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Monetary Policies, Exchange Rate Pass-through and Prices in Asian Economies: A Long and Short-run Analysis

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Abstract

The financial crisis in 2007-2008 has turned into the most far-reaching international financial and economic crisis since the Great Depression. Indeed, the crisis-affected Asian countries experienced varying degrees of changes in the exchange rate and prices following an initial shock of sharp depreciation of their currencies in the second half of 1997. Moreover, questions connected with the exchange rate regime have been an important part of understanding macroeconomic policies and outcomes in Asia. Thus, the objective of this paper is to examine pass-through effects on domestic prices among the four selected Asian countries, Japan and S. Korea from the east and Iran and Turkey from the west, with special emphasis on an interaction between prices, monetary policies and exchange rate changes. In order to take into account dynamic effects between these variables, the structural vector auto-regression (SVAR) method is employed, by which the responses of such shocked variables are evaluated during 1970- 2015. The empirical results confirmed a dynamic relationship between exchange rate pass-through and other macro variables in the selected countries. Also, the results have shown that the pass-through shocks in the short-run are more effective in the countries which benefit from a managed floating exchange rate regime and inflation targeting policy.

Keywords: Monetary Policies, Pass-through, Financial Crises, SVAR Regression, Exchange Rate.
JEL Classification: C22, C32, F31, F40.

1. Introduction

The collapse of the US housing market and the ensuing sub-prime mortgage market crash in the summer of 2007 triggered a global financial crisis, which is considered the first global crisis since the Great Depression

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(Claessens et al., 2010). As Dooley and Hutchison (2009) point out, financial reforms in emerging economies made it possible to temporarily insulate themselves from adverse shocks originating from the US until the summer of 2008. This relatively tranquil period of time, however, was ended by a direct shock in the form of the Lehman failure in September 2008. However, the crisis-affected Asian countries experienced varying degrees of changes in the exchange rate and prices following an initial shock of sharp depreciation of their currencies in the second half of 1997. In some countries, such as Korea, a sharp nominal depreciation was followed by a sharp reversal within several months, with little effect on domestic inflation rates. After the crisis, a large depreciation resulted in a period of high inflation in Indonesia, while the country gradually lost price competitiveness due to an appreciating real exchange rate (Ito and Sato, 2007; Burstein and Gopinath, 2014).

Moreover, questions connected with the exchange rate regime have been an important part of understanding macroeconomic policies and outcomes in Asia. In the period leading up to the Asian crisis of 1997, many Asian economies had highly inflexible exchange rates. In the aftermath of the Asian crisis, while many economies announced reforms of the exchange rate regime, there was a substantial difference between the *de jure* and *de facto* exchange rate regime, and that many economies had gone back to a high degree of exchange rate inflexibility after the crisis (Calvo and Reinhart, 2002). However, the desire has been to stabilize domestic inflation in the emerging Asian economies with substantial exchange rate pass-through.

The macroeconomic policy framework in some Asian countries has involved a certain interlocking set of features: exchange rate inflexibility, large current account surpluses, and the accumulation of large foreign exchange reserves. This has led to concerns about global imbalances. The resolution of these imbalances may be critically linked to modifying the exchange rate regime in some Asian economies (Lane and Milesi-Ferretti, 2004).

The novelties of this paper are three-fold: First, by focusing on the interaction between the exchange rate changes and inflation, this paper highlights the role of the real exchange rate while most of existing studies examine the nominal exchange rate to describe the recovery and non-recovery process. Second, a VAR analysis, which allows the reverse causality from inflation to the exchange rate, is applied to crisis-affected countries. Although some studies, such as Baig and Goldfajn (1999), employed a VAR analysis among the crisis-hit countries in Asia, the variables were limited to the exchange rate and the stock prices. This paper is the first to apply the VAR with the exchange rate, monetary policy, and inflation of the crisis-hit countries. Third, by using foreign and domestic price indices, we examine how both long-run and short-run pass-through effects can be transmitted from changes in exchange rates to import prices, from import prices to wholesale prices, and then to consumer prices in the selected Asian countries.

The objective of this paper is thus to examine pass-through effects on domestic prices among the selected Asian countries (Japan, South Korea, Iran and Turkey) with special emphasis on an interaction between prices, monetary policies and exchange rate changes. In order to take into account dynamic effects among these variables, a structural vector auto-regression (SVAR) analysis is employed, by which the responses of such shocked variables are evaluated. The time series data are used during 1970- 2015.

The remainder of the present paper is organized as follows. Section 2 provides a brief literature review. In Section 3, we present our empirical models and discuss estimation techniques employed. Section 4 analyzes the empirical results. Some concluding remarks and policy implications are reported in the final section.

2. Literature Review

The relationship between exchange rate and the price level has received a large amount of attention since the breakdown of Bretton Woods. However, very few contributions have analyzed the complete pass-through, i.e., the effect of an exchange rate change on various prices measures along

the production chain (including export/import prices and a measure of consumer inflation). Instead, most research focuses on particular segment, such as import/export price pass-through, or synchronization of different price level measure.

Generally the direct impact of exchange rate movement occurs through prices of internationally traded goods. Goldberg and Knetter (1997) survey the literature on pass-through to import prices, and raise an important question why the pass-through might be incomplete in this context. Many theoretical explanations have been found to this question, for instance, Menon (1995) who surveys a large number of contributions such as the type of exchange rate regime. Most prominently, Dornbusch (1987) and Krugman (1987) show that a less than one-to-one transmission can be explained by imperfect competition, or "pricing-to-market". Foreign producers adjust their mark-up to maintain a stable market share in the domestic economy. This strategic behavior can in principle drive the rate of pass-through to zero. Gosh and Wolf (2001) show that imperfect short-run pass-through may also arise from menu costs. On the other hand, Borensztein and De Gregorio (1999) examine currency crises, and Goldfajan and Werlang (2000) show in a panel framework that the main determinants of the extent of pass-through are the cyclical state of the economy, the initial over/ undervaluation, the initial rate of inflation, and the degree of openness of the economy. They also find that pass-through peaks after twelve month.

