Exchange rate pass-through and inflation in Australia, China and India: A comparative study with disaggregated data

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Abstract

This article analyses the exchange rate shocks and its pass-through to various levels of prices in two emerging economies and one developed country by employing a structural VAR framework over the period 1990-2011. We assess the pass-through into import, export, producer and consumer prices in Australia, China and India in industries including mining, agriculture and manufacturing. We test whether the exchange rate pass-through to import prices is more complete in any particular sector and estimate the pass-through to consumer prices to investigate whether there is any linkage between the pass-through and the average inflation rate across these countries. The impulse responses indicate that exchange rates have less effect in the rising mining and natural resources prices in Australia than in China and India. Moreover, the pass-through of exchange rate to aggregate consumer prices is greater in China and India than Australia. This will have important policy implications for the monetary authorities.

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1 Introduction

Since the mid-twentieth century Australia's primary trade partners have shifted from US/Europe to Asia, with four out of five of Australia's top trading partners located in the Asian region. Natural and mining resources have been continuously exploited at increasing speeds, with the economic expansion accelerating in the region.[3] In recent years, consistent growth in demand from fast-growing economies in Asia, most notably China and India, has driven up the demand for Australian resources in the world market, and in turn increases the demand for the Australian dollar (AUD), which has led to the decade long appreciation of AUD in the recent past.[4] Moreover, Australia has been building strong economic linkages with Asia, the world's biggest and fastest growing regional economy, and actively participated in and promoted the regional integration with its

[3] According to the Australian Bureau of Statistics (ABS), Australia has abundant, high quality and diverse energy resources, and is the world's leading producer of bauxite and iron ore; the second largest producer of alumina, lead and manganese; the third largest producer of brown coal, gold, nickel, zinc and uranium; the fourth largest producer of aluminium, black coal and silver; and the fifth largest producer of tin. Resource exports, which include metal ores, coal and other mineral fuels, metals and gold, account for around 60 per cent of Australia's total value of exports in 2011.

[4] The Australian dollar (AUD) has started floating since December 1983 and is one of the most traded currencies in the world. The high demand for the Australian dollar has pushed it up against the major currencies since the early 2000s and it reached parity with United States dollar (USD) for the first time since becoming a freely traded currency in December 2010 and subsequently maintained a rate close to USD1.10 per AUD until May 2013 before dropping below parity. The exchange value of AUD against the Chinese Renminbi (RMB) was 4.2 in early 2001 and since then continuously rose up to 7.2RMB per AUD by the middle of 2011before showing a downward trend. With a similar pattern, the AUD has continuously appreciated over time against Indian Rupees from 22 Rupees level in March 2001 to about 62 Rupees per AUD by late 2013. In recent years Australia has seen remarkable growth in the trading relationship between China and India.

priority neighbors. The trade and investment ties between Australia, China and India have grown rapidly in recent years, with Australia's strength in exporting primary products, particularly minerals and fuels, as well as value added services to China and India, and in return importing back mostly manufactured goods from the two economies. Bilaterally, China has been Australia's largest two-way trading partner in goods and services since late 2007, and become India's largest trading partner since 2008. Further strengthening and deepening this relationship Australia has signed the free trade agreement (ChAFTA) with China in November 2014, and launched negotiations to conclude a Comprehensive Economic Cooperation Agreement (CECA) with India in 2011.[5] Upon success, the CECA is expected to further strengthen bilateral economic relations and promote businesses in both countries raising the volume of investment in India and Australia.

With the recent remarkable decade-long increase of the Australian dollar, low inflation and soft domestic demand in Australia, along with the high inflation and high domestic demand in China and India, it is important to raise questions about the magnitude and stability of exchange rate pass-through to import prices in these increasingly integrated resource-based three economies. The answers to such questions have both impor-

[5] Australia has nine FTAs currently in force, six of which are located in East Asia. The landmark China-Australia Free Trade Agreement (ChAFTA) was concluded in November 2014 and will enter into force when domestic processes in both countries have been completed. Australia?India FTA negotiations, formally known as the Australia?India Comprehensive Economic Cooperation Agreement negotiations launched in 2011, will cover investment and trade in goods and services, and are expected to be concluded in a year's time. Trade liberalization and complementarity of Australia's economy and the economies of China and India have resulted in extraordinary growth in bilateral trade over the past several decades. According to ABS, Australian merchandise trade with China has grown from around US$102 million in 1972 when diplomatic relations were formally established between Australia and China to US$140 billion in 2013, while China's share of Australia's total merchandise trade rose from 1 per cent in 1972 to almost 28 per cent in 2013. China is Australia's largest trading partner in terms of both exports and imports, and Australia is China's sixth largest trading partner, with 25 per cent of Australia's manufactured imports coming from China and 13 per cent of its exports being thermal coal to China. Australian merchandise trade with India has also expanded rapidly from US$1.65 billion in 2001 to US$11.6 billion in 2013. In 2013 Australia's goods exports to India totalled US$9.2billion, or 3.6 per cent of total goods exports, making India Australia's fifth-largest goods export market, and the total goods imports from India equalled US$2.3 billion in 2013, comprising just one per cent of Australia's total imports.

tant academic and policy implications for an integrated world and for an appropriate stance of monetary policy. The reasons for understanding pass-through to import prices relate to the connection between import prices and the various price levels, in particular, expectation of domestic inflation. Changes in exchange rate can generally be expected to impact various price levels including import, export, producer and consumer prices, and the inflation rate of an importing country. To assess the likely consequences of the AUD appreciation and to allow for more effective monetary policy, it is vital to understand and anticipate the changes in pass-through rates in the increasingly interdependent economies like the aforementioned trio.

Hence, this research presents a comparative study by exploring the literature relating to pass-through for import, export as well as domestic prices bilaterally in the increasingly integrated and interdependent economies of Australia, China and India for the period 1990-2011 by employing structural vector autoregressive (VAR) techniques with a disaggregated data set. The remaining part of the paper is organized as follows. Section 2 provides an overview of exchange rate pass-through, Section 3 discusses the analytical framework and Section 4 discusses data used in the analysis. Section 5 presents the empirical results. Section 6 provides some concluding remarks.

2 Exchange rate pass-through: An overview

An important issue for exchange rate pass-through (ERPT) is the extent to which exchange rate changes affect the prices of imported and exported goods and the domestic consumer prices, which is of a major concern for monetary policy. In theory, ERPT refers to the transmission of changes in exchange rate into import (export) prices of specific goods in the destination market currency. The pass-through effects of exchange rate changes on import prices will contribute to domestic inflation, while the export prices affect price competitiveness, hence net exports and real activity. ERPT is said to be incomplete if the import (export) prices change by less than one. Whether ERPT is incomplete or pervasive, it is expected that an appreciation of the currency reduces import prices and the reverse ensues in the case of depreciation (Tivig, 1996; Gagonon and Knetter, 1995; Varangis and Duncun, 1993; Krugman, 1987).

Since the 1970s, there has been a large number of studies investigating the reasons for incomplete exchange rate pass-through even in the long-run and why the degree of pass-through is different across countries and over time (see, for instance, Bouakez and Rebei, 2008; Choudhri and Hakura. 2006; Campa and Goldberg, 2005; Bailliu and Fujii, 2004; Gagonon and Ihrig, 2001). The existing literature on incomplete pass-through has demonstrated that incomplete pass-through appears to be not only a common, but also a widespread phenomenon. Ceglowski (2010) finds evidence of a significant decline in pass-through to US import prices from some, but not all, of the trading partners, and a growing divergence in the import price response to a uniform dollar decline. These differences rule out a universal decline in pass-through rates to bilateral US import prices. Gopinath et al. (2010) report that the pass-through rates for US imports are found to relate to the currency of pricing across countries and within disaggregated sectors. Most of the existing theoretical and empirical studies have focused predominantly on large economies, particularly the USA, Japan and Germany. However, for relatively small economies such as Australia and the Asian economies, the empirical research is rather scanty.

Traditionally it is believed that developing countries experience greater and more rapid pass-through of exchange rate changes than high-income countries. A recent study by Frankel et al. (2012) finds that the pass-through coefficients in poor countries declined significantly in the 1990s, and the downward trend among rich countries is much less, and for the CPI, it is not statistically significant. As a consequence, slow and incomplete pass-through is no longer exclusively a luxury of industrialized countries. Furthermore, Dees et al. (2013) report that the degree of pass-through for goods imported from emerging economies is significantly lower than for those from the developed economies. It should be noted here that the import price pass-through reflects the price behavior of foreign firms and this behavior may not be strongly related to the domestic inflationary environment. Thus, evidence on the pass-through to domestic prices (e.g., consumer price index (CPI)) would provide a more appropriate test of the Taylor view.

