate fluctuations during the post-float period in Australia.

Impulse response functions (IRFs).

The dynamic response of each of the macro-variable for a unit innovation (one standard deviation of the shock) is traced over a 20 quarter forecast horizon and the graphs are given in Figures 1 to 3 for Australia-United States, Australia-Japan and Australia-Rest-of-the world as proxied by the trade-weighted index (TWI). The dashed lines in the figures give the two-standard-error bands estimated on the basis of 500 bootstrap replications following the procedure of Runkle (1987). The dynamic responses are consistent with the priors prescribed by the stochastic rational expectations open macro-model.

The movements of endogenous variables in response to shocks appear to be consistent with prior expectations as real exchange rate fluctuates more than relative prices, which in turn fluctuates more than relative outputs.

Supply (AS) shocks

For Australia-US a positive aggregate supply (AS) shock results in a rise in relative output over the first 6 quarters and is associated with a fall in relative prices over the same period. The real exchange rate rises, that is, depreciates over the same period before settling at a new long-run equilibrium level. (See Fig. 1 Panel 1). For Australia-Japan a positive AS shock leads to a monotonic rise in relative output. Relative prices fall over the first 6 quarters and real exchange rate depreciates over the same period before reaching a new equilibrium. (See Fig. 2 Panel 1). For Australia and the rest-of-the world as proxied by the TWI, a positive AS shock leads to a rise in output during the first 4 quarters, relative prices fall and the real exchange rate depreciates and reaches a new equilibrium thereafter. (See Fig. 3, Panel 1). These dynamic responses of the endogenous variables to the exogenous AS-shock are consistent with the theoretical priors established by the open economy macro-model and are therefore impregnated with economic meaning.

Demand (IS) shocks

A positive IS shock causes real output to rise but with major fluctuations in the case of Australia-US. Relative prices decline over the first 6 quarters and real exchange rate depreciates over the same period (Panel 2, Fig. 1). In the case of Australia-Japan, a positive IS shock causes real output to rise over the first 8 quarters and relative prices fall over the first 4 quarters and then rise to a new equilibrium level, while real exchange rate depreciates over the first 4 quarters and reaches a new equilibrium thereafter. (Panel 2, Fig. 2). For Australia and the rest-of-the-world a positive IS shock causes relative output to rise during the first 2 quarters, relative prices also rise and the real exchange rate depreciates before settling at a new equilibrium level (Panel 2, Fig. 3).

The counterintuitive IS shock observed above should be interpreted as a negative shock to give it economic content. This is because the SVAR method does not pin down the sign of the elements of the principal diagonal of impulse response matrices, which in turn are based on the positive or negative roots of the solution of quadratic equation (Astley and Garrat 2000, Taylor 1999). In the Australian context the IS shocks should be interpreted as negative give it economic content as they are associated with the fiscal consolidation policies implemented during the post-float period.

Thus the dynamic response of the real demand or negative IS shocks result in depreciation and deflation and are consistent with the theoretical priors specified by the open macro model.

Money (LM) shocks

A positive nominal money (LM) shock causes some fluctuation in relative output in the short run but over the forecast horizon of 20 quarters, the relative output does not appear to change for Australia-US. Relative prices increase over the first 4 quarters and then decline to a new long-run equilibrium level. The real exchange rate depreciates during the first 2 quarters and sluggishly reaches a new equilibrium conjuring the picture that it is unaffected by the positive monetary (LM) shock . (Panel 3, Fig. 1). In the case of Australia-Japan nominal money (LM) shocks do not appear to cause a change in relative output over the whole forecast horizon. Relative prices appear to overshoot the long-run equilibrium during the first 4 quarters before reverting to its long-run equilibrium level. Similarly real exchange rates depreciates during the first 4 quarters and sluggishly adjust towards a long-run equilibrium level which indicates that the monetary shocks have no effect on the real exchange rate (Panel 3, Fig.2). In the case of Australia and rest-of-the world a positive money (LM) shock causes relative output to rise in the first 2 quarters before sluggishly reaching the long-run equilibrium level indicating that LM shock has no relative output effects. Relative prices rise in response to the monetary shock and reach higher relative price equilibrium. The real exchange rate depreciates and reaches a new long run equilibrium after about 8 quarters (Panel 3, Fig. 3).

