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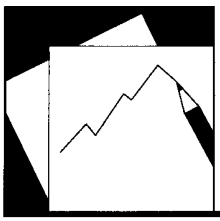

IMF Working Paper

Exchange Rate Pass Through to Prices in Maldives

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Exchange Rate Pass Through to Prices in Maldives

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Abstract

This study examines the degree of exchange rate pass through (EPRT) into producer and consumer prices in Maldives. ERPT to consumer prices is first estimated using a nonparametric approach. A recursive vector autoregression is then used to model both consumer and producer price changes. The nonparametric estimation indicates that ERPT to consumer prices is very high, both in absolute terms and relative to other countries. The dynamics of ERPT as derived from the empirical estimation indicate that ERPT to consumer and producer prices is significant but not complete, and that the impact of exchange rate changes persists into the second year.

JEL Classification Numbers:C32, E31, F31, O53

Keywords: Inflation, Exchange Rate, Maldives

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I. INTRODUCTION

The degree to which changes in the exchange rate are reflected in domestic prices is commonly referred to as exchange rate pass through (ERPT). The price indices for traded (or tradable) goods and nontraded (or nontradable) goods as well as the aggregate consumer and producer price indices can all be affected by exchange rate movements. An understanding of ERPT into these different domestic prices is important for a number of reasons. First, forecasting inflation and setting monetary policy in response to inflation shocks requires knowledge of the degree and speed of pass-through of shocks to prices. Second, in the design of macroeconomic policy to support stabilization, the choice of stabilization options such as devaluation or aggregate demand management policies could depend crucially on the degree and speed of ERPT. For example, if tradable and nontradable goods prices respond by a similar proportion to changes in the exchange rate, relative prices will not be much affected and thus there will be limited expenditure switching from foreign to domestic goods (although changes in import volumes would still result from the income effects of the exchange rate changes).

This study examines the extent of exchange rate pass-through into domestic prices in Maldives since 1994, after the country moved from a managed float to a fixed exchange rate regime (vis-à-vis the US dollar). In particular, it investigates the following issues:

- *What is the extent of exchange rate pass through in the Maldives?*
- *What is the speed of the pass through to different prices, and what are the key drivers?*
- *Given the findings of the research, what would be the likely impact of an exchange rate shock on prices?*

The study undertakes both nonparametric and parametric estimations to address these questions. The nonparametric estimation uses a methodology developed by Campa and Goldberg (2006) to calculate the share of imported inputs in total costs using the Maldives Supply and Use Table (SUT). On this basis we measure the overall static sensitivity of the CPI to exchange rate changes. The econometric estimation utilizes a recursive VAR model to explain the ERPT to consumer and producer price indexes using quarterly data for 1994–2010. While the first approach is a static analysis and provides a point estimate of the pass through coefficient, the second approach allows for understanding of the speed of pass through of exchange rate changes to prices in a longer time frame.

The result of the nonparametric estimation indicates that ERPT to consumer inflation in Maldives is very high in absolute terms, and relative to other countries. The VAR estimation, in turn, suggests that ERPT has strong impacts on consumer and producer prices, though pass through is incomplete. Shocks on producer and consumer price indexes arising from changes in the nominal effective exchange rate persist for most of the time horizon.

The remainder of the paper is organized as follows. A brief survey of the literature is undertaken in Section 2. Section 3 examines recent exchange rate and price developments in Maldives. In

Section 4, a static nonparametric estimation of the pass through of exchange rate changes to prices is carried out. Section 5 estimates a recursive vector autoregressive (VAR) model to explain the impact of exchange rate movements on prices. Section 6 concludes.

II. THEORETICAL BACKGROUND AND EMPIRICAL LITERATURE

In a first approximation, changes in the consumer price index generated by shocks to the exchange rate are expected to be proportionate to the share of imported goods in consumption. However, there are several reasons why pass through could be higher or lower. First, it is possible that prices of domestically produced consumption goods are also affected by shocks to import prices. In such cases, the total pass through coefficient on exchange rate changes to domestic prices would be *greater* than the share of imports in consumption. For example, in Maldives, a devaluation would not only lead to an increase in the domestic price of gasoline, but could also put pressure on electricity tariffs, whose rates are indexed to fuel prices, and on other imported components of domestically-produced goods and services. This would feed back into other domestic prices (and possibly pressures on wages), through indirect or second round effects. It is also possible that the change in consumer prices generated by an exchange rate shock may be *smaller* than the import share of consumption. This would be the case if (a) the pass through to import prices is incomplete (for instance, because there is pricing to market) or (b) the shock results in a decline in demand for other goods (a negative income effect) that is not offset by an increase in export income in domestic currency terms.

The empirical evidence indicates a lower pass through coefficient of consumer prices for industrial or advanced economies than for developing economies. Menon's (1995) analysis of 43 industrialized economies found ERPT to consumer prices to be generally incomplete but very different in magnitude across different countries, with greater ERPT for smaller or more open economies. In a similar finding, Goldfajn and Werlang's (2000) study of 71 developed and emerging market countries found that the pass-through effects on consumer prices increase over time and reach a maximum after 12 months, and are substantially higher in emerging market economies than in developed economies. For developing countries, the overwhelming evidence is that exchange rate pass through is high for consumer and other price indices, though incomplete.