The degree of pass-through is an important issue in determining appropriate monetary policies of a country. A low ERPT provides greater freedom for pursuing an independent monetary policy and makes it easier to implement inflation targeting (Frankel et al., 2012; Choudhri and Hakura, 2006). Flamini (2007) and Adolfson (2007) also point out that the characteristic of ERPT may affect the choice of the measure of inflation that the central bank should target, either inflation involving exclusively domestic products or total inflation including imports. The magnitude of the pass-through affects the various prices at different levels of the production chain and is closely related to the ability of importers and producers to transfer their higher costs to consumers, which may eventually jeopardise price stability. However, most of the literature suggests that ERPT is essentially determined by microeconomic factors (e.g., demand elasticities, production cost, market structure etc.) and is exogenous to macroeconomic policy (Devereux and Engel, 2001; Goldberg and Knetter, 1995).

Taylor (2000) argues that the recently observed declines in the pass-through to aggregate prices are the result of a low inflation environment. In this view, the pass-through depends on the policy regime: a credible low inflation regime will automatically achieve a low pass-through. Recently, Parsons and Sato (2006) report that little pass-through is occurring in Southeast Asia and this lack of pass-through is more likely attributable to the fact that they are small countries in a relatively integrated market, rather than evidence of pricing to market. Slavov (2008) shows a similar finding that ERPT tends to decline in countries participating in a common currency arrangement, and currency boards do not appear to be different from currency unions ? both reduce the pass-through from depreciation to inflation. Winkelried (2014) finds evidence of a similar decline in the pass-through due to the establishment of a credible regime of low inflation in Peru.

This comparative study explores the pass-through for import, export as well as domestic prices bilaterally for the economies of Australia, China and India for the period 1990-2011. We employ structural vector autoregressive (SVAR) techniques to investigate the pass-through with a disaggregated data set. The objectives of this study are to (i) test whether the exchange rate pass-through to import prices is complete in mostly resource-based trading economies, (ii) estimate the pass-through to CPI to investigate whether there is any association between the pass-through and the average inflation rate across these countries, (iii) examine the pass-through in three major sectors, i.e. mining and natural resources, agriculture including processed products, and manufacturing to compare the degree of pass-through across the sectors. The main contribution of this study is that it investigates the pass-through to various prices along the distribution chain to assess producers' business strategy in an increasingly interdependent environment at such a highly disaggregated level. The study pursues a comparative analysis relating to the Australian economy where the main focus of monetary policy is inflation targeting.

Based on the analysis, we are in a position to evaluate the role of monetary policies in China and India and whether these countries require changing their monetary policy targets, especially in view of the increasing economic integration among these three economies. Such a study undoubtedly contributes to the available vast literature on ERPT relationship, and more importantly, to the debate between the US and China with regard to the Chinese trade surplus against the US even when its currency is appreciating. In addition, the results assist relevant studies that consider the impacts of market share and trade liberalization on pass-through rates, and have important implications for business firms and policy-makers in these economies. Methodologically, the use of the structural VAR model to examine exchange rate pass-through has some advantages over single equation methods. By investigating exchange rate pass-through into a set of prices along the distribution chain, the VAR model characterizes not only absolute but relative pass-through in upstream and downstream prices as well. The impulse-response functions (IRFs) from the VAR estimation are used to calibrate the key behavioral parameters that can help reproduce the pattern of pass-through and external adjustment in different sectors in these three countries. The VAR analysis potentially allows one to identify specific structural shocks affecting the system through the Cholesky decomposition of innovations.

3 Analytical framework

The main motive for this study is to assess the exchange rate pass-through for the prices of imports and exports and domestic inflation in Australia, China and India using the VAR approach which enables us to identify the specified shocks controlling for other factors at the most disaggregated level. We first examine the pass-through of exchange rate fluctuations to import prices, export prices, domestic producer and consumer prices in three different sectors across three countries using a standard VAR model specified below:

$$X_t = \phi + \Pi_1 X_{t-1} + \Pi 2 X_{t-2} + \ldots + \Pi_k X_{t-k} + \mu_t \quad (1)$$

where X_t denotes vector of endogenous variables, μ_t is a vector of innovations that may be contemporaneously correlated but are uncorrelated with their own lagged values and uncorrelated with all right-hand side variables, ϕ is a vector of constants and Π are matrices of coefficients to be estimated. Identification of the structural shock is achieved by appropriately ordering the variables of interest and applying the Cholesky decomposition to the variance matrix of the reduced form residuals μ_t. The Choleski decomposition encompasses the decomposition of the variance covariance matrix Ω of the reduced form residuals in a lower triangular matrix S. Thus, the $n(n-1)/2$ economic restrictions are imposed on the triangular matrix in order to identify the structural shocks where some of the structural shocks do not have contemporaneous impacts on other variables, where n denotes the number of endogenous variables. The literature on exchange rate pass-through typically includes interest rate or money supply in a VAR model to identify the monetary policy and GDP shocks to capture the demand side effects. Following McCarthy (2000), Hahn (2003) and Ito and Sato (2008), we set up the baseline model with the vector of six endogenous variables, i.e., oil price inflation ($oilp$), interest rate ($inrt$), industrial output (ip), bilateral exchange rate (exr), import price ($impi$), and domestic prices (p) for each country, and specify the relationship between the reduced-form VAR residuals (μ_t) and the structural shocks (ε_t) of the model as follows:

$$\begin{bmatrix} \mu_t^{oip} \\ \mu_t^{inrt} \\ \mu_t^{ip} \\ \mu_t^{exr} \\ \mu_t^{impi} \\ \mu_t^{p} \end{bmatrix} = \begin{bmatrix} S_{11} & 0 & 0 & 0 & 0 & 0 \\ S_{21} & S_{22} & 0 & 0 & 0 & 0 \\ S_{31} & S_{32} & S_{23} & 0 & 0 & 0 \\ S_{41} & S_{42} & S_{43} & S_{44} & 0 & 0 \\ S_{51} & S_{52} & S_{53} & S_{54} & S_{55} & 0 \\ S_{61} & S_{62} & S_{63} & S_{64} & S_{65} & S_{66} \end{bmatrix} \begin{bmatrix} \varepsilon_t^{oip} \\ \varepsilon_t^{inrt} \\ \varepsilon_t^{ip} \\ \varepsilon_t^{exr} \\ \varepsilon_t^{impi} \\ \varepsilon_t^{p} \end{bmatrix} \quad (2)$$

Variables ordered in the base model are to examine how the identified shocks contemporaneously affect their corresponding variables and those variables that are ordered at a later stage, but have no impact on those that are ordered before. Oil price inflation and industrial output reflect the real sector of the economy whereas interest rate is included to examine the impact of monetary policy. Oil price shock is ordered first because the reduced-form residuals of oil prices are unlikely affected contemporaneously by any other shocks except oil price shock itself, while it may affect the reduced form residuals of all equations and thus all variables in the system contemporaneously.[6] Monetary shock is captured by the change in interest rate and ordered next to allow for a contemporaneous impact of monetary policy shocks on industrial output and the exchange rate. The ordering is motivated by the observation that monetary policy shock would affect prices at different stages contemporaneously and is the main contributing factor to domestic inflation.[7] In addition, Kim and Roubini (2000), Hahn (2003), Kim and Ying (2007) and Ito and Sato (2008) deem exchange rate as a forward-looking asset price and assume that the exchange rate tends to respond fairly promptly and contemporaneously to macro-economic shocks. This ordering further implies that monetary policy does not react to realized inflation but to expected inflation and may thus affect prices at different stages contemporaneously. The output variable is ordered prior to the exchange rate and domestic prices to allow the exchange rate to

[6] All the three economies have a high dependence on imported oil. With their rapid economic growth, energy demands in China and India are galloping. With China being the second-largest consumer and India the fourth largest consumer of oil in the world, China's oil dependence rate has reached 57.5% in 2011, and India's current dependency on foreign oil exceeds more than 75% which is expected to grow to 90% by 2025, according to UNESCAP. The increasing dependence on imported oil has made both economies highly vulnerable to external shocks. Australia is richly endowed with energy resources, having vast reserves of coal, national gas and uranium, but has only 3.9 billion barrels of proved oil reserves, or 0.2% of world total. According to the Australian Mines and Metals Association, Australia has only one decade of known oil resources at current production rate. Australian refineries are almost entirely dependent on imported oil. Australia's growing dependency on imported oil, and easily disrupted or fractured supply chains, is an increasing economic and strategic vulnerability.