In the empirical literature, the degree of pass-through is often examined for its implication of macroeconomic policy discussions in the more advanced countries. When the degree of pass-through to tradable prices is found to be high, the exchange rate changes affect the relative prices of tradable and non-tradable goods, so that the adjustment in trade balances will be relatively prompt. When the degree of pass-through is low, the exchange rate changes do not help external adjustment of the economy. For example, depreciation would not restrain imports when trade deficits should be controlled (Ito and Sato, 2007; Gopinath, 2015).

Also in the literature of currency crises among emerging market economies, whether and how much inflation flares up due to a sharp depreciation would make a difference in the recovery process from a crisis. If domestic prices in general respond to the nominal exchange rate depreciation one-to-one (that is, complete pass-through not only to import prices but to *CPI* in general), then any export competitiveness gained from nominal depreciation would be cancelled out, as the real exchange rate would not change at all. A combination of nominal depreciation and high inflation leaves the export competitiveness unchanged, while corporations and financial institutions that have net foreign-currency liabilities would become burdened by larger real debts and nonperforming loans. This would be the worst management for a crisis-hit country. Hence the analysis of pass-through is important, and the methodology is applied here with some modifications (Ito and Sato, 2007, Gopinath, 2015).

From the viewpoint of using the exchange rate changes as an instrument for correcting (reducing deficits and possibly making surpluses in) the trade balance, the pass-through to import prices and possibly wholesale/producer prices to force expenditure switching is good, but the pass-through to CPI, raising all price levels, would be unfair. Monetary policy should be operated with knowledge of this distinction.

Moreover, a trade-off between exchange rate regimes (or monetary policy rules) may be quite different for an emerging market economy with very high exchange rate pass-through than for an advanced economy with limited short-run exchange rate pass-through (Devereux, 1999). In the emerging-market case, a flexible exchange rate rule (such as the Taylor rule or the rule that stabilizes non-traded inflation) will help to stabilize the real economy in the face of external shocks. By facilitating adjustment in both the real exchange rate and real interest rate, these rules can cushion the economy from the impact of external shocks. The markup-stabilization rule appears to be the best rule to achieve this result. But, to stabilize GDP and consumption, the rule has to allow a high volatility in the nominal exchange rate and, therefore, high inflation volatility. Hence, there is a clear trade-off between output/ consumption volatility and inflation volatility. If the

authorities are concerned with consumer price inflation (over and above non-traded goods inflation), then the flexible exchange rate regime brings some costs as well as benefits. Moreover, the same logic implies that a policy of strict inflation targeting is quite undesirable in an open economy, since it effectively amounts to a requirement of fixing the exchange rate. It stabilizes inflation at the expense of a lot of output instability (Devereux, 1999).

The situation is quite different when pass-through is limited. Devereux (1999) modeled this process by assuming that foreign firms follow a practice of setting prices in domestic currency and only gradually adjust to exchange rate changes. In this environment, he found that there is no trade-off between output volatility and inflation volatility. In fact, a flexible exchange rate can deliver lower output variance and lower inflation variance than a fixed exchange rate regime. Of all the rules considered, the markup-stabilization rule minimizes the variance of output, consumption, and inflation (Devereux, 1999, Jasová et al., 2016).

The recent financial crises in Asia, Brazil, and Russia have rekindled the debate on the choice of exchange rate regimes. In other words, the debate over the appropriate exchange rate regime has once again taken center stage. A popular argument in favor of fixed exchange rates is that a commitment to a currency peg may reduce the probability of banking crises, as it would discipline policy makers (Eichengreen and Rose, 1998). Put differently, the restrictions imposed by the objective of maintaining an exchange rate anchor would discourage the propensity towards erratic policies and, therefore, minimize the occurrence of domestic shocks that lead to banking crises. Furthermore, as argued by Calvo (1999) random shocks that affect economies may be a function of the exchange rate regime. Thus, the transparency and credibility associated with fixed exchange rates may insulate a country from contagion and rumors.

The traditional argument for supporting the adoption of flexible exchange rate systems is that they offer the possibility of a more stabilizing monetary policy. Accordingly, the exchange rate could be used to absorb some of the real shocks the economy faces and could reduce the burden on

the interest rate. More precisely, confronted with an adverse external shock, floaters can let the exchange rate bear the force of the adjustment so that interest rates need not be raised. Thus, output is protected through increased competitiveness and more favorable financial conditions.

Finally as realized fact, the financial crisis of 1997 and 1998 in East Asian countries totally changed the monetary policies and exchange rate regimes in these countries. According to the International Monetary Financial (IMF) classifications, the countries including Korea, Thailand and Philippines have moved to flexible regimes. The move from rigidity to more flexible regimes gives some effects on the volatility of the exchange rate, foreign exchange reserves and the interest rate. In general, the change in the regimes has led to higher fluctuations in exchange rate in these Asian countries. However, the foreign exchange reserves and interest rate have declined in these countries after the crisis. Besides moving to the more flexible exchange rate regimes, these Asian countries also alter their monetary policy and adopt the inflation targeting regime after the financial crisis of 1997. For example, Korea was the first country in East Asian that has adopted the inflation targeting regime, i.e. in April 1998. Thailand followed the step in May 2000 and later Philippines in January 2002 (Hernandez and Montiel, 2001; Osawa, 2006; Jasová et al., 2016).

3. Methodology

3.1 Long-run Framework

In this section we describe a simple macroeconomic model for the countries considered in the study which incorporates both long-run and short-run restrictions based on the economic theory. While the former are linear restrictions on the co-integrating vectors and capture money demand, excess demand, monetary policy response function of central bank and price function, the short-term restrictions are imposed on the error covariance matrix.