Pass through to consumer prices appears to be more modest than to other price indices. Murgasova's (1996) study of the devaluation of the Spanish peseta during the Exchange Rate Mechanism crisis in 1992 and 1993 found a one-to-one pass-through to import prices but only a 10 percent pass-through to the CPI. Rowland (2004) found that import prices respond quickly to an exchange rate change, with about 80 percent of such a change passed onto prices of imports within 12 months. The pass-through was found to be modest for producer prices and very limited for consumer prices. McCarthy (1999) presents a comprehensive study of ERPT for a number of industrialized countries using a "distribution chain" model. Using a recursive VAR methodology, pass through is evaluated for import, producer and consumer price indices, using data from 1976 to 1998. In most of the countries analyzed, the ERPT to consumer prices is found

to be modest, particularly in larger economies. On the other hand, ERPT to producer and import prices was found to be significant though incomplete. Gueorguiev (2003) found that, for Romania, the pass through to both consumer and producer prices is relatively large and fast, ranging from 60-70 percent for producer prices and 30-40 percent for consumer prices, depending on the exchange rate benchmark used. In addition, ERPT to producer prices account for a sizeable fraction of inflation, while that to consumer prices is a more moderate determinant of inflation.

Studies have uncovered several factors that explain why, given ERPT to import prices of similar magnitudes, the impact on the domestic price level could differ. In cases where the pass through is less than complete, the main finding is that when the exchange rate changes, importing and exporting firms may choose to adjust only their own mark-up on prices rather than pass on the change, thereby holding the final price constant, a practice known as "pricing-to-market". Krugman (1987) found that a desire to maintain market share encourages firms to delay increasing their price in response to higher import prices. This assumption is largely supported by the findings of Goldberg and Knetter (1997), which indicate that only around 60 percent of exchange rate changes are passed on to import prices in the United States, and that the figure varies significantly across industries[2]. In general, studies found that companies tend to adjust their profit margins rather than pass on the change in the exchange rate, and this is more prevalent within competitive industries.

Domestic economic conditions are strong determinants of the extent of ERPT when there is a regime switch or large devaluation. Borensztein and De Gregorio (1999) found that about 30 percent of large devaluations are offset by higher inflation after three months, while the offset increases to about 60 percent after two years. This appears to hold true more for devaluation in the context of a currency crisis or regime switch. Goldfajn and Werlang (2000) show that during a devaluation or regime switch, the main determinants of the extent of pass-through to consumer prices are the cyclical state of the economy, the initial over or undervaluation, the initial rate of inflation, and the degree of openness of the economy. The study found that depreciation, initial inflation and GDP above trend are positively related to inflation, while overvaluation and openness (in some cases) moderate inflation outcomes.

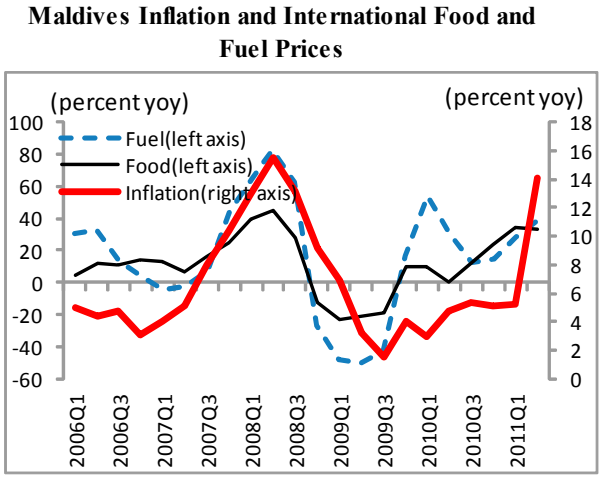
Exchange rate pass through to prices in Maldives is expected to be consistent with the findings of previous studies. Consistent with the findings of Goldfajn and Werlang's (2000) for emerging market and less developed economies, exchange rate pass through should be high in Maldives. Given the high level of import dependence in the country, there is an expectation that not only will the pass through coefficient be high, but the speed of pass through should also be quick. It is also possible to find evidence of less than proportionate pass through, as indicated in studies by Krugman, and Goldberg and Knetter, given the relative openness of the Maldivian economy. The dynamics of exchange rate pass through to prices and empirical estimates of the coefficients of pass through would indicate the extent to which these assumptions hold in Maldives.

[2] Other findings with similar results include Devereux, Engel and Tille (1999).

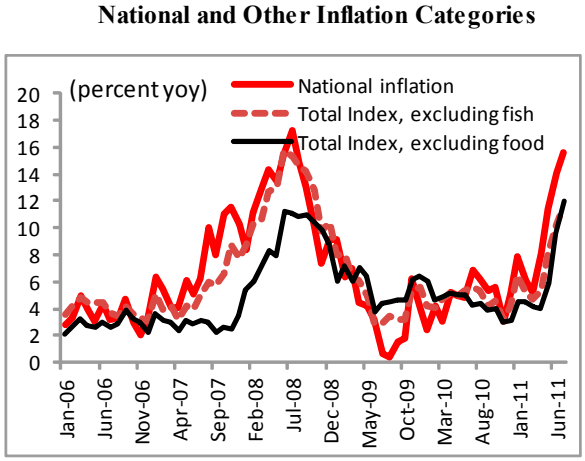
III. Maldives: Economy, Prices and Exchange Rates

Maldives's inflation has moved roughly in line with global commodity prices, peaking at 17 percent on a y-o-y basis in July 2008 in the wake of high global food and fuel prices. By end 2010, inflation had decelerated and stabilized at 5 percent as international commodity prices fell. Given their large weights in the domestic consumption basket, food and housing, and water, electricity, and fuels, are the main drivers of Maldives's inflation, and most of the movement in national CPI inflation can be explained by these two groups. Between January 2008 and March 2009 movement in the food group accounted for more than 50 percent of total inflation, while housing, water, electricity, and fuels accounted for a quarter. Inflation "excluding fish prices" and core inflation, or "inflation excluding food prices", remained lower than overall inflation between mid-2008 and end-2010, reflecting the rise in fish and food prices during the period.