[7] For the purpose of robustness check, the VAR model using two different orderings(i. e. placing interest rate respectively after industrial production and the exchange rate) have been estimated. The results (available upon request) show that the responses of trade and domestic prices to exchange rate shocks are very similar across different orderings of VAR for all the three economies, which is consistent with the test results for Korea, Malaysia, Singapore and Thailand in Sek and Kapsalyamova (2008) and for Indonesia in Ito and Sato (2008).

respond contemporaneously to, among others, the demand shocks in the system. Also due to the lagged availability of output data, it is more reasonable to allow for a contemporaneous impact of monetary policy shocks on industrial output.

Usually, the literature on the exchange rate pass-through places the domestic prices at the bottom of the VAR ordering, so that the price variables are contemporaneously affected by all other shocks while the price shock has no contemporaneous impact on the other variables. Following the literature, we place the domestic prices including CPI and PPI at the bottom of the VAR ordering with the assumption that the price variable is contemporaneously affected by all other shocks while the price shock has no contemporaneous impact on the other variables (see Hahn, 2003). Since exchange rate and domestic prices variables are the main focus of the analysis, we employ and order different price variables in the VAR model according to the distribution chain to assess the pass-through effect of the exchange rate change in the empirical analysis. In the second step, we repeat the same procedure for three different sectors i.e., mining, agriculture and manufacturing. Finally, we replace the export price in place of import price to examine the pass-through effect of exchange rate.

4 Data

The study uses the unit values of bilateral exports and imports between the concerned economies as proxies for the bilateral import and export prices. We classify bilateral trade in commodities into three broad sectors, namely mining and natural resources, agriculture and processed products, and manufacturing sector. All data is in monthly frequency, collected from China's Bureau of Customs, Directorate General of Commercial Intelligence and Statistics, Government of India, and Australian Bureau of Statistics. Monthly data for each country for industrial production, producer price, consumer price, exchange rate and interest rate is obtained from the International Monetary Fund, International Financial Statistics, National Bureau of Statistics of China, Bank of International Settlements, and Reserve Bank of Australia respectively, covering the period from 1990:01 until 2011:03. The oil price data in terms of the US dollar is obtained from

Datastream. For the purpose of this study the bilateral cross exchange rates are calculated from the normally quoted exchange rate against the US dollar. All data is in monthly frequency, and is expressed in natural logarithms. The descriptive statics of the variables are reported in the appendix Table A1.

In order to assess the time series properties of the data, we conduct both standard and seasonal unit root tests. As a standard measure we apply both the Augmented-Dicky-Fuller (ADF) and Phillips Perron (PP) tests for unit roots. Table 1 reports the results for the standard unit root tests. We select the lag length following Akaike Information Criteria (AIC). We also report the results with the first-differenced series to confirm that all the variables under investigation are I(1). The regression equation for unit root test includes both intercept and trend. From Table 1, we can infer that CPI for all three countries, PPI and industrial production for India, interest rate for China and India and bilateral exchange rates series contain unit roots in levels and are non-stationary. However, all variables in the first-difference are stationary. In addition to standard unit root test, we conducted the HEGY tests for unit roots at seasonal frequencies. The HEGY seasonal unit root tests confirm these results and further indicate that we can reject unit roots at the 5% level at all the seasonal frequencies with the exception of zero frequency, although the results are not reported here.[8] Given these properties of the data, the VAR model in the first differences of the non-stationary variables is considered as an appropriate specification of the models. This framework allows for examining underlying dynamic inter-relations among prices at different stages of distribution and other variables of interest, and enables to trace the dynamic responses of prices to external shocks, i.e. it captures both the size as well as the speed of the pass-through (see Hahn, 2003). The choice of using the VAR model in this study also considers the facts that our analysis focuses on the short-term dynamics rather than the long-term equilibrium relationships between variables, and is constrained by the short-sample periods of the disaggregated dataset from these countries.

[8] The results of the HEGY test based on Franses (1991) and Franses and Hobijn (1997) will be available from authors upon request.

Table 1. The results of unit root tests

Panel A: Augmented Dickey Fuller

Variable	Australia		India		China	
	Lag	Test-Stat	Lag	Test-Stat	Lag	Test-Stat
$impi(1)$	0	-16.050***	1	-7.761***	12	-5.064***
$\Delta impi(1)$	6	-11.688***	7	-10.411***	11	-7.896***
$impi(2)$	3	-4.551***	2	-3.886**	0	-3.0386
$\Delta impi(2)$	3	-13.326***	2	-14.618***	0	-13.769***
$impi(3)$	2	-5.711***	0	-13.816***	13	-6.421***
$\Delta impi(3)$	2	-16.338***	6	-11.404***	12	-5.012***
$expi(1)$	0	-15.388***	0	-7.024***	3	-3.022
$\Delta expi(1)$	11	-9.802***	1	-15.764***	11	-7.767***
$expi(2)$	0	-16.686***	0	-3.3174*	0	-12.816***
$\Delta expi(2)$	4	-13.760***	0	-15.514***	3	-12.996***
$expi(3)$	1	-5.417***	3	-3.471**	9	-0.2162
$\Delta expi(3)$	1	-16.273***	9	-7.421***	8	-9.024***
cpi	7	-0.968	12	-0.057	12	-1.906
Δcpi	6	-5.009***	11	-2.528	11	-4.672***
$oilp$	0	-13.682***	0	-13.682***	0	-13.748***
$\Delta oilp$	9	-10.368***	9	-10.368***	9	-10.366***
ppi	1	-7.338***	1	-0.571	1	-4.224***
Δppi	2	-14.108***	0	-11.669***	0	-5.910***
$inrt$	2	-3.993***	3	-1.831	0	-1.477
$\Delta inrt$	2	-6.896***	2	-11.694***	0	-14.585***
ip	1	-4.399***	13	-1.044	3	-3.791**
Δip	2	-16.538***	12	-3.608***	2	-14.027***
$exr_{A\text{-}C}$	1	-2.512				
$\Delta exr_{A\text{-}C}$	0	-12.716***				
$exr_{A\text{-}I}$			1	-2.717*		
$\Delta exr_{A\text{-}I}$			0	-12.610***		
$exr_{C\text{-}I}$					0	-2.253
$\Delta exr_{C\text{-}I}$					0	-13.99***

Panel B: Phillips-Perron Test Statistic

Variable	Australia		India		China	
	Bandwidth	Test-Stat	Bandwidth	Test-Stat	Bandwidth	Test-Stat
$impi(1)$	1	-16.049***	5	-13.959***	4	-3.692**
$\Delta impi(1)$	43	-105.347***	56	-98.288***	2	-16.124***
$impi(2)$	9	-13.268***	10	-11.822***	4	-3.174*
$\Delta impi(2)$	25	-63.571***	33	-71.300***	1	-13.768***
$impi(3)$	10	-12.141***	2	-13.817***	6	-3.236*
$\Delta impi(3)$	10	-34.196***	39	-73.461***	5	-8.398***
$expi(1)$	6	-15.534***	5	-7.022***	10	-10.043***
$\Delta expi(1)$	51	-85.951***	22	-30.334***	28	-62.859***
$expi(2)$	4	-16.715***	4	-3.514**	7	-13.464***
$\Delta expi(2)$	51	-124.235***	0	-15.513***	71	-130.565***
$expi(3)$	9	-9.594***	6	-3.424**	11	-5.371***
$\Delta expi(3)$	18	-46.139***	4	-8.807**	42	-18.904***
cpi	8	-0.553	0	-2.099	8	-1.730
Δcpi	4	-10.487***	1	-11.588***	4	-11.536***
$oilp$	8	-13.521***	8	-13.493***	8	-13.583***
$\Delta oilp$	251	-190.554***	250	-198.196***	255	-189.885***
ppi	8	-12.546***	5	-0.212	8	-3.506**
Δppi	42	-76.793***	3	-11.808***	1	-5.999***
$inrt$	10	-4.479***	11	-1.935	7	-1.833
$\Delta inrt$	10	-15.638***	15	-14.843***	5	-14.664***
$exr_{A\text{-}C}$	5	-2.397				
$\Delta exr_{A\text{-}C}$	2	-12.676***				
$exr_{A\text{-}I}$			5	-2.381		
$\Delta exr_{A\text{-}I}$			3	-12.556***		
$exr_{C\text{-}I}$					5	-2.627*
$\Delta exr_{C\text{-}I}$					3	-13.987***

Notes: i) impi(1), impi(2) and impi(3) and expi(1), expi(2) and expi(3) represent import and export prices for mining and natural resources, agriculture and processed products and manufacturing sector, respectively. ii) ***, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.