Our analysis starts with the investigation of the long-run properties of the data, focusing on the presence of co-integration relationships. The first long-run relationship we consider is a conventional money demand function of the form (Cologni and Manera, 2008):

$$M_t = \alpha_0 + \alpha_1 GAP_t + \alpha_2 i_t + \alpha_3 P_t + \varepsilon_{1t} \quad (1)$$

where *M* is money balances, *GAP* is defined as the deviation of log gross domestic product from its *H-P* filtered trend series (*Y-Trend*), *i* a short-term nominal rate of interest and *P* the price level. The parameter α_1 measures the long-run income effect, which varies due to disequilibrium between total supply and total demand, while α_2 measures the opportunity cost of money demand.

Several channels of transmission of monetary policy have been identified in modern financial systems. The most conventional mechanism is the interest rate channel, which alters the marginal cost of lending and borrowing, affecting investment, savings, and aggregate demand. For instance, an interest rate cut reduces the marginal cost of borrowing, which boosts current spending, hence aggregate demand. In contrast, rising interest rates reduce cash-flow and spending, but raise savings. A key aspect is the extent to which a change in the central bank-controlled policy interest rate affects domestic prices especially in the long-term, leading to a change in exchange rate as well (Horváth and Maino, 2006).

The exchange rate channel describes the effect of the exchange rate on the domestic economy through aggregate demand (net exports) and supply (domestic value of imports), bearing a total effect on gross domestic price. Its effectiveness depends on the extent of exchange rate pass-through, so that the level of the pass-through to the local currency price of imported goods and services and, hence, to overall price changes depends on the import share, the magnitude of the depreciation/devaluation of the national currency and its timing, as well as structural characteristics of the economy. In general, the larger the import share and the magnitude of a depreciation/devaluation, the larger the pass-through can be seen particularly in the long-run.

Generally in the literature, two channels of the effect of exchange rate can be identified. First, the direct channel of the exchange rate: that it affects inflation via the import prices pass-through effect. That is, changes

in the nominal exchange rates directly affect import prices, which in turn cause domestic prices to rise. Second, the indirect channel of the exchange rate: that it affects real GDP through the balance of payments. It is important to recognize these possible implications of different exchange rate regimes, i.e. the costs and benefits of introducing a different exchange rate regime. Ganev et al. (2002) analyze the dynamic effect of monetary policy on real GDP and inflation in 10 CEE countries. The evaluation of the pass-through effect of monetary policy on real GDP and inflation is examined by two indicators: the interest rate and the exchange rate. Positive exchange rate shocks (deprecation) seem to boost real GDP in most countries, though this effect dies out after a short-period.

The second long-run equation relates the difference between output and its trend (excess demand) to the inflation rate, the rate of interest, the real exchange rate and oil prices:

$$GAP_t = \beta_1 + \beta_2 P_t + \beta_3 i_t + \beta_4 RER_t + \beta_5 O_t + \varepsilon_{2t} \qquad (2)$$

where RER and O are the log real exchange rate and the log oil price, respectively. The role of the later variable, i.e. oil price, in growth is crucial to be investigated for two types of the selected countries which are oil exporting or importing. The long-run production effect of oil price for both sides could be ambiguous in which countries are faced with different results if the oil price, for example, goes up.

In the emerging markets, economies are quite open and the exchange rate plays an improving role to the performances of monetary policy rules and enhances higher welfare of agents (Ball, 1999; Batini et al., 2003). Exchange rate contributes to the demand channel through the effects of foreign and domestic prices and creates the direct exchange rate channel through the convert of domestic currency prices of foreign produced goods. It affects the aggregate demand for domestic goods (Senay, 2001).

The research on the exchange rate pass-through shows that exchange rate and monetary policy are correlated to each other. Many studies show that exchange rate pass-through in emerging countries is higher than that

in the developed countries. Therefore, it is argued that emerging countries face higher difficulties in their efforts to target at low inflation rate and maintain price stability (Minella et al., 2003; Fraga et al., 2003; Nogueira Junior, 2007; Forbes et al., 2015). However, a number of studies show that the pass-through rate has declined in many countries and researchers have different explanations for that. One of the famous explanations is that the low pass-through rate correlates with low inflation rate as a consequence of strong commitment towards price stability by Taylor (2000). The view of Taylor is supported by many empirical studies such as Edwards (2006), Gagnon and Ihrig (2004) and Nogueira Junior (2007).

Moreover, the role of exchange rate in the conduct of monetary policy rules is a way to study the relationship between exchange rate and monetary policy. The results from the empirical studies are quite controversial. By estimating the Taylor rule, Mohanty and Klau (2004) show that the monetary policy responds to exchange rate strongly in most of the emerging countries. Frömmel and Schobert (2006) estimate the simple Taylor type policy rules for six Central and Eastern European countries. They find that exchange rate affects money supply significantly within the fixed exchange rate regimes. However, the influence disappears after these countries have switched to the flexible regimes. Osawa (2006) finds no evidence of monetary policy response to the exchange rate in three Asian inflation targeting countries. The reason is that including the crisis period in the sample of estimation may overestimate the response of monetary policy to exchange rate. In addition, the exchange rate pass-through effect has not been considered in his model.

Contrary to the above arguments on the role of exchange rate in the open economy framework, Taylor (2001) argues that adding exchange rate into the policy reaction function may induce loss of credibility in targeting inflation. The reasons are: first, exchange rate affects inflation and output in the policy reaction function indirectly; second, giving a direct role to exchange rate in the Taylor rule may add volatility to the monetary policy (Taylor, 2001). Due to the above reasons, Mishkin (2000) and Schmidt-Hebbel (2002) express that the central bank should pay attention at the

effects of exchange rate fluctuations on inflation and output gap but should not give an independent role for the exchange rate in the policy reaction function. In the long run, thus, the pass-through effect should appear on money policy through changes in prices.