Figure 1. International Commodity Prices and Maldives Inflation Developments, 2006–2011



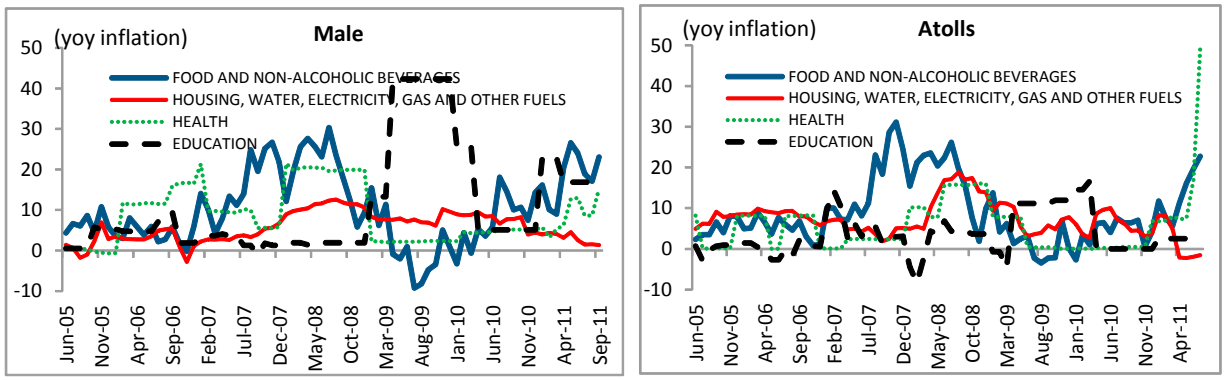
Source: Department of National Planning, International Monetary Fund.



Source: Department of National Planning.

Maldives's peculiar topography—1,192 islands with a total land area of about 298 square kilometers spread over more than 90,000 square kilometers of ocean—produces strong regional variations in inflation outcomes. Inflation in the capital Malé was lower than inflation in the other atolls between 2007 and mid-2009, reflecting higher prices for food, housing, water, electricity and fuels at the atoll level. Since then, however, the trend has reversed. The increase in the cost of housing, water, electricity, fuel, and education were the main drivers of the recent hike in Malé inflation. Housing rent continues to be the leading domestic driver of Malé inflation, while the cost of education also rose sharply due to increases in fees for secondary education.

Figure 2: Male and Atolls CPI Inflation by Components

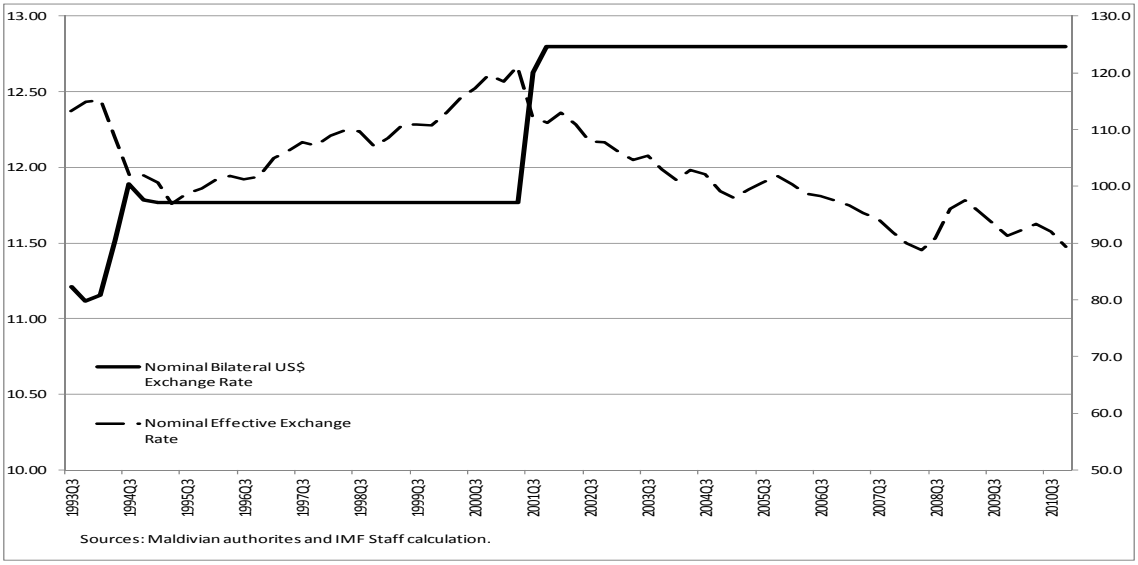


Source: Department of National Planning.

Since 1994, the exchange rate in Maldives has moved only twice. The first instance was through a devaluation of 8.8 percent in 2001. The second was in April 2011, when the currency depreciated by almost 20 percent following the introduction of an exchange rate band of +/- 20 percent around the parity of Rufiyaa 12.8 per US dollar. Given that Maldives is an import-dependent open economy, exchange rate changes can be expected to be a key driver of inflation outcomes. In addition, with the exchange rate referenced to the US dollar, dollar appreciation against major currencies provides some relief from high international prices, thereby moderating inflation, with the converse being true when the dollar is depreciating.[3] The next section undertakes a non-parametric analysis of the impact of exchange rate changes on prices in Maldives.

[3] Within the fixed exchange rate regime, which serves as the nominal anchor, monetary policy has been conducted to protect the exchange rate and reserves. The MMA actively manages excess liquidity through reserve targeting, with a view to increasing banks' demand for domestic currency and reducing exchange rate pressure. Banks are subject to a 25 percent reserve requirement on both foreign exchange and domestic currency deposits, which are expected to be fulfilled in the respective currencies (USD and Rufiyaa, though the USD reserve requirement is partially met in Rufiyaa). In addition, MMA conducts weekly open market operations aimed at absorbing excess liquidity from banks, while at the same time implicitly signaling the direction of short term interest rates. As a result of proactive monetary policy, inflation outcomes are sometimes more moderate than expected in a fixed exchange rate regime.