5 Empirical results

5.1 Import price pass-through

As discussed above, the model is estimated using structural VAR estimation technique consisting of seven variables i.e. oil price inflation, interest rate, industrial output, exchange rate, import/export price, PPI and CPI. The VAR model estimates the degree of pass-through from the exchange rate shock to the three price variables, namely, import price (*impi*), producer price index (*ppi*), and consumer price index (*cpi*) for three different sectors (mining and natural resources, agriculture and processed products, and manufacturing sector) in each economy.

The VAR estimation results show that the adjusted R^2 values for the price variables for the three industries vary from 0.15 to 0.31, while those for the rest of the equations take on values from 0.09 to 0.38.[9] The response of domestic inflation to interest rate and oil price changes are both positive and statistically significant in the case of Australia-China and China-India, taking on values ranging from 0.002 to 0.006 for interest rate and 0.005 to 0.012 for oil price, but not significant in the case for Australia-India. The coefficients relating import and export prices, PPI and CPI to exchange rates with one lag are all positive but statistically significant only in the case of Australia-India. The coefficients with two lags of the exchange rates are all negative and insignificant except in the case of Australia-China. Since the focus of this study is on the responses of the concerned variables to shocks and speed of adjustment, the reduced form residuals from the VAR are orthogonalized using the Cholesky decomposition. We use the impulse response analysis and variance decomposition to assess the pass through from exchange rate changes to prices. In particular, we first examine the impulse responses of the price variables due to exchange rate shock and then estimate the variance decomposition of the variables under examination.

In this subsection we estimate the VAR model specified previously and examine the degree of pass-through from the exchange rate shock to the three price variables, namely, import price (for three different sectors i.e. *imp*1, *imp*2 and *imp*3), producer price index (*ppi*) and consumer price index (*cpi*) in each economy at the bilateral level, i.e. Australia-China, India-Australia and China-India.[10] The lag order of the VAR model is selected based on the Akaike information criterion (AIC). We first estimate

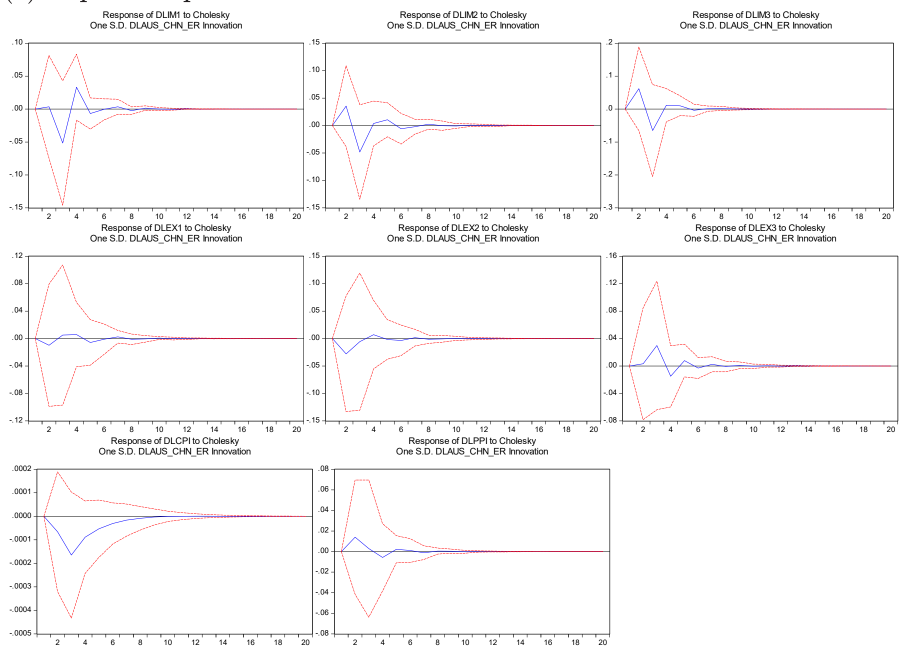
9 The results are available upon request from the authors.

10 Australia-China bilateral relationship for example, is defined as Australia's exports to China and imports from China. Due to data limitation, we do not differentiate any possible re-exports via Hong Kong from China's total exports to Australia and India.

the baseline models, and then analyse the impulse response functions of a variable in response to the shock over a period of 20 months. As the bilateral exchange rate is used for each bilateral trade countries and is defined indirectly as number of units of the second currency equivalent to the one unit of the first currency,[11] an increase in the exchange rate implies an appreciation of the first currency and depreciation of the second country concerned. Figure 1 plots the exchange rate shocks and its impact on the variables estimated by imposing long-run restrictions on the structural VAR model. The exchange rate shock is standardised to 1% shocks. The vertical axis in Figure 1 reports the approximate percentage change in the variables in response to one standard deviation innovation. The solid line in each graph is the estimated response while the dotted lines denote a two standard error confidence band around the estimate.

Figure 1. Impulse responses of price variables to the exchange rate shocks

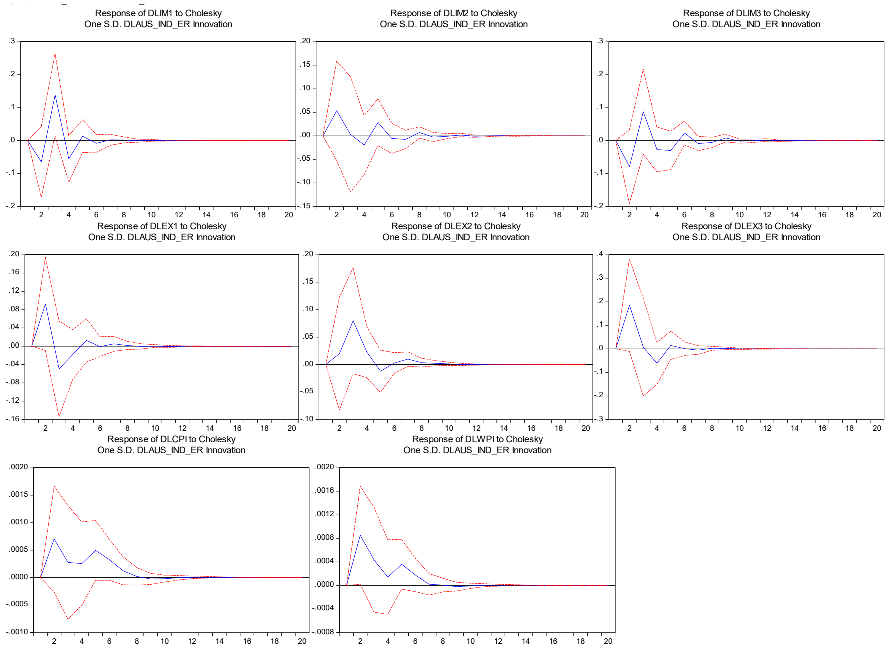
(a) Impulse response for AUS-CHINA



[11] For example, the Australia-China exchange rate is defined as one unit of Australian dollar equivalent to number of units of Chinese Renminbi. However, the India-Australia exchange rate is defined as one unit of Australian dollar equivalent to number of units of Indian rupees.