Following Mohanty and Klau (2004) and Osawa (2006), the monetary policy reaction function takes the form of:

$$i_t = \gamma_0 + \gamma_1 P_t + \gamma_2 GAP_t + \gamma_3 RER_t + \varepsilon_{3t} \quad (3)$$

As discussed in Osawa (2006), $\gamma_1 > 1$ points out that the central bank attempts to stabilize the inflation. If $\gamma_1 < 1$, an increase in nominal interest rate may is lower than the real interest rate to fully offset an increase in the inflation shocks. According to Mohanty and Klau (2004), γ_3 is positive indicating an expected direct effect of pass-through on monetary policy.

According to Sahminan (2002) and An (2006), exchange rate movement passes on to the domestic prices through imports and domestic goods priced in foreign currency prices. More specifically, An (2006) discusses that the exchange rate pass-through can be divided into two categories: micro and macro levels. The micro level focuses on the analysis of the exchange rate pass-through into domestic prices based on the foreign firm's pricing behavior, disaggregated product bundles/industries and the market structures. The macro level on the other hand, investigates the exchange rate pass-through from the monetary policy view. It estimates exchange rate pass-through into producer prices index (*PPI*), import price index (*IMP*) and consumer prices index (*CPI*).

In the long-run, change of domestic price is assumed to depend on difference of the output from its long-run trend which is an income effect on inflation (Sahminan, 2002). It is also a function of money level, the real exchange rate, the import price (*IMP*) and the world oil price. Accordingly, depreciating the national currency will positively influence the domestic price, which can be a positive signal of the pass-through effect. Besides increases in import and oil prices will also positively affect the inflation

rate so that such effects can be evaluated via a domestic price equation. Hence, a domestic price equation is specified as follows:

$$P_t = \lambda_0 + \lambda_1 M_t + \lambda_2 GAP_t + \lambda_3 RER_t + \lambda_4 O_t + \lambda_5 IMP_t + \varepsilon_{4t} \quad (4)$$

where λ_i (i = 1, 2, 3, 4, 5) is assumed to be positive.

Finally, as previously focused on the pass-through hypothesis, the import price index is assumed to depend on the price level, the real exchange rate and the world oil price as below:

$$IMP_t = \varphi_0 + \varphi_1 P_t + \varphi_2 RER_t + \varphi_3 O_t + \varepsilon_{5t} \quad (5)$$

where if $\varphi_1 = 1$, this means that the degree of pass-through is complete (Sahminan, 2002).

3.2 Short-run Framework

The exchange rate is determined by, among others, the interest rate, inflation rate, and other macroeconomic variables that are subject to monetary and fiscal policies. It is theoretically well-known and empirically verifiable in the low frequency data that high inflation rate will cause depreciation of the currency and that the low interest rate tends to do the same (Ito and Sato, 2007). However, many relatively high-frequency empirical studies have found that the exchange rate is unpredictable and statistically exogenous to many macroeconomic variables. The changes in the exchange rate tend to affect pricing behaviors of the firms and to influence macroeconomic policies. Therefore, any analysis of interaction between the exchange rate and domestic inflation should allow an interacted causal relationship: from the exchange rate to domestic variables and from domestic variables to the exchange rate. The effect of the exchange rate changes on domestic price is pass-through, while the reverse effect is the determination of the exchange rate in open macroeconomics.

In order to examine what exactly happened in the post-crisis Asian economies in terms of pass-through at different levels, we need to build a framework that includes different kinds of price indices as well as the nominal exchange rate. The pass-through question is thus to examine the direction of causation from the exchange rate to domestic prices. There is a large literature of pass-through effects, with a single-equation regression explaining responses of a domestic price index from the changes in the exchange rate. See, for example, Feenstra (1989), Olivei (2002), Campa and Goldberg (2005), Campa et al. (2005), Otani et al. (2005), Forbes et al. (2015).

In the fixed exchange rate regime, policies are assigned to keep the exchange rate at the committed exchange rate. Capital flows arising from macroeconomic shocks and investors' evaluation of the country as a destination of portfolio investment have to be countered by policies, so that the interest rate and the inflation rate may vary, but not the exchange rate. In the floating exchange rate regime, the exchange rate is an endogenous variable that respond to economic policies (Ito and Sato, 2007). Since the exchange rate and the inflation rate are expected to be influencing each other in many theoretical models, it is most appropriate to estimate a system that would treat both of them endogenous. In particular, during the currency crisis period, a large swing of the exchange rate is likely to affect domestic macroeconomic variables. A VAR is a useful approach to allow for such interaction between the exchange rate and domestic variables.

However, a single-equation pass-through regression ignores the fact that domestic inflation may affect the exchange rate. In order to examine a reinforcing mechanism between domestic prices and the exchange rate, a VAR analysis is necessary. Recent studies, such as McCarthy (2000), Hahn (2003) and Faruqee (2006), use a VAR approach for an analysis of pass-through of several types of shocks to domestic price. However, these studies examine the pass-through in advanced countries and the data covers the relatively non-crisis time which contrasts sharply with the crisis period experienced by East Asian economies, the task which has been done by this paper.

A VAR analysis of the exchange rate pass-through has the following advantages over a single equation of pass-through analysis. First, a VAR technique enables us to identify structural shocks through a Cholesky decomposition of innovations. Effects of structural shocks to other macroeconomic variables on domestic price are also investigated under a VAR framework. Second, previous studies typically analyze the exchange rate pass-through into a single price index by employing a single-equation-based approach. A VAR approach, in contrast, allows us to investigate dynamically the exchange rate pass-through into a set of domestic prices along the pricing chain from the import/producer level to the consumer level.