Figure 3. Maldives: Nominal Bilateral (Rufiyaa per US Dollar) and Nominal Effective Exchange Rates, 1993–2010



IV. NON-PARAMETRIC EVIDENCE OF ERPT FROM THE MALDIVES SUPPLY AND USE TABLE

As noted above, the Maldivian economy is very import intensive, suggesting the CPI may be highly sensitive to changes in the exchange rate. Out of 85 products tracked in the Maldivian SUT 2003[4], about a third (29) are imports, 19 have import content exceeding 50 percent, and only 23 are fully domestic. If the imported content of domestic inputs is considered (2nd round effects), the number of products for which total imported content is over 50 percent would be 62.

[4] The Department of National Planning kindly shared the SUT 2003 with staff and gave authorization to analyze this issue. The DNP is currently compiling a SUT 2007 under an ADB project.

Table 1. Maldives: Total Exchange Rate Pass Through to CPI (1st and 2nd round effects)

Product	1st round effect 1/ (A %)	2nd round effect 2/ (B %)	Total impact 3/ (A+B %)	CPI Weights (C)	Pass-through to CPI ((A+B)*C %)
Total Maldives	**0.51**	**0.28**	**0.79**	**1.00**	**0.79**
Food and non-alcoholic beverages	0.67	0.22	0.89	0.33	0.30
Tobacco and narcotics	1.00	0.00	1.00	0.03	0.03
Clothing and footwear	0.40	0.48	0.89	0.06	0.05
Housing, water, electricity, gas and other fuels	0.15	0.67	0.81	0.19	0.16
Furnishings, household equipment and routine maintenance of	0.85	0.04	0.89	0.05	0.05
Health	0.41	0.05	0.46	0.05	0.02
Transport	0.24	0.36	0.61	0.05	0.03
Communications	0.16	0.23	0.39	0.06	0.02
Education	0.27	0.16	0.43	0.03	0.01
Hotels, cafes and restaurants	0.01	0.32	0.33	0.01	0.00
Miscellaneous goods and services	0.96	0.01	0.97	0.08	0.08
Religion	0.00	0.12	0.12	0.00	0.00

Source : Maldivian authorities, and Fund staff calculations.

1/ First round effect is the direct impact of a 1 percent change in the exchange rate on the cost of an item's imported inputs. This analysis is based on the Supply and Use Table (2003).

2/ Second round effect is the impact of a 1 percent change in the exchange rate change on the price of an item through the change in the imported content cost of domestic inputs used in the production of that item.

3/ Total impact is the sum of the first and second round effects of a 1 percent change in the exchange rate on the price of the corresponding item, expressed in percent.

In this section, nonparametric evidence of the ERPT to consumer inflation is derived, using the SUT measures of imported inputs for 10 major groups. The sensitivity of the CPI to exchange rates was then computed using CPI weights from the disaggregated CPI series. In measuring the degree of ERPT, the first round impact, defined as the share of imported inputs in total costs by 85 specified entry level items was measured. This is followed by an estimate of second round impact, derived by multiplying the share of domestic inputs by their imported input shares. Finally, by applying the CPI weights to total impacts which are the sum of first and second round impacts, we arrive at a measure of the sensitivity of the CPI to exchange rate changes. The results indicate that the total ERPT into CPI is around 79 percent, meaning that a 10 percent depreciation in the exchange rate would lead to an increase in consumer prices of 7.9 percent (Table 1).

The analysis above does not consider the possibility of substitution in production and consumption or the possible response of distribution margins to changes in the exchange rate. Following the approach in Campa and Goldberg (2006) and using, for comparability, their calibrated elasticity parameters, the ERPT coefficient is computed allowing for these effects. The coefficient for Maldives was estimated at 77 percent, which is extremely high compared to other countries and far higher than the 26 percent average ERPT that Campa and Goldberg computed for their sample of 21 (mainly OECD) countries (Table 2). This unusually high pass through is likely explained by the structural features of the Maldivian economy—in particular, the high import content in production and consumption, the lack of domestic substitutes, and relatively small distribution margins. In addition, there are indications that certain product distributors/retailers would pass through to consumers 100 percent of their additional costs

caused by exchange rate change given the absence of domestic substitutes. Similarly, non-tradable sectors such as health, transport, construction and education would face substantial effects from devaluation or depreciation given the high second round impact arising from the use of intermediate materials heavily dependent on imports.

Table 2. Maldives: Exchange Rate Pass Through to CPI Accounting for Substitution Effects and Distribution Margins

	Maldives	Campa & Goldberg (2006) 5/				
		Average	Max		Min	
Share of imported inputs (in percent) 1/	45.9	25.1	48.5	Ireland	8.20	United States
Average distribution margins (in percent) 2/	9.7	16.0	23.9	United States	8.40	Hungary
Imported input share of tradables in consumption	0.85	0.40	0.59	Austria, Denmark	0.20	United States
Share of tradables in consumption 3/	0.65	0.36	0.59	Estonia	0.25	United States
Share of imported input cost in tradable production costs	0.89	0.31	0.49	Ireland	0.10	United States
Share of imported input cost in nontradable production costs	0.48	0.13	0.35	Ireland	0.03	United States
Exchange rate pass through into CPI 4/	**0.77**	**0.26**	**0.56**	**Ireland**	**0.07**	**United States**

Source: Maldivian authorities, Campa & Goldberg (2006), and Fund staff calculations.
1/ Refers to the ratio of the total value of imported intermediate inputs by an industry to the value of total intermediate inputs.
2/ Calculated as the simple average of all distribution margins relative to the purchasers' prices for 29 industries.
3/ Sum of CPI weights for tradables.
4/ Assumes distribution margin sensitivity to exchange rates is -0.5 (that is, in response to a 1 percent depreciation, distributors would lower margins by 0.5 percent).
5/ "Distribution margins, imported inputs, and the sensitivity of the CPI to exchange rates", *NBER Working Paper*, No. 12121 (March 2006).