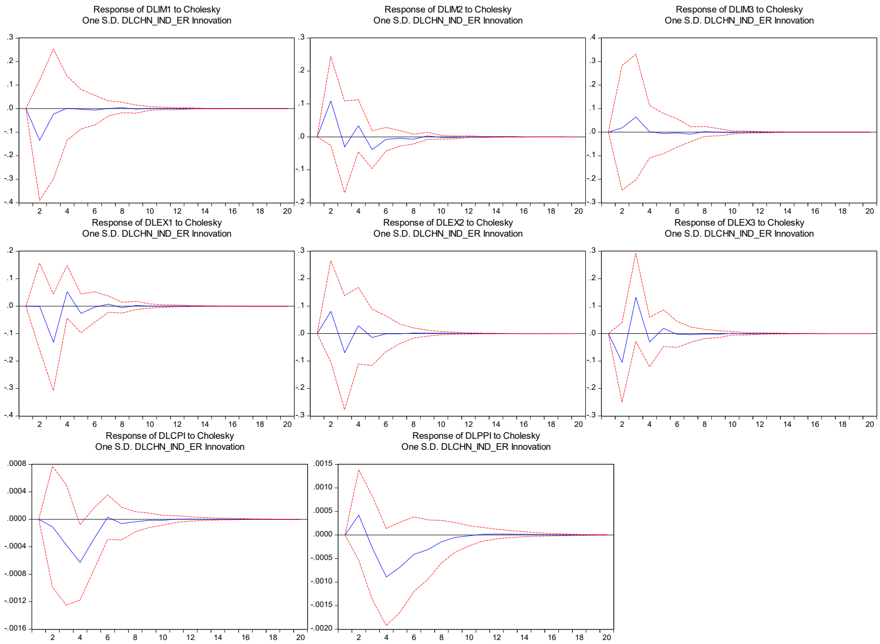
Note: The solid blue line shows the impulse response of the concerned variables to a 1% exchange rate shock. The dotted red lines indicate a 2 SE confidence band around the estimate. DL denotes first difference of each variable. DLIMP1, DLIMP2 and DLIMP3 and DLEX1, DLEX2 and DLEX3 represent first differenced import and export prices for mining and natural resources, agriculture and processed products and manufacturing sector, respectively.

(b) Impulse response for India-Australia



Note: The solid blue line shows the impulse response of the concerned variables to a 1% exchange rate shock. The dotted red lines indicate a 2 SE confidence band around the estimate. DL denotes first difference of each variable. DLIMP1, DLIMP2 and DLIMP3 and DLEX1, DLEX2 and DLEX3 represent first differenced import and export prices for mining and natural resources, agriculture and processed products and manufacturing sector, respectively.

(c) Impulse response for China-India



Note: The solid blue line shows the impulse response of the concerned variables to a 1% exchange rate shock. The dotted red lines indicate a 2 SE confidence band around the estimate. DL denotes first difference of each variable. DLIMP1, DLIMP2 and DLIMP3 and DLEX1, DLEX2 and DLEX3 represent first differenced import and export prices for mining and natural resources, agriculture and processed products and manufacturing sector, respectively.

It can be seen from Panel (a) of Figure 1, the response of import prices in Australia to the exchange rate shock shows no impact in the mining and natural resource sector for the initial two months and then it turns negative for a month before turning positive. The results indicate that there is no pass through effect on import price for the mining sector in Australia, which can be explained by the monopoly power that Australian mining giants enjoy in dealing with Asian countries. For the agriculture and manufacturing sectors the response is positive for the initial months suggesting that an appreciation of the AUD increases the import price in these sectors. This finding is inconsistent with the theory, but seems to be consistent with the observation that the strong AUD in the last few years did not lead to falls in the domestic prices of imports (especially imported vehicles and electronic products) in Australia. On the other hand, the response of import prices to the exchange rate shock in India and China shows a similar pattern but is short lived in most of the cases. As can be seen in Panels (b) and (c) in Figure 1, the large negative effects in the initial months are found in the manufacturing sector in India and in the mining and natural resources sectors in China. In particular, the import price for the natural resources and mining sector in India decreases with appreciation of the Chinese Renminbi (RMB) against Indian rupees, suggesting that Chinese exporters in the resources sector are more likely to absorb the price shocks that result from the RMB appreciation to retain their export market. This is also true in China's agricultural sector.

Now we turn to the impact of the exchange rate shock on the domestic prices. As can be seen from Panel (a) of Figure 1, CPI shows a negative response to the exchange rate shock in Australia with an increasing trend over time before dying out 9 months later, implying that the exchange rate does matter for domestic inflation in Australia. In other words, an increase in the Australian dollar decreases the import price and in turn decreases the domestic prices, which is quite consistent with the reality. Likewise, the response of CPI is positive and lasting for about a year in India, indicating that depreciation of the Indian rupee leads to an increase in CPI and imported inflation. This finding confirms that exchange rate variation does matter for domestic price variation in India, especially in recent years. For the China-India pair, the Chinese CPI is found to be negatively affected by the exchange rate shock, with the negative response lasting for over 6 months before gradually dying out. This finding has important policy implication in dealing with high domestic inflation.

The impulse responses of PPI to the exchange rate shock show a similar pattern in Australia and China, namely rising in the first few months and then falling and gradually fading out in subsequent months. In comparison, the shock impact on PPI is much larger than that on CPI in both countries, which is consistent with our expectation that the transmission of exchange rate shocks to domestic prices is declining along the price chain. On the other hand, the impulse response of India's WPI to the exchange rate shock is positive and remains effective up to 10 months. It is also found that the response for WPI is much larger than that for CPI, and again shows a declining trend along the price chain.

Thus, the pass-through to import price in Australia is the highest in the manufacturing sector (close to 10 per cent), followed by the agriculture and processing sector, and the least effect is in the mining and natural resources sector. On the other hand, the maximum response in India and China is in the mining and natural resources sector. The degree of the pass-through to import price is greater than CPI and PPI in all three economies. Moreover, the degree of pass-through to CPI is found greater in China and India than in Australia, which is likely due to the gradual reductions of fiscal subsidy in fuel and natural gas in both countries. We have also investigated the impact of exchange rate shocks on trade and domestic prices using dummy variables for the Asian crisis in 1997 and the change in the Chinese exchange rate system in 2005 but the results remain similar.[12]

In order to estimate the dynamic ERPT elasticity or coefficient from the impulse response function, we divide the cumulative change in each price variable by the cumulative change in the exchange rate shock across the specified time horizon, which can be defined as:[13]

$$PT_{t,t+j}=\sum_{j=1}^{T} \Delta P_{t,t+j} / \sum_{j=1}^{T} \Delta ER_{t,t+j}$$

Where $\Delta P_{t,t+j}$ denotes the impulse response of the price change to the exchange rate shock after j months and $\Delta ER_{t,t+j}$ stands for the corresponding impulse response of the exchange rate change. The dynamic ERPT coefficient, $PT_{t,t+j}$, represents the predicted adjustment of prices after j months to the initial exchange rate shock normalized by the corresponding responses of the exchange rate change. Table 2 reports the dynamic ERPT elasticities for the price variables in these three economies. Given the indirect quotation of the exchange rate, negative pass-through implies that devaluation of the home currency will lead to an increase in prices.

12 The results are not reported here but will be available upon request from authors.

13 Belaisch (2003), Faruqee (2006) and Ito and Sato (2008) have applied this approach to assess the dynamic ERPT elasticities.

Table 2. The Results of Dynamic ERPT

Panel (a): Australia-China

Period	1	5	10	15	20
DLPPI	0	0.437	0.45	0.453	0.453
DLCPI	0	-0.012	-0.014	-0.014	-0.014
DLEX1	0	-0.146	-0.125	-0.129	-0.128
DLPPI	0	0.468	0.476	0.48	0.48
DLCPI	0	-0.012	-0.014	-0.014	-0.014
DLEX2	0	-0.897	-0.992	-1	-0.999
DLPPI	0	0.563	0.494	0.5	0.499
DLCPI	0	-0.011	-0.013	-0.013	-0.013
DLEX3	0	0.855	0.823	0.832	0.831
DLPPI	0	0.475	0.482	0.483	0.483
DLCPI	0	-0.013	-0.014	-0.014	-0.014
DLIMP1	0	-0.697	-0.621	-0.624	-0.624
DLPPI	0	0.396	0.461	0.461	0.461
DLCPI	0	-0.012	-0.014	-0.014	-0.014
DLIMP2	0	0.044	-0.177	-0.16	-0.161
DLPPI	0	0.405	0.411	0.418	0.417
DLCPI	0	-0.012	-0.014	-0.014	-0.014
DLIMP3	0	0.587	0.562	0.566	0.565

Note: DL denotes first difference of each variable. DLIMP1, DLIMP2 and DLIMP3 and DLEX1, DLEX2 and DLEX3 represent first differenced import and export prices for mining and natural resources, agriculture and processed products and manufacturing sector, respectively.