Thus overall the impulse response empirics of Australia and her trading partners reveal that the positive nominal monetary (LM) shocks leads to real exchange rate depreciation and increase in relative prices with no perceptible effects on relative real outputs in the long run. Thus, if the economy is subject to positive monetary shocks the ensuing results appear to be consistent with the predictions of the pass-through perspective.

5   CONCLUDING OBSERVATIONS

The empirical results reported in this paper challenge the predictions of a number of recent studies based on the pass-through perspective for the post-float period in Australia. The analysis presented in the paper is grounded on the theoretical framework of a rational expectations

stochastic open macro-economic model which exhibits all the features of the work-horse open-economy Mundell-Fleming model.

The exogenous shocks impacting the economy have been identified using the structural var (SVAR) methodology by appealing to long-run classical neutrality postulates. The dynamic responses of macro-variables to shocks have been analysed using forecast error variance decompositions (FEVDs) and impulse response functions. The empirics show that real demand (IS) shocks have been the major cause of real exchange rate movements while nominal monetary (LM) shocks are the major cause of relative price movements during the post-float period in Australia.

The empirics reported in the paper have been generated using a systems or general equilibrium methodology and indicate that shocks affect exchange rate through a several transmission channels. The real IS and AS shocks have caused real exchange rate depreciation and fall in relative prices or deflation during the post-float period. Such findings contradict one-track predictions of the partial equilibrium pass-through perspective that depreciation causes rise in relative prices and inflation.

The empirics also provide insights on two other ancillary propositions. First, it is observed that during the post-float period, real demand (IS) shocks are the dominant cause of real exchange rate movements rather than nominal monetary (LM) shocks. These findings lend support to the equilibrium exchange rate theories emphasising real shocks (Stockman 1987) rather than the rival disequilibrium theories (Dornbusch 1976) emphasising nominal shocks as the critical determinant of exchange rate movements.

Second, during the study period, the real demand (IS) shocks while explaining real exchange rate movements played a minor role in explaining relative output or relative price movements. This warrants the deduction that real shocks caused permanent rather than temporary changes in the equilibrium exchange rate during the post-float period in Australia.

The empirical analysis presented in the paper has demonstrated that real demand (IS) shocks underpinned the real exchange rate depreciation observed during the post-float period and furthermore this depreciation was associated with relative price declines or deflation. These

findings are consistent with the theoretical priors of the open macro-model and observed facts during the post-float period for Australia and they contradict the assertions of the popular pass-through perspective that depreciation inevitably results in inflation. The findings based on open economy macro-economic theory and systems based identification of shocks offer policy guidelines for the analysis of the nexus between depreciation and inflation. This nexus operates through several transmission channels and the pass-through perspective is only one such channel and it did not provide a plausible explanation of the depreciation and deflation observed in Australia during the post-float period.

The systems approach based on SVAR modelling identifies the existence of several transmission channels that links exogenous shocks to endogenous macro-variables. The existence of multiple transmission channels rather than a single transmission channel linking depreciation caused by nominal shocks to inflation is an important revelation for policy making. In conclusion, we can suggest that empirical analysis followed in this paper can be refined further by addressing several methodological shortcomings. The long-run identifying restrictions given by the SVAR approach provides theoretically appealing dynamic responses in terms of forecast error variance decompositions and impulse response functions that can be checked against theoretical priors provided by a well articulated open economy macro-model. Nonetheless, there are at least three potential problems related to the long-run restrictions used for the identification of structural shocks. They relate to improper temporal aggregation, improper spatial aggregation, and the problems due to the imposition of infinite horizon restrictions on data generated by finite samples (Faust and Leper 1997). Improper temporal aggregation of structural shocks is likely to be more severe for annual data than quarterly data. Improper spatial aggregation of structural shocks can seriously confound the dynamics if fewer shocks structural shocks than are present in the data generation process are allowed for in the analysis. This could be akin to bias resulting from an omitted variable. But inclusion of irrelevant in a VAR could also result in serious problem (Abadir, Hadri and Tzavalis 1999). Some of these limitations could be surmounted by increasing the number of structural shocks expanding the dimensions of the SVAR analysis. Furthermore the temporal aggregation problem could be overcome by using monthly or high frequency data. Future research in this arena could address the above issues and provide more robust empirical insights on the exchange rate inflation dynamics in an open macroeconomy.

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