The devaluation episode of July 2001[5] illustrates quite well the response of prices in Maldives to exchange rate changes. On July 25, 2001, the Rufiyaa/US$ rate was devalued by 8.8 percent, while a fixed parity was maintained. Despite negative underlying domestic inflation (as measured by the annual average rate over the preceding 12 months) and a sharp fall in international commodity prices during that time, average inflation rose to 3.7 percent in the year

[5] This analysis does not estimate the impact of the April 2011 depreciation, which occurred as the research was being undertaken.

after the devaluation. A simple analysis estimates the pass through during that episode at 90.6 percent (Table 3).

Table 3. Maldives: Estimated Exchange Rate Pass Through to CPI from July 2001 Devaluation

		(percent)
Devaluation rate [= (e_t - e_{t-12})/e_{t-12}*100] 1/		8.8
Average yoy change in bilateral exchange rates over t+12	A	8.8
Average yoy inflation over t-12	B	-1.4
Average yoy change in commodity price over t+12, weighted by CPI weights	C	-2.9
Average yoy inflation over t+12	D	3.7
Lag (in months) between t and maximum average yoy inflation over t+12		2
Lag (in months) between t and maximum yoy inflation over t+12		6
Pass-through into CPI	(D-C-B)/A*100	90.6

Sources: Maldivian authorities and IMF Staff calculations.

1/ t = July 2001 (month when the rufiyaa/US$ exchange rate was devalued).

V. ECONOMETRIC ESTIMATION

The results of the foregoing analysis of ERPT to consumer price inflation apply only to a specific point in time, and may or may not reflect the long run trend in the response of inflation to exchange rate changes. Effective policy response to inflation and exchange rate developments requires knowledge of the transmission mechanism of exchange rate changes to prices. Therefore, this section undertakes a dynamic estimation to complement the static analysis. While the focus of the model is on the response of prices to shocks from the exchange rate, the estimation uses the nominal effective exchange rate because the operation of a fixed exchange rate regime in Maldives during the period analyzed precludes the use of the bilateral US dollar exchange rate.

The analytical framework for the empirical estimation draws from McCarthy (1999), which examined the pass through of exchange rate changes to different types of prices along a distribution chain in a recursive VAR framework[6]. With identified shocks to prices coming from commodity prices, economic activity, and the exchange rate, the model is estimated as a five variable VAR system consisting of change in all commodity prices ($ComP_t$), the output gap ($\tilde{y}_t$), the exchange rate (Δe_t), producer (π_t^p), and finally consumer prices (π_t^c)[7]:

Supply shock

$$ComP_t = E_{t-1}(ComP_t) + \varepsilon_t^s$$

Demand shock

[6] The McCarthy model includes import price inflation, which is not included in this model. Given that Maldives is a small open economy with a high rate of dollarization, exchange rate pass through to import prices can be taken as complete and given.

[7] The output gap is difficult to measure, especially in small economies, and is subject to uncertainty in practice. Therefore, real GDP growth is used in an alternative specification.

$$\tilde{y}_t = E_{t-1}(\tilde{y}_t) + a_i\varepsilon_t^s + \varepsilon_t^d$$

Exchange rate shock

$$\Delta e_t = E_{t-1}(\Delta e_t) + b_1\varepsilon_t^s + b_2\varepsilon_t^d + \varepsilon_t^e$$

Producer Price Inflation

$$\pi_t^p = E_{t-1}(\pi_t^p) + \beta_1\varepsilon_t^s + \beta_2\varepsilon_t^d + \beta_3\varepsilon_t^e + \varepsilon_t^p$$

Consumer Price Inflation

$$\pi_t^c = E_{t-1}(\pi_t^c) + \gamma_1\varepsilon_t^s + \gamma_2\varepsilon_t^d + \gamma_3\varepsilon_t^e + \gamma_4\varepsilon_t^p + \varepsilon_t^c$$

Where ε_t^s, ε_t^d , and ε_t^e are the supply, demand and exchange rate shocks; ε_t^p , and ε_t^c are the producer price and consumer price shocks; and E_{t-1} is the expectation of a variable conditional on the information set at the end of period $t-1$.

All commodity prices, the output gap and the exchange rate are each modeled as the product of the expected variable based on previous period inflation, and the preceding shocks. Unlike in the McCarthy model, where supply shock is approximated by the dynamics of oil price change denominated in local currency, we assume that for Maldives the supply shock is better proxied by an index of all commodity prices, which includes oil and nonoil commodities. This is because Maldives is an extremely open economy that relies heavily on both fuel and nonfuel imports, and commodity prices are a major source of domestic price pressures on household, corporate, and government expenditure. Consistent with previous research, the output gap is modeled as a major source of the demand shock[8]. Finally external shocks are reflected in the nominal effective exchange rate, after taking into consideration supply and demand shocks. The model assumes that there are two stages of inflation: producer and consumer inflation.. In general, period *t* inflation at any stage is the product of expected inflation based on information at period *t-1*, supply and demand shocks on inflation at period *t*, contemporaneous exchange rate shocks to that inflation, the effects of inflation shocks at previous stages, and finally an own inflation shock.[9] The model is recursive because an initial shock to commodity prices is transmitted first through the output gap, followed by the exchange rate, and then on to producer and consumer prices, in that order.

A. Data and Econometric Issues

Data: Empirical estimation is based on quarterly[10] observations from 1994Q3-2010Q4. This sample starts after the adoption of the fixed peg to the US dollar, and ends in the quarter before the change in the exchange rate regime from a fixed peg to a horizontal band. Except for a modest change in the parity in 2001, the exchange rate system remained a fixed one during the period. This study does not focus on the period following the April 2011 exchange rate regime change due to insufficient data to observe the impact of that change.

[8] See Gueorguiev (2003).

[9] As presented, the model assumes that shocks are not contemporaneous. It is plausible that this may not be the case in all instances, for example between PPI and CPI. This is more so since there is no restriction on the lag structure of the model, However, this does not significantly impact the assessment of exchange rate pass through to prices.