Panel (b): India-Australia

Period	1	5	10	15	20
DLPPI	0	0.059	0.063	0.063	0.063
DLCPI	0	0.057	0.069	0.069	0.069
DLEX1	0	1.245	1.398	1.382	1.382
DLPPI	0	0.068	0.072	0.072	0.072
DLCPI	0	0.054	0.067	0.067	0.067
DLEX2	0	3.647	4.153	4.153	4.155
DLPPI	0	0.063	0.065	0.066	0.066
DLCPI	0	0.061	0.07	0.071	0.071
DLEX3	0	4.872	4.708	4.714	4.715
DLPPI	0	0.059	0.059	0.059	0.059
DLCPI	0	0.034	0.044	0.044	0.044
DLIMP1	0	1.138	0.948	0.937	0.937
DLPPI	0	0.057	0.059	0.06	0.06
DLCPI	0	0.027	0.04	0.04	0.04
DLIMP2	0	2.33	1.953	1.994	1.996
DLPPI	0	0.054	0.056	0.057	0.057
DLCPI	0	0.027	0.039	0.039	0.039
DLIMP3	0	-1.707	-1.206	-1.204	-1.21

Note: DL denotes first difference of each variable. DLIMP1, DLIMP2 and DLIMP3 and DLEX1, DLEX2 and DLEX3 represent first differenced import and export prices for mining and natural resources, agriculture and processed products and manufacturing sector, respectively.

Panel (c): China-India

Period	1	5	10	15	20
DLPPI	0	-0.097	-0.16	-0.155	-0.154
DLCPI	0	-0.094	-0.101	-0.1	-0.1
DLEX1	0	-7.172	-7.184	-7.12	-7.123
DLPPI	0	-0.174	-0.291	-0.29	-0.288
DLCPI	0	-0.091	-0.117	-0.118	-0.117
DLEX2	0	1.496	1.667	1.76	1.754
DLPPI	0	-0.065	-0.136	-0.133	-0.133
DLCPI	0	-0.08	-0.09	-0.09	-0.089
DLEX3	0	0.964	0.352	0.294	0.301
DLPPI	0	-0.143	-0.227	-0.222	-0.221
DLCPI	0	-0.127	-0.138	-0.137	-0.136
DLIMP1	0	-10.403	-10.599	-10.548	-10.544
DLPPI	0	-0.137	-0.217	-0.217	-0.216
DLCPI	0	-0.125	-0.135	-0.135	-0.135
DLIMP2	0	4.637	3.514	3.435	3.446
DLPPI	0	-0.157	-0.246	-0.241	-0.24
DLCPI	0	-0.107	-0.122	-0.12	-0.12
DLIMP3	0	5.154	4.359	4.347	4.357

Note: DL denotes first difference of each variable. DLIMP1, DLIMP2 and DLIMP3 and DLEX1, DLEX2 and DLEX3 represent first differenced import and export prices for mining and natural resources, agriculture and processed products and manufacturing sector, respectively.

It is shown in Table 2 that exchange rate pass-through to trade prices and PPI as well as CPI is incomplete though varying across the three economies, particularly in the short run. The degree of the pass-through elasticities of IMP are the largest and less than one in Australia and the elasticity values are negative in the mining and natural resources and agriculture sectors but positive relations exist in the manufacturing sector. Import prices are highly elastic in China, in particular, in the natural resources sector. This is to a certain extent due to the competition in the resources market. Pass-through in consumer prices is the smallest in all the cases. The industry level data show similar results. In particular, for all the three countries, pass-through to the trade prices is the largest in the mining and manufacturing industries and least in the agricultural sector, and pass-through to the domestic prices is similar in all the three sectors. Our findings are consistent with the expectation that ERPT to prices diminishes along the distribution chain, and is also industry based, a reflection of different business strategies across sectors. We also find evidence that exchange rate shock contributes to domestic inflation.

5.2 Export price pass-through

Figure 1 shows the impulse response of the export prices to exchange rate shock in all three economies as well. As can be seen in Panel (a) of Figure 1, the response of export prices in the mining and natural resources and agriculture sectors in Australia decreases during the first two months, and then moves back towards the original value after that. However, the response of the export price to the exchange rate shock in the manufacturing sector is positive in the first three months and after that the response oscillates around the mean value before dying out a year later. In Panel (b) of Figure 1, it can be seen that, in India, the responses of all the three sectors are positive in the first few months and then become negative and gradually die out. For the China-India pair, the agriculture sector shows a large positive effect in the first two months and then the response oscillates and dies out about a year later. It is interesting to note that there is no response to the exchange rate shock in the initial two months in the mining sector and after that the effect is negative and then positive over time. A similar response pattern can be seen in the manufacturing sector. Overall, the response of the export prices to the exchange rate shock is found to be larger in China and India than in Australia. This is also supported by the dynamic ERPT elasticities. As can be seen in Table 2, the degree of the dynamic ERPT elasticities of export prices is found to be the largest and closer to unity in Australia, and more than one in China and India. It is also noted that the mining and natural resources sector in China is quite responsive to the exchange rate shocks.

5.3 Variance decomposition

We now turn to a variance decomposition analysis. Variance decompositions examine the fluctuations of each price variable that are due to the exchange rate shocks or other factors. Table 3 displays only the results for all price variables at 5 months intervals up to 20 months.[14] It is important to note that the variables IM1, IM2 and IM3 enter the regression equation separately in Table 3. It is found that the bulk of the movements in oil price, interest rate, industrial output, exchange rate and CPI are mainly explained by the importance of composite shocks to their own shocks. As regards the import prices, it is found that industrial production, oil price and exchange rate shocks are the next important factors in explaining import price variance in Australia for mining and natural resources, where the share changes from 2.47% to 3.25%, 0.05% to1.84% and 0% to 1.61%, respectively.[15] In India, the domestic prices and production are the next important factors in accounting for the variance of IMP, in addition to its own shocks. The exchange rate shocks account for about 1.16% of import price variance in the manufacturing sector in India. It is interesting to note that in China, the variance of import prices is largely explained by the IMP shock originated from the mining and energy sector and agriculture sector, which accounts for around 10% of the variance in all the three sectors (Panel (c) of Table 3). This finding is consistent with our early discussion of China's high dependency on imported mining and energy products from around the world. The impact of the exchange rate shocks on the import price is not strong.

[14] The results of the other variables are available upon request from the authors.
[15] The results are available upon request from the authors.

Table 3. The results of variance decomposition

(a) Australia-China

	Period	S.E.	DLCPI	DLPPI	DLIM1	DLIM2	DLIM3	DLERAC
DLCPI	1	0.001	100	0	0	0	0	0
	5	0.002	83.188	0.111	2.379	1.251	0.109	0.410
	10	0.002	81.340	0.139	2.325	1.236	0.122	0.920
	15	0.002	81.293	0.140	2.324	1.236	0.122	0.936
	20	0.002	81.291	0.140	2.324	1.236	0.122	0.936
DLPPI	1	0.432	0.005	99.484	0	0	0	0
	5	0.537	0.088	95.457	0.230	1.210	1.073	0.544
	10	0.538	0.090	95.096	0.319	1.285	1.077	0.551
	15	0.538	0.090	95.093	0.319	1.285	1.077	0.552
	20	0.538	0.090	95.093	0.319	1.285	1.077	0.552
DLIM1	1	0.595	0.243	0.045	97.170	0	0	0
	5	0.768	1.001	0.247	88.749	1.420	1.651	1.610
	10	0.771	0.995	0.300	88.439	1.610	1.689	1.613
	15	0.771	0.995	0.301	88.436	1.610	1.689	1.613
	20	0.771	0.995	0.301	88.436	1.610	1.689	1.613
DLIM2	1	0.569	0.299	0.292	0.231	97.435	0	0
	5	0.721	1.067	3.244	0.897	86.315	0.353	2.261
	10	0.724	1.059	3.493	0.970	85.559	0.427	2.307
	15	0.724	1.059	3.497	0.971	85.546	0.428	2.307
	20	0.724	1.059	3.497	0.971	85.546	0.428	2.307
DLIM3	1	0.986	0.002	0.241	0.066	0.257	98.224	0
	5	1.113	0.403	1.292	1.087	0.603	94.867	0.029
	10	1.115	0.405	1.398	1.103	0.633	94.663	0.044
	15	1.115	0.405	1.398	1.103	0.634	94.661	0.045
	20	1.115	0.405	1.398	1.103	0.634	94.661	0.045
DLERAC	1	0.038	1.196	0.001	0.766	0.235	7.64E-05	92.662
	5	0.040	1.927	0.086	1.103	0.264	0.320	90.930
	10	0.040	1.940	0.087	1.102	0.265	0.324	90.798
	15	0.040	1.940	0.087	1.102	0.265	0.324	90.795
	20	0.040	1.940	0.087	1.102	0.265	0.324	90.795

Note: DL denotes first difference of each variable. DLIMP1, DLIMP2 and DLIMP3 represent first differenced import prices for mining and natural resources, agriculture and processed products and manufacturing sector, respectively.