Following the construction of SVAR (Structural VAR) model in analyzing the concurrent effects of shocks in which the long-run relationships of the relevant variables have been discussed in the previous, the SVAR model is defined as follows:

$$X_t = (\Delta O_t \quad GAP_t \quad \Delta M_t \quad \Delta RER_t \quad \Delta IMP_t \quad \Delta PPI_t \quad \Delta CPI_t) \tag{6}$$

where O_t stands for the world oil price, GAP_t denotes the output gap, M_t is money supply, RER_t denotes the real exchange rate, IMP_t is the import price, PPI_t shows producer price index and CPI_t stands for consumer price index. Δ denotes the first differenced operator. Except for the output gap, all other variables are in logarithms. Changes in the oil price can be interpreted as supply shocks, in output gap as demand shocks, in monetary aggregate as policy shocks, in RER as real exchange rate shocks and in the three domestic price indices as non-oil price shocks.

The Choleski decomposition is applied to identify the structure of the shocks in such a way that the decomposition of the variance covariance matrix of the reduced form residuals is written in a lower triangular matrix. Totally $n(n-1)/2$ 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. The reduced-

form of VAR residuals (u_t) is correlated with the structural disturbances (ε_t) in the following form:

$$\begin{pmatrix} u_t^{\Delta O_t} \\ u_t^{GAP_t} \\ u_t^{\Delta M_t} \\ u_t^{\Delta RER_t} \\ u_t^{\Delta IMP_t} \\ u_t^{\Delta PPI_t} \\ u_t^{\Delta CPI_t} \end{pmatrix} = \begin{pmatrix} S_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\ S_{21} & S_{22} & 0 & 0 & 0 & 0 & 0 \\ S_{31} & S_{32} & S_{33} & 0 & 0 & 0 & 0 \\ S_{41} & S_{42} & S_{43} & S_{44} & 0 & 0 & 0 \\ S_{51} & S_{52} & S_{53} & S_{54} & S_{55} & 0 & 0 \\ S_{61} & S_{62} & S_{63} & S_{64} & S_{65} & S_{66} & 0 \\ S_{71} & S_{72} & S_{73} & S_{74} & S_{75} & S_{76} & S_{77} \end{pmatrix} \begin{pmatrix} \varepsilon_t^{\Delta O_t} \\ \varepsilon_t^{GAP_t} \\ \varepsilon_t^{\Delta M_t} \\ \varepsilon_t^{\Delta RER_t} \\ \varepsilon_t^{\Delta IMP_t} \\ \varepsilon_t^{\Delta PPI_t} \\ \varepsilon_t^{\Delta CPI_t} \end{pmatrix} \quad (7)$$

The ordering of the variables determines the structure of the shocks. The first variable is assumed to have impacts on all other variables while does not receive any effect from them. The second variable only receives the effect from the first variable. Also it does not have any impact on the first variable but influences all the following variables. This rule applies to the all succeeding variables.

Following Ito and Sato (2007), the oil price index is ordered first as the oil price shocks may affect the other variables but are unlikely affected contemporaneously by other shocks. The output gap is ordered next. It is assumed to be affected by the oil price shocks only and can affect all the variables in the system except for oil price shocks. The money supply shock can be interpreted as the short-run role of monetary policy in the economies. The import price is affected by all shocks in the system except the non-oil price shocks, while with the exception of *CPI* all shocks influence the producer price. *CPI* is ordered last as it is assumed to be affected by all shocks and it does not affect any variable contemporaneously. It is thus possible to estimate the SVAR model in different ordering of variables for robust comparisons.

3.3 Data Structure

This study focuses on the four Asian countries from east and west, namely Japan, Korea and Iran and Turkey. The full sample series are from 1970-2015. The data are obtained from the World Development Indicator (WDI) of World Bank. The data consists of money demand or M1 (M), output gap (is defined as the deviation of log gross domestic product in constant price 2010 from its HP filtered trend series as GAP), bilateral real national currency per USD exchange rate (RER), the world oil price (O), consumer price index (CPI), production price index (PPI), import price index (IMP) and money market rate or interest rate of lending by banking system (i). All the series are in logarithm form except for the interest rate.

4. Empirical Results

Using data described in the previous section, we analyze the estimation results for both long-run and short-run. Before this, we have tested unit roots of the variables, in which the results obtained indicate they are integrated of order one [I(1)] at the 5% significance.

4.1 Long-run Results

The first step of our empirical analysis is to investigate the number of co-integrating relationships. The Johansen (1995) LR approach is then used to test the identifying long-run restrictions imposed on the co-integrating vectors. The lag order of the VAR which is behind the co-integration analysis has been selected according to the Schwarz Criterion (SC). According to the individual estimates of the Eigen-values, the max-Eigen-value co-integrating test as well as trace test strongly suggests the existence of long-run relationship for each country.

Since the matrices α and β are not uniquely identified without additional information, restrictions on their coefficients are required[1]. ML estimates

[1]. Pesaran and Shin (2002) showed that r^2 restrictions are needed for exact identification. The restrictions must be evenly distributed across the co-integrating vectors, i.e. there must be r restrictions per vector. In our paper, we exploit restrictions on the β coefficients only.

of the model's parameters subject to linear restrictions on the long-run coefficients are. Tables (1) to (4) represent the co-integration results of the restricted system for each country including Iran, Japan, Korea and Turkey, respectively.[1]

Table 1: Long-run Results for Iran

Variable	Money Demand Eq.	Excess Demand Eq.	Monetary Policy Eq.	Price Eq.	Pass-through Eq.
M	1	0	0	-0.009	0
GAP	-1.24	1	-2.12	0.293	0
i	-0.084	-0.043	1	0	0
P	-1.32	3.43	-8.52	1	-0.052
RER	0	0.625	-1.023	0.168	- 0.079
O	0	-1.29	0	-0.237	-0.797
IMP	0	0	0	-0.213	1
C	-0.089	-0.577	0.123	0.014	-0.035

Source: Research findings

Table 2: Long-run Results for Japan

Variable	Money Demand Eq.	Excess Demand Eq.	Monetary Policy Eq.	Price Eq.	Pass-through Eq.
M	1	0	0	-0.120	0
GAP	-0.679	1	8.45	-0.051	0
i	0.086	-0.236	1	0	0
P	-3.181	-4.04	-9.55	1	-0.252
RER	0	-2.68	-7.30	0.208	-0.494
O	0	0.546	0	-0.057	-0.245
IMP	0	0	0	-0.072	1
C	-0.005	-0.832	14.66	0.006	-0.073

Source: Research findings

[1]. The results are an implicit vector where the sign of parameters should be change for economic interpretation.