[10] See Appendix I for data description.

The key variables used in the estimation are defined as follows:

- *All Commodity Price Index,* an index of commodity prices faced by Maldives, as computed by IMF World Economic Outlook

- *Output gap* is constructed by interpolating quarterly GDP from annual series, and then taking the deviations of the log of real GDP from a trend derived through the Hodrick Prescott filter. An alternative specification uses the growth rate of real GDP.

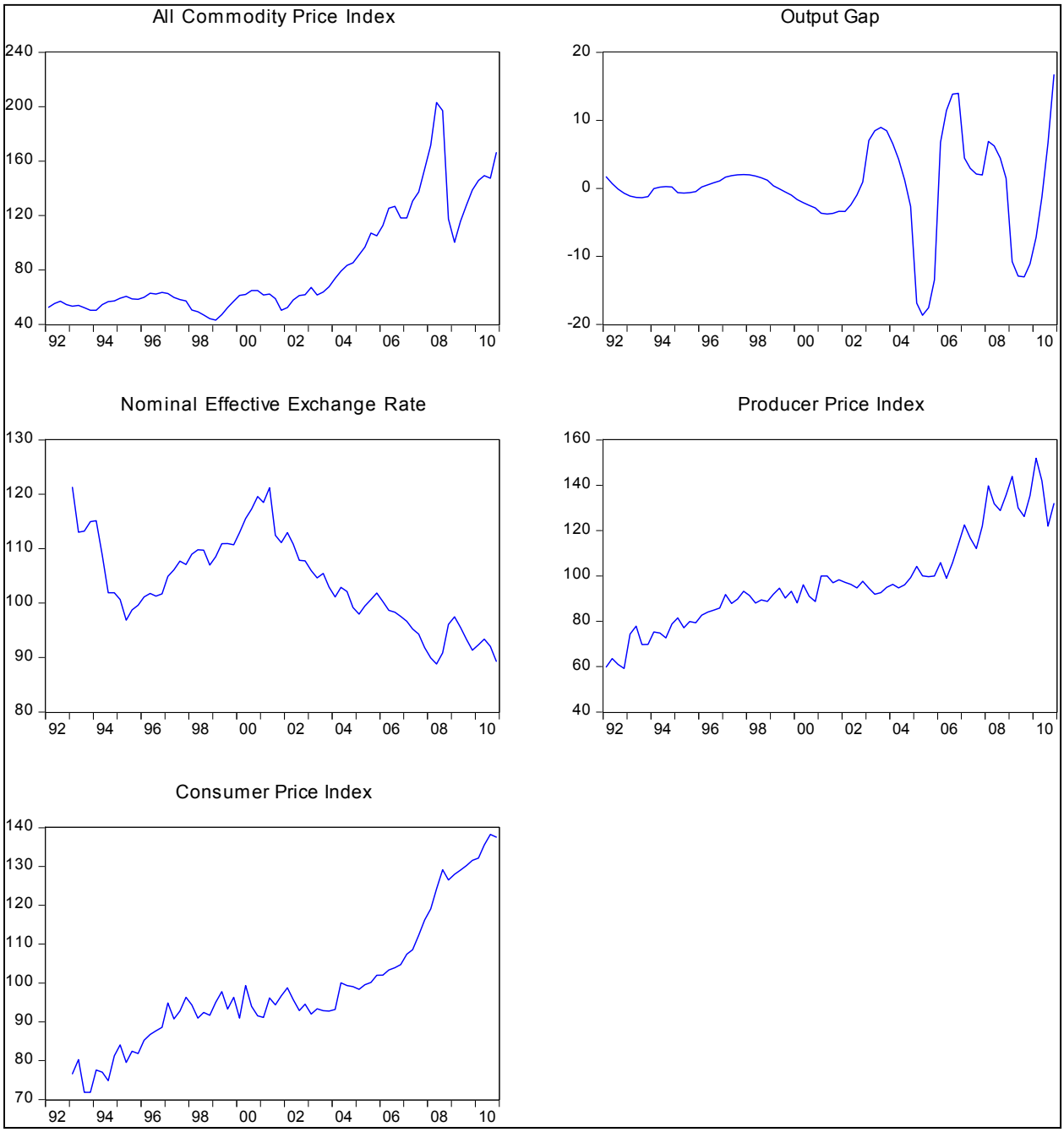
- Exchange rate, using the *nominal effective exchange rate (NEER)* index, which, as defined earlier, is the nominal exchange rate weighted by trade shares of major trading partners. Use of the nominal effective exchange rate is supported by the fact that Maldives had a fixed exchange rate regime, and the bilateral US dollar / rufiyaa exchange rate did not fluctuate;

- *Producer price index, PPI* is reported by the authorities from 1994. Pre-1994 series are interpolated using official CPI data;

- *Consumer price index, CPI,* as reported by Maldives authorities;

As indicated in Figure 4, all variables followed a relatively similar trend. Two key developments are, however, worth noting. The devaluation of 2001 results in a strong dip in the NEER, as expected. Strong deviation from trend is hardly noticeable in the other indicators. A second development is the extreme volatility in the output gap in the latter part of the estimation period. In large part this was due to a series of adverse developments: the tsunami of 2004, and the global economic downturn beginning in the 2008. While output was extremely volatile during these periods, prices were largely on trend, indicating a low correlation between domestic developments and movement in prices.

Figure 4: Trends in Key Variables



Data Sources: Maldivian authorities IMF staff calculations.