(b)Variance Decomposition of India-Australia

	Period	S.E.	DLCPI	DLWPI	DLIM1	DLIM2	DLIM3	DLERAI
DLCPI	1	0.008	100	0	0	0	0	0
	5	0.009	80.022	6.997	0.194	1.050	0.257	0.580
	10	0.009	79.858	6.968	0.198	1.061	0.266	0.672
	15	0.009	79.857	6.968	0.198	1.062	0.266	0.672
	20	0.009	79.857	6.968	0.198	1.062	0.266	0.672
DLWPI	1	0.006	15.065	80.401	0	0	0	0
	5	0.007	12.531	69.056	0.124	0.205	0.080	1.972
	10	0.007	12.521	68.886	0.128	0.231	0.140	2.001
	15	0.007	12.521	68.885	0.128	0.231	0.141	2.001
	20	0.007	12.521	68.885	0.128	0.231	0.141	2.001
DLIM1	1	0.826	0.242	1.188	98.204	0	0	0
	5	1.058	1.320	1.908	91.533	1.177	2.354	0.364
	10	1.059	1.322	1.904	91.303	1.327	2.384	0.363
	15	1.059	1.322	1.904	91.303	1.327	2.384	0.363
	20	1.059	1.322	1.904	91.303	1.327	2.384	0.363
DLIM2	1	0.807	0.001	0.230	0.757	97.716	0	0
	5	1.020	0.045	1.024	0.576	92.573	1.255	0.723
	10	1.024	0.050	1.058	0.624	92.005	1.516	0.747
	15	1.024	0.051	1.058	0.624	91.996	1.520	0.747
	20	1.024	0.051	1.058	0.624	91.996	1.520	0.747
DLIM3	1	0.849	0.135	1.615	0.099	0.037	96.686	0
	5	1.067	1.009	1.495	1.089	0.818	91.755	1.117
	10	1.070	1.016	1.495	1.100	0.885	91.533	1.163
	15	1.070	1.016	1.495	1.100	0.888	91.528	1.163
	20	1.070	1.016	1.495	1.100	0.888	91.528	1.163
DLERAI	1	0.029	0.460	1.005	0.420	0.157	0.037	85.271
	5	0.031	1.250	1.112	1.057	0.242	0.979	81.102
	10	0.031	1.265	1.118	1.058	0.246	1.010	81.031
	15	0.031	1.265	1.118	1.058	0.246	1.010	81.031
	20	0.031	1.265	1.118	1.058	0.246	1.010	81.031

Note: DL denotes first difference of each variable. DLIMP1, DLIMP2 and DLIMP3 represent first differenced import prices for mining and natural resources, agriculture and processed products and manufacturing sector, respectively.

(c) Variance Decomposition of China-India

	Period	S.E.	DLCPI	DLPPI	DLIM1	DLIM2	DLIM3	DLERCI
DLCPI	1	0.005	100	0	0	0	0	0
	5	0.006	73.189	3.053	0.407	1.349	1.951	3.976
	10	0.006	72.867	3.067	0.412	1.403	1.943	4.009
	15	0.006	72.864	3.068	0.413	1.404	1.943	4.010
	20	0.006	72.864	3.068	0.413	1.404	1.943	4.010
DLIM1	1	1.665	0.411	0.021	98.043	0	0	0
	5	1.928	1.368	0.035	93.301	0.139	1.519	0.524
	10	1.928	1.375	0.038	93.268	0.142	1.524	0.524
	15	1.928	1.375	0.038	93.268	0.142	1.524	0.524
	20	1.928	1.375	0.038	93.268	0.142	1.524	0.524
DLIM2	1	0.916	0.348	0.046	4.526	93.583	0	0
	5	1.031	0.573	1.169	4.117	82.255	0.463	0.346
	10	1.033	0.646	1.179	4.152	82.013	0.465	0.368
	15	1.033	0.646	1.179	4.152	82.010	0.465	0.368
	20	1.033	0.646	1.179	4.152	82.010	0.465	0.368
DLIM3	1	1.698	0.999	0.454	3.315	5.104	87.524	0
	5	1.886	1.682	2.619	4.656	5.009	82.154	0.551
	10	1.888	1.690	2.621	4.656	5.018	81.989	0.562
	15	1.888	1.690	2.621	4.656	5.018	81.988	0.563
	20	1.888	1.690	2.621	4.656	5.018	81.988	0.563
DLERCI	1	0.015	4.474	0.248	5.86E-06	0.023	5.555	88.344
	5	0.016	6.265	0.464	0.409	1.258	4.904	82.384
	10	0.016	6.268	0.494	0.420	1.257	4.900	82.292
	15	0.016	6.268	0.494	0.420	1.257	4.900	82.290
	20	0.016	6.268	0.494	0.420	1.257	4.900	82.290

Note: DL denotes first difference of each variable. DLIMP1, DLIMP2 and DLIMP3 represent first differenced import prices for mining and natural resources, agriculture and processed products and manufacturing sector, respectively.

The results show that the variances of CPI and PPI in Australia are mainly explained by their own (respectively CPI and PPI) shocks, followed by the exchange rate shock and import price shock. The exchange rate shock accounts for about 4% of the variance of CPI in the short run and 6% for the variance of PPI in the long run, In India, the variance of CPI is mainly explained by its own (CPI) shock, over 80% in the first 5 months. The exchange rate shock, industrial production, oil price and PPI account for less than 18% of the variance. However, the exchange rate shock contributes over 2% of the PPI variance in the long run. In China, the variance of its CPI is equally explained by its own and IP shocks, accounting for about 84% of variation in the long run. The variance of PPI is explained by its own shock and IP as well as CPI and oil price, with IP accounting for close to 7% of the variance in PPI, and CPI and oil price for around 37%.

The variance decompositions thus suggest that external factors explain the modest portion of the variance of domestic consumer prices in Australia, and Australia's CPI inflation was mainly caused by the import price and the exchange rate pass-through. Whereas, the effect is opposite in China and India where internal factors like PPI and industrial output account for moderate variation in CPI. This finding is consistent with our casual observation that external factors tend to have greater influence in a more open economy like Australia than in India and China.

6 Conclusion

This paper examines the pass-through of exchange rate into trade prices and domestic prices for three selected economies, namely, Australia, China and India at the most disaggregated level. Using a structural VAR model, we find that pass-through of exchange rate to aggregate consumer prices is greater in China and India than in Australia; however, depreciation of the Australian dollar against the Chinese RMB leads to an increase in the domestic CPI inflation. On the other hand, depreciation of the Chinese RMB against the Indian rupee will lead to an increase of the import price in the mining and resource sector, but decrease in import prices in the agriculture and manufacturing sectors, and it also has an inflationary effect on domestic prices over the period 1990-2011. It is found that internal factors like industrial production, interest rate and producer prices are effective on domestic consumer prices, but external factors account for little variation in domestic prices in these two countries. The results show that domestic inflation in all three economies are predominantly caused by their own shocks, and monetary shocks play a very limited role in affecting the domestic prices. This is credited to the inflation targeting policy implemented in these countries. The results substantiate the interactive impacts of the exchange rate shock across the three economies, and have important implications for domestic monetary policy and monetary policy coordination in these three increasingly integrated and interdependent economies. As much of the inflation during the period of study is likely due to internal factors, attention in these economies should be given to revisiting the monetary policy target and how it can be restructured to control inflation.

References

Adolfson, M., "Incomplete exchange rate pass-through and simple monetary policy rules," *Journal of International Money and Finance* 26, 2007, 468-94.

Belaisch, A., "Exchange rate pass-through in Brazil," IMF Working Paper WP/03/141, International Monetary Fund, 2003.

Bailliu, J. and E. Fujii, "Exchange rate pass-through and the inflation environment in industrialized countries: An empirical investigation," Bank of Canada, Working Paper No. 21, 2004.

Bouakez, H. and N. Rebei, "Has exchange rate pass-through really declined in Canada?," *Journal of International Economics* 75, 2008, 249-67.

Campa, J. and L. Goldberg, "Exchange rate pass-through into imports prices," *The Review of Economics and Statistics* 87, 2005, 679-690.