Table 3: Long-run Results for Korea

Variable	Money Demand Eq.	Excess Demand Eq.	Monetary Policy Eq.	Price Eq.	Pass-through Eq.
M	1	0	0	-0.063	0
GAP	-1.82	1	-4.84	-0.126	0
i	-0.473	-0.042	1	0	0
P	2.83	-2.03	- 7.19	1	-1.09
RER	0	-2.46	13.9	0.327	- 0.335
O	0	-0.063	0	0.201	-0.338
IMP	0	0	0	-0.505	1
C	-0.081	-0.359	2.01	0.016	-0.014

Source: Research findings

Table 4: Long-run Results for Turkey

Variable	Money Demand Eq.	Excess Demand Eq.	Monetary Policy Eq.	Price Eq.	Pass-through Eq.
M	1	0	0	-0.994	0
GAP	-0.794	1	0.943	0.718	0
i	0.074	-0.622	1	0	0
P	-1.133	0.661	-1.84	1	-0.188
RER	0	-2.44	-2.03	-0.054	0.348
O	0	-6.72	0	0.411	-1.18
IMP	0	0	0	- 0.183	1
C	-0.024	-2.11	-0.578	0.029	-0.047

Source: Research findings

The estimated results in Tables (1) to (4) show that the income gap explains changes in money demand directly, while the coefficient is elastic for Iran and Korea. Also, the results indicates that the interest rate is not an effective proxy for opportunity cost in Iran and Turkey, while the coefficient of this variable is consistent with the theoretical expectations for Japan and Korea. Moreover, the coefficient of the price level show that the money demand increase when the price level increase, and the agents hold more money to do their transactions.

For the excess demand equation, the result show that there is a long-run relation among excess demand and interest rate, price level, real exchange rate and oil price, which the coefficients are almost consistent with the

theoretical expectations. Also, the figures in Table (1), related to Iran, show that the long-run coefficient of the oil price is significant and elastic in the production equation implying the important role of oil revenues in the Iranian economy.

The results for monetary policy equation show that the output gap is a determinant to explain changes in the monetary policy in the long-run, and the monetary authorities have considered this variable to conduct their policy. However, the sign of this variable is not consistent with the theoretical expectations for Japan and Turkey, which can show that the monetary authorities have been sensitive to inflation more than output gap. Moreover, the price level coefficient in the monetary policy response function is consistent with the theoretical expectations, and hence, the monetary authorities have been pursued the inflation targeting policy. Finally, the real exchange rate have been determined as an effective variable in the monetary policy equation in long-run, and the monetary authorities tried to adjust their policy with considering this variable.

The empirical results indicate that money supply has affected price level of four countries in the long-run, while the effect is more pronounced in Turkey than that of Iran, Japan and Korea. Due to the results reported by Tables (1) to (4), it is evident there is a long-run excess demand effect in the price equations; however, it is different for Iran and Turkey. It may implied that the excess demand can be controlled by import. The sign of coefficients of the real exchange rate are theoretically consistent, and indicate when the real exchange rate increase, the price level will decrease in long-run. Moreover, the oil price has different sign in the price equation for the selected countries. The results show that an increase in the oil price has an inflationary effect for Iran and Japan, while the effect is deflationary for Korea and Turkey. Finally, according to Table (1) to (4), the price level have had a positive response to the import price in long-run, while its coefficient is really different for the selected countries.

According to the long-run estimates for the pass-through (import price) equation, the pass-through has been affected directly by price level in Iran, Japan, Korea and Turkey. Moreover a change in real exchange rate has led

to positive pass-through in Iran, Japan, Korea and Turkey. The positive effect for Japan is more pronounced than that of other countries so that in the long-run this has been relatively inflationary to this country. Nonetheless, the degree of pass-through is in not complete for each country. Also, the oil price affects positively import price, which is a signal of positive pass-through arising possibly from oil earning for oil exporting countries, and oil spending for oil importing countries.

4.2 Short-run Results

Estimating structural coefficients, as specified in Section 3-2, are applied to determine the short-run effects arising from variable shocks through their long-run relationships. Hence, the estimation results of the structural *VECM* coefficients have been summarized in Tables (5) to (8), which belong to Iran, Japan, S. Korea and Turkey, respectively. To evaluate the impacts of exchange rate shocks on other variables, particularly on prices (*IMP*, *PPI* and *CPI*), we focus on estimates of three specific coefficients: $S_{54,}$ S_{64} and S_{74}, which have been shown in (5) and the following tables. S_{54} shows a direct effect of the exchange rate pass-through, while the other ones imply the indirect effects. It is of course expected that the direct effect of pass-through should be greater than the indirect effect so that it has been confirmed by the results obtained.

Accordingly, it is expected that the degree of pass-through to *IMP* would be larger than that of *PPI* and that of *PPI* is larger than that of *CPI*, because non-tradable components, such as distribution costs, rents and profits, are larger in *PPI* than *IMP* and even larger in *CPI* than *PPI*. Going down the supply chain may naturally result in a decline in the degree of pass-through from upstream to downstream prices. By comparing pass-through coefficients of *IMP*, *PPI* and *CPI*, it becomes possible for us to determine whether and how much the domestic reactions to the exchange rate shock mitigated or aggravated the external shocks.