Stationarity tests and other econometric issues: Unit root tests performed on the log levels of the variables confirmed that the series are nonstationary[11], as a result of which they were transformed to achieve stationarity (Appendix II). Granger causality tests support that producer

[11] Results of unit root tests are presented in Appendix II.

prices help predict consumer prices. Eight lags of the variables were used in the estimation, following standard lag-length tests using the Akaike Information Criterion.[12]

In order to recover the structural shocks from the VAR residual, we use a Cholesky decomposition of the residual variance-covariance matrix, which assumes zero-restrictions on the simultaneous correlation among residuals. The decomposition assumes that a shock to the last ordered variable in the system does not contemporaneously affect the previous variables.

B. Estimation Results

The five variable system was estimated as a VAR in first differences. All level variables were transformed to natural logarithms and seasonally adjusted using X-12. Since the focus is on responses to shocks and speed of adjustment, the reduced form residuals from the VAR are orthogonalized using Cholesky decomposition. Impulse responses and variance decompositions are used to assess the pass through from exchange rate changes to prices. The impulse responses to exchange rate shocks are estimated over a two-year (eight-quarter) horizon, standardized to correspond to the response to a 1% shock in the exchange rate. The variance decomposition of PPI and CPI is used to assess how much of the (forecast) variance in the price indices can be attributed to variations in the other variables in the system. Thus, the variance decomposition provides information about the relative importance of each random innovation in affecting the variables in the VAR.

Impulse Response Functions: The orthogonalized impulse response functions of variables in the system to one standard deviation innovation show results that are broadly in line with expectations, and both the output gap model and real GDP growth model yield broadly similar results (see Appendices III and IV for IRF charts).[13] Focusing specifically on the IRF of producer and consumer prices, the results are consistent with findings in previous studies. In order to estimate the ERPT coefficient from the impulse response functions, we divide the cumulative change in each price index by the cumulative change in the exchange rate from one period to the other:

$$\mathrm{PT}_{t,\, i+j} = \sum_{j=1}^{T} \Delta P_{t,t+j} \;/\; \sum_{j=1}^{T} \Delta E_{t,t+j}$$

This indicates the predicted adjustment of prices in each period to the initial exchange rate shock after accounting for the disturbances of the other endogenous variables in the model. The derived coefficients (Appendix V) confirm that the ERPT to prices is strong in Maldives.

- 74 percent of the change in the NEER is passed through to producer prices by the end of the fourth quarter following the NEER change, and the speed of pass through is gradual.

[12] The use of the AIC for lag length selection in the VAR is largely informed by the lower penalty on parameters, while the Schwartz criterion was used for the ADF test (Appendix II), as the number of parameters was not an issue.
[13] Given the similarity in IRF results, the rest of the discussion focuses on the output gap model.

Consistent with some findings in the literature, EPRT to producer or wholesale prices is initially slow and not complete because producers may not immediately pass through changes in the exchange rate. The result is not surprising for two reasons. First, PPI prices are closer to exchange rate changes along the distribution chain, and producers may be reluctant to make frequent adjustments. Secondly, resorts and hotels account for 57 percent, and air transport accounts for 7.5 percent, of the weight in Maldives's PPI. Given the strong external linkage of these sectors, and the prevalence of dollar pricing, short run changes in the NEER may not be passed on immediately, but could provide the opportunity for profit margins to adjust, especially if prices have been competitive in the past. Furthermore, most tourism packages are sold up to a year in advance, leaving little room for short run adjustments when exchange rates change.

- The coefficient of the CPI is consistent with expectations on ERPT, as 88 percent of the change in NEER is passed on to consumer prices by the end of the fourth quarter. Though the CPI is slower to adjust than the PPI in the initial period, the overall pass through is stronger, and it persisted through the fifth quarter following the NEER change, before falling strongly as prices adjust to the change in the NEER.

The derived coefficient of 88 percent for ERPT to CPI by the end of the first year is close to the 79 percent derived as the first round effect using the nonparametric method (Table 1). The results contrast with some studies which found PPI coefficients to be generally higher than CPI coefficients. For Romania, Gueorguiev (2003) found that PPI coefficients range from 32 percent to 72 percent, while CPI coefficients ranged from 16 percent to 43 percent. Rabanal and Schwartz (2001) found that, for Brazil, the coefficient for the wholesale producer index, the proxy for PPI, ranged from 18 percent to 64 percent, while that of the CPI ranged from 4 percent to 43 percent.

Variance Decomposition

A variance decomposition analysis is undertaken to determine the percentage of changes in each of the variables that are attributable to variations or shocks to all variables in the system, including own shocks (Appendix VI). The exercise indicates that the variables of the system exhibit differing degrees of change from other variables in the system, including from own past values. Focusing specifically on the price indexes, the results are as follows:

- PPI is initially most influenced by own changes, but beyond the first five quarters, changes in international commodity prices are strong determinants of the forecast variance.

- Variance decomposition for the CPI indicates that, compared to other indices, more of its variation is determined by variables within the system, other than own changes. Commodity price shocks and shocks to PPI are the main source of variation in the CPI.

The result indicates that the role of external factors, especially international commodity prices, is strong in overall price determination. Another interesting result is the moderate proportion of variation explained by the output gap. While a positive result is consistent with theoretical expectations that the output gap plays an important role in producer price determination, the small size of the economy and its close link to the international cycle would seem to moderate the impact.

VI. Summary and Conclusion

This study examined ERPT to price indices in Maldives during 1994–2010. A nonparametric estimation indicates that ERPT to the CPI is quite high, with around 79 percent of exchange rate changes passed on to consumer prices. The dynamics of exchange rate pass through was derived from a recursive distribution chain model, based on McCarthy (1999). The estimated 88 percent pass through of exchange rate changes to the CPI is higher than that derived in the nonparametric estimation. ERPT to the PPI and the CPI is as theoretically expected and is incomplete, consistent with findings from other studies. Based on the variance decomposition, international commodity price shocks are an important source of variation in the two price indices, in addition to exchange rate changes. Furthermore, other variables such as the output gap, play a role in price determination. This may reflect the link of the Maldivian economy to the international cycle, signaling the role for policies to be proactive in response to changing external demand conditions that are likely to have an impact on Maldives.