Ceglowski, J., "Exchange rate pass-through to bilateral import prices," *Journal of International Money and Finance* 29, 2010, 1637-1651.

Choudhri, E.U. and D.S. Hakura, "Exchange rate pass-through to domestic prices: Does the inflationary environment matter?," IMF Working paper WP/01/194, 2001.

Choudhri, E.U. and D. Hakura, "Exchange rate pass-through to domestic prices: Does the inflationary environment matter?," *Journal of International Money and Finance* 25, 2006, 614-639.

Dees, S., M. Burgert and N. Parent, "Import price dynamics in major advanced economies and heterogeneity in exchange rate pass-through," *Empirical Economics* 45, 2013, 789-816.

Devreux, M. and C. Engel, Endogenous currency of price setting in a dynamic open economy model, Mimeo, 2001.

Faruqee, H., "Exchange rate pass-through in the Euro area," IMF Staff Papers, 53, 2006, 63-88.

Flamini, A., "Inflation targeting and exchange rate pass-through," *Journal of International Money and Finance* 26, 2007, 1113-50.

Frankel, J.A., D.C. Parsley, and S.J. Wei, "Slow pass-through around the world: A new import for developing countries?," *Open Economies Review* 23, 2012, 213-51.

Franses, P.H., "Seasonality, non-stationarity and the forecasting of monthly time series," *International Journal of Forecasting* 7, 1991, 199-208.

Franses, P.H. and B. Hobijn, "Critical values for unit root tests in seasonal time series," *Journal of Applied Statistics* 24, 1997, 25-48.

Franses, P.H. and M. McAleer, "Cointegration analysis of seasonal time series," *Journal of Economic Surveys* 12, 1998, 651-78.

Gagnon, J.E. and M. Knetter, "Mark-up adjustment and exchange rate fluctuations: Evidence from panel data on automobile exports," *Journal of International Money and Finance* 14, 1995, 289-310.

Gagnon, J.E. and J. Ihrig, "Monetary policy and exchange rate pass-through," *International Journal of Finance and Economics* 9, 2004, 315-38.

Goldberger, P. and M. Knetter, "Goods prices and exchange rates: What have we learned?," *Journal of Economic Literature* 35, 1997, 1243-72.

Gopinath, G., O. Itskhoki and R. Rigobon, "Currency choice and exchange rate pass-through," *American Economic Review* 100, 2010, 304-336.

Hahn, E., "Pass-through of external shocks to Euro area inflation," European Central Bank Working Paper No. 243, 2003.

Hylleberg, S., R.F. Engle, C.W.J. Granger, and B.S. Yoo, "Seasonal integration and cointegration," *Journal of Econometrics* 44, 1990, 215-38.

Ito, T. and K. Sato, "Exchange rate changes and inflation in post-crisis Asian economies: Vector autoregression analysis of the exchange rate pass-through," *Journal of Money, Credit and Banking* 40, 7, 2008, 1047-1438.

Krugman, P., "Pricing to market when the exchange rate changes," in:

S. Arndt, and J. Richardson (ed.), *Real-Financial Linkages among Open Economies*, Cambridge: MIT Press, 1987.

McCarthy, J., "Pass-through of exchange rates and import prices to domestic inflation in some industrialized economies," Mimeo, Federal Bank of New York, 2000.

Parsons, C. R. and K. Sato, "Exchange rate pass-through and currency invoicing: Implications for monetary integration in East Asia," *The World Economy* 29, 2006, 1759-1788.

Sek, S.K. and Z. Kapsalyamova, "Exchange rate pass-through and volatility: Impacts on domestic prices in four Asian countries," MPRA Paper No. 11130, 2008.

Slavov, S.T., "Does monetary integration reduce exchange rate pass-through?," *The World Economy* 31, 2008, 1599-1624.

Taylor, J., "Low inflation, pass-through, and the pricing power of firms," *European Economic Review* 44, 2000, 1389-1408.

Tivig, T., "Exchange rate pass-through in two-period duopoly," *International Journal of Industrial Organization* 14, 1996, 631-45.

Varangis, P.N. and R.C. Duncan, "Exchange rate pass through: An application to US and Japanese steel prices," *Resources Policy* 19, 1, 1993, 30-9.

Winkelried, D., "Exchange rate pass-through and inflation targeting in Peru," *Empirical Economics* 46, 2014, 1181-1196.

Appendix: Descriptive statistics

(1) Australia

	Mean	Median	Max	Min	Std. Dev.	Skewness	Kurtosis	Observation
DLIM1	0.006	0.022	3.280	-3.399	0.752	-0.058	8.619	263
DLIM2	0.002	-0.019	2.927	-2.352	0.688	0.128	4.314	263
DLIM3	0.011	0.013	5.099	-3.704	1.060	0.584	6.106	261
DLEX1	0.000	0.016	3.190	-3.066	0.818	-0.261	4.681	263
DLEX2	0.006	0.000	4.264	-4.291	0.982	0.065	6.092	263
DLEX3	-0.001	0.018	2.965	-2.862	0.746	-0.022	6.607	251
DLCPI	0.002	0.002	0.018	-0.002	0.002	2.345	14.398	254
DLPPI	0.002	0.002	5.814	-5.814	0.517	-0.012	126.962	254
DLINRT	-0.005	0.000	0.168	-0.268	0.044	-1.338	11.604	254
DLINDP	0.001	0.001	0.233	-0.233	0.021	-0.204	115.732	254
DLERAC	0.002	0.002	0.437	-0.172	0.038	5.193	66.482	272
DLOILP	0.005	0.014	0.377	-0.337	0.085	-0.302	5.318	257

(2) China

	Mean	Median	Max	Min	Std. Dev.	Skewness	Kurtosis	Observation
DLIM1	0.011	0.000	6.383	-5.628	1.965	0.089	3.764	229
DLIM2	-0.024	0.000	4.973	-6.964	1.187	-0.749	12.101	203
DLIM3	0.030	0.000	8.623	-5.979	1.832	0.416	6.537	202
DLEX1	0.012	0.016	3.812	-3.827	1.134	-0.114	6.474	240
DLEX2	0.053	-0.005	6.073	-6.788	1.430	-0.029	9.681	190
DLEX3	0.016	0.050	3.354	-3.418	1.016	-0.120	4.767	226
DLCPI	0.000	0.000	0.022	-0.026	0.008	-0.172	3.794	254
DLPPI	0.000	0.000	0.039	-0.044	0.009	-0.102	7.881	187
DLINRT	-0.008	0.000	0.194	-0.448	0.051	-5.662	46.862	254
DLINDP	0.001	0.000	0.286	-0.211	0.043	0.709	15.209	253
DLERCI	0.003	0.002	0.195	-0.404	0.033	-6.634	99.885	257

(3) India

	Mean	Median	Max	Min	Std. Dev.	Skewness	Kurtosis	Observation
DLIM1	0.029	-0.005	2.981	-3.844	1.006	-0.176	4.151	240
DLIM2	0.015	0.001	5.575	-6.268	0.985	-0.408	12.966	240
DLIM3	0.003	0.000	3.835	-2.867	1.020	0.077	5.104	239
DLEX1	0.001	0.000	4.512	-4.169	0.843	-0.152	10.201	238
DLEX2	-0.008	0.000	4.804	-7.048	0.781	-2.295	36.870	236
DLEX3	0.006	0.000	10.294	-6.196	1.614	0.913	12.678	238
DLCPI	0.006	0.006	0.045	-0.021	0.009	0.253	4.768	253
DLWPI	0.005	0.004	0.031	-0.019	0.007	0.442	4.021	253
DLINRT	-0.002	0.000	0.201	-0.154	0.026	0.311	28.390	253
DLINDP	0.005	0.004	0.215	-0.329	0.064	-1.063	8.220	253
DLERAI	0.005	0.005	0.211	-0.107	0.029	1.283	12.845	257

Note: DL denotes first difference of each variable. DLIMP1, DLIMP2 and DLIMP3 and DLEX1, DLEX2 and DLEX3 represent first differenced import and export prices for mining and natural resources, agriculture and processed products and manufacturing sector, respectively. OILP, CPI, PPI, WPI, INRT, INDP represent oil price inflation, consumer price index, producer price index, wholesale price index, interest rate and industrial production, respectively. Bilateral exchange rate for Australia-China, China-India and Australia-India are denoted by ERAC, ERCI and ERAI, respectively.