In summary, the results reported in Table (5) represent that the direct effect of the pass-through shock is about 0.04 in Iran, while the indirect effects on PPI and CPI are 0.02 and 0.02, lower than the direct effect. Although expected, the results shown in Table (6) reveal higher pass-

through effects than those of Iran. In this case, the direct effect of the shock is about 0.08, while the indirect effects on *PPI* and *CPI* are quite small: 0.007 and 0.002 respectively. Due to the empirical results in Table (7), the direct effect of the pass-through shock for Korea is about 0.03, a lower than that of Iran and Japan, while the indirect effects on *PPI* and *CPI* are not significant. Finally, Table (8) shows the empirical results for Turkey arising from the macro-variable shocks in the short-run. Based on the results obtained, the direct effect of the pass-through shock in Turkey is about 0.02, which is smaller than that other countries. Meanwhile, the indirect effects of the pass-through shocks for this country are not significant.

Overall, the implication is that pass-through shocks in the short-run are more effective in the countries, like Iran, that their exchange markets have been relied on a relatively the fixed exchange rate regime. Furthermore, the results imply that the more floating regime lead to the more pass-through shocks on an economy, at least in the short-run.

Table 5: Short-run Results for Iran

Effect	Coefficient	Std. Error	z-Statistic	Prob.
S_{11}	0.262427	0.031824	8.246211	0.0000
S_{21}	0.023572	0.011172	2.109862	0.0349
S_{22}	0.062977	0.007637	8.246211	0.0000
S_{31}	0.002229	0.009242	0.241154	0.8094
S_{32}	0.005999	0.009209	0.651443	0.5148
S_{33}	0.053529	0.006491	8.246211	0.0000
S_{41}	-0.077017	0.105415	-0.730609	0.4650
S_{42}	0.008063	0.104996	0.076791	0.9388
S_{43}	0.158366	0.103220	1.534264	0.1250
S_{44}	0.591359	0.071713	8.246211	0.0000
S_{51}	0.076171	0.027926	2.727630	0.0064
S_{52}	0.072321	0.024852	2.910122	0.0036
S_{53}	0.026149	0.023035	1.135167	0.2563
S_{54}	**0.038697**	**0.022328**	**1.733097**	**0.0831**
S_{55}	0.127287	0.015436	8.246211	0.0000
S_{61}	0.029671	0.009579	3.097583	0.0020

S_{62}	-0.001792	0.008875	-0.201918	0.8400
S_{63}	0.011222	0.008767	1.280009	0.2005
S_{64}	**0.016716**	**0.008420**	**1.985261**	**0.0471**
S_{65}	0.005452	0.008146	0.669362	0.5033
S_{66}	0.047340	0.005741	8.246211	0.0000
S_{71}	0.007006	0.008874	0.789501	0.4298
S_{72}	-0.007558	0.008786	-0.860238	0.3897
S_{73}	0.007932	0.008684	0.913390	0.3610
S_{74}	**0.016038**	**0.008409**	**1.907167**	**0.0565**
S_{75}	0.000264	0.008181	0.032260	0.9743
S_{76}	0.031737	0.007219	4.396171	0.0000
S_{77}	0.035614	0.004319	8.246211	0.0000
Log likelihood	206.3733			

Source: Research findings

Table 6: Short-run Results for Japan

Effect	Coefficient	Std. Error	z-Statistic	Prob.
S_{11}	0.258689	0.028567	9.055385	0.0000
S_{21}	0.008030	0.003022	2.656635	0.0079
S_{22}	0.018502	0.002043	9.055385	0.0000
S_{31}	0.002025	0.005472	0.370035	0.7114
S_{32}	0.007189	0.005410	1.328901	0.1839
S_{33}	0.034266	0.003784	9.055385	0.0000
S_{41}	0.016132	0.017264	0.934404	0.3501
S_{42}	0.016735	0.017072	0.980243	0.3270
S_{43}	-0.021142	0.016811	-1.257684	0.2085
S_{44}	0.106597	0.011772	9.055385	0.0000
S_{51}	0.088126	0.019452	4.530333	0.0000
S_{52}	0.017973	0.016726	1.074570	0.2826
S_{53}	-0.008702	0.016580	-0.524887	0.5997
S_{54}	**0.081618**	**0.013882**	**5.879190**	**0.0000**
S_{55}	0.067609	0.007466	9.055385	0.0000
S_{61}	0.016276	0.004213	3.862886	0.0001
S_{62}	7.54E-05	0.003811	0.019774	0.9842
S_{63}	0.003274	0.003794	0.862950	0.3882
S_{64}	**0.006501**	**0.003707**	**1.753638**	**0.0795**
S_{65}	0.021290	0.002775	7.671414	0.0000

S_{66}	0.009442	0.001043	9.055385	0.0000
S_{71}	0.004113	0.001603	2.565428	0.0103
S_{72}	0.001020	0.001533	0.665372	0.5058
S_{73}	0.001307	0.001522	0.858504	0.3906
S_{74}	**0.001787**	**0.001503**	**1.189217**	**0.2344**
S_{75}	0.006541	0.001303	5.021188	0.0000
S_{76}	0.004622	0.000956	4.832961	0.0000
S_{77}	0.005179	0.000572	9.055385	0.0000
Log likelihood	559.3029			

Source: Research findings

Table 7: Short-run Results for Korea

Effect	Coefficient	Std. Error	z-Statistic	Prob.
S_{11}	0.231366	0.025550	9.055385	0.0000
S_{21}	0.006895	0.003637	1.895852	0.0580
S_{22}	0.022773	0.002515	9.055385	0.0000
S_{31}	-0.010178	0.014553	-0.699396	0.4843
S_{32}	-0.007149	0.014488	-0.493480	0.6217
S_{33}	0.092630	0.010229	9.055385	0.0000
S_{41}	-0.036720	0.013811	-2.658703	0.0078
S_{42}	-0.057543	0.011573	-4.972365	0.0000
S_{43}	0.013830	0.009551	1.448061	0.1476
S_{44}	0.060366	0.006666	9.055385	0.0000
S_{51}	0.027698	0.015435	1.794443	0.0727
S_{52}	-0.048533	0.014148	-3.430335	0.0006
S_{53}	0.009434	0.013052	0.722788	0.4698
S_{54}	**0.026854**	**0.012668**	**2.119805**	**0.0340**
S_{55}	0.078861	0.008709	9.055385	0.0000
S_{61}	0.008868	0.006356	1.395245	0.1629
S_{62}	-0.018898	0.005923	-3.190599	0.0014
S_{63}	0.000754	0.005542	0.136071	0.8918
S_{64}	**-0.000272**	**0.005542**	**-0.049164**	**0.9608**
S_{65}	0.031100	0.004349	7.150889	0.0000
S_{66}	0.017085	0.001887	9.055385	0.0000
S_{71}	-0.000274	0.003867	-0.070873	0.9435
S_{72}	-0.005890	0.003812	-1.545177	0.1223
S_{73}	0.004016	0.003730	1.076655	0.2816

S_{74}	**-0.003776**	**0.003680**	**-1.026234**	**0.3048**
S_{75}	0.016158	0.003191	5.063859	0.0000
S_{76}	0.012666	0.002245	5.641451	0.0000
S_{77}	0.011246	0.001242	9.055385	0.0000
Log likelihood	475.4862			

Source: Research findings

Table 8: Short-run Results for Turkey

Effect	Coefficient	Std. Error	z-Statistic	Prob.
S_{11}	0.260083	0.032014	8.124038	0.0000
S_{21}	0.004460	0.005415	0.823679	0.4101
S_{22}	0.030945	0.003809	8.124038	0.0000
S_{31}	-0.007471	0.017122	-0.436360	0.6626
S_{32}	-0.007312	0.017074	-0.428240	0.6685
S_{33}	0.097944	0.012056	8.124038	0.0000
S_{41}	-0.033717	0.015588	-2.162979	0.0305
S_{42}	-0.048852	0.013770	-3.547785	0.0004
S_{43}	0.030323	0.011812	2.567224	0.0103
S_{44}	0.064375	0.007924	8.124038	0.0000
S_{51}	0.099423	0.024839	4.002716	0.0001
S_{52}	0.108887	0.016958	6.421131	0.0000
S_{53}	-0.013620	0.010252	-1.328521	0.1840
S_{54}	**0.017148**	**0.009891**	**1.733575**	**0.0830**
S_{55}	0.055513	0.006833	8.124038	0.0000
S_{61}	0.009812	0.013433	0.730453	0.4651
S_{62}	-0.009358	0.013329	-0.702116	0.4826
S_{63}	0.038049	0.012426	3.062129	0.0022
S_{64}	**0.001754**	**0.011507**	**0.152455**	**0.8788**
S_{65}	0.032168	0.010802	2.977824	0.0029
S_{66}	0.057736	0.007107	8.124038	0.0000
S_{71}	-0.002083	0.011000	-0.189382	0.8498
S_{72}	0.001034	0.010996	0.093997	0.9251
S_{73}	0.031795	0.010276	3.094263	0.0020
S_{74}	**-0.006974**	**0.009462**	**-0.736989**	**0.4611**
S_{75}	0.017297	0.009180	1.884354	0.0595
S_{76}	0.047209	0.006780	6.963338	0.0000

S_{77}	0.020061	0.002469	8.124038	0.0000
Log likelihood	317.0673			

Source: Research findings

5. Conclusion

Our study has contributed to strand of the exchange rate literature. Although there are a number of researches on the exchange rate pass-through, its analysis (especially for Iran) is still limited. To fill this gap, this study has focused on some Asian economies, namely Iran, Japan, Korea and Turkey.

In this paper, the pass-through effects of the exchange rate changes on imported prices, producer (wholesale) prices, and consumer prices were analyzed for the period 1970-2015, including pre and post-crisis periods of East Asia and the recent global crisis. Basically, the VAR analysis of the exchange rate pass-through has revealed several new important facts. First, the degree of pass-through of an exchange rate shock to different domestic price indices varies, but consistently with prediction: the pass-through effect is the largest for import price (*IMP*), the second for producer price index (*PPI*) and the smallest on consumer price index (*CPI*). This is quite consistent with common sense that the degree of pass-through depends on the degree of tradable contents. Second, the degrees of the indirect effects to the exchange rate shock are by far the largest in Iran compared to other Asian countries. Third, the difference of price response to the exchange rate shock was most pronounced in *IMP* for Japan than other countries. Fourth, a notable difference in the long-run and short-run results has been attributable to the reactions of macro variables in pre and post-crisis periods.

The empirical findings obtained by this paper confirmed a dynamic relationship between exchange rate pass-through and other macro variables in the countries under consideration. Indeed, changes in exchange rates in those countries, with different exchange rate regimes, have led to changes in prices, indicating a significant direct effect of pass-through in import prices, while a significant indirect effect of pass-through in domestic

prices. Such effects have been different in East Asian countries (Korea and Japan) compared with those of the West Asian ones (Iran and Turkey).

In general, the results have shown that the pass-through shocks in the short-run are more effective in the countries, like Iran, which benefit from a managed floating exchange rate regime. This implies the more floating regime, the more pass-through shocks on an economy at least in the short-run. Hence, the implication is that moving toward a floating exchange regime during a post-crisis period should lead to a not better condition of the exchange market in covering exchange rate risks.

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