The findings provide useful information for the design of policies for either macro stabilization or response to sudden exogenous shocks. Most of the shocks to prices persist beyond the first year, indicating that any response of monetary policy to changes in the price level, due either to exogenous shocks or deliberate policy, need to take into consideration a long horizon. Assuming that a devaluation policy is being contemplated to address exogenous shocks or to stabilize domestic demand, a high pass through of the change in exchange rate to prices would be expected, based on the findings of the nonparametric model. This should then inform the design of an appropriate monetary policy response to mitigate the inflationary impact of the devaluation. By the same token, knowledge of the speed and dynamics of the variations in prices is useful in the choice of specific policy intervention points.

One possible extension of the econometric model is to include a monetary aggregate as one of the variables of the system. Such analysis could provide an additional insight into how changes in monetary policy impact on price development in Maldives. The findings could also provide a framework for appropriate monetary policy response to future price shocks, including depreciation.

APPENDIXES

Appendix I. Data Description and Sources

Data	Description	Source
All Commodity Price Index	Commodity Price Index, 2005 = 100, includes both Fuel and Non-Fuel Price Indices	IMF Sources
Output gap	The deviation of output from its long run trend.	Derived by taking the deviations of the log of real GDP from a trend derived through the Hodrick Prescott filter
Real output	Growth rate of real output.	Maldivian and IMF Sources
Nominal Effective Exchange Rate	Trade weighted index of bilateral exchange rates of major trading partners.	IMF Sources
Producer Price Index	Index of the price of goods and services as they leave the place of production or as they enter the production process.	Maldives Department of National Planning / Staff calculations
Consumer Price Index	Index of prices faced by consumers	Maldives Department of National Planning

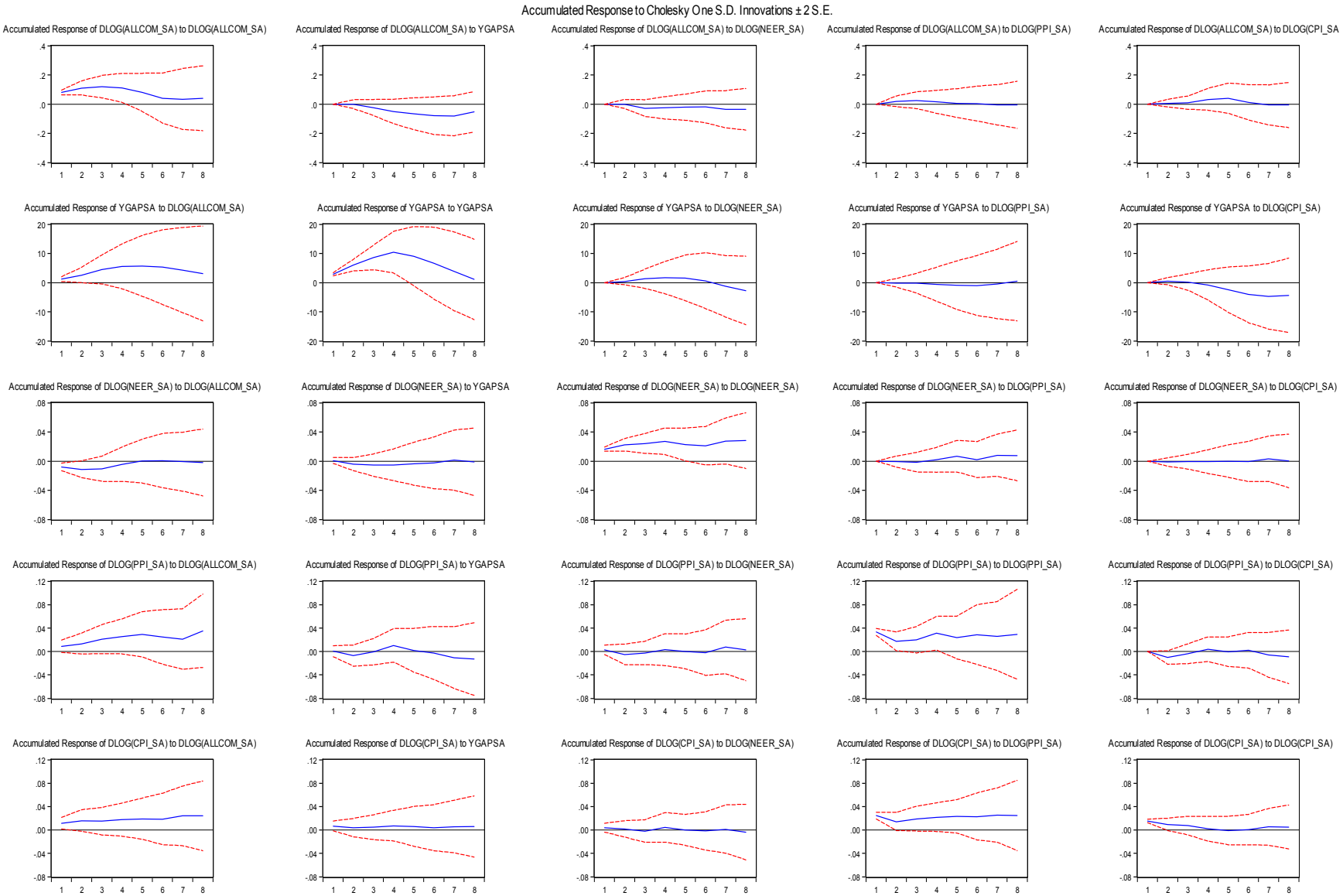
Appendix II. Unit Root Tests

Variable [1/]	**ADF Test** [2/]
All Commodity Price Index	<1%
Output gap	<1%
Nominal Effective Exchange Rate	<1%
Producer Price Index	<5%
Consumer Price Index	<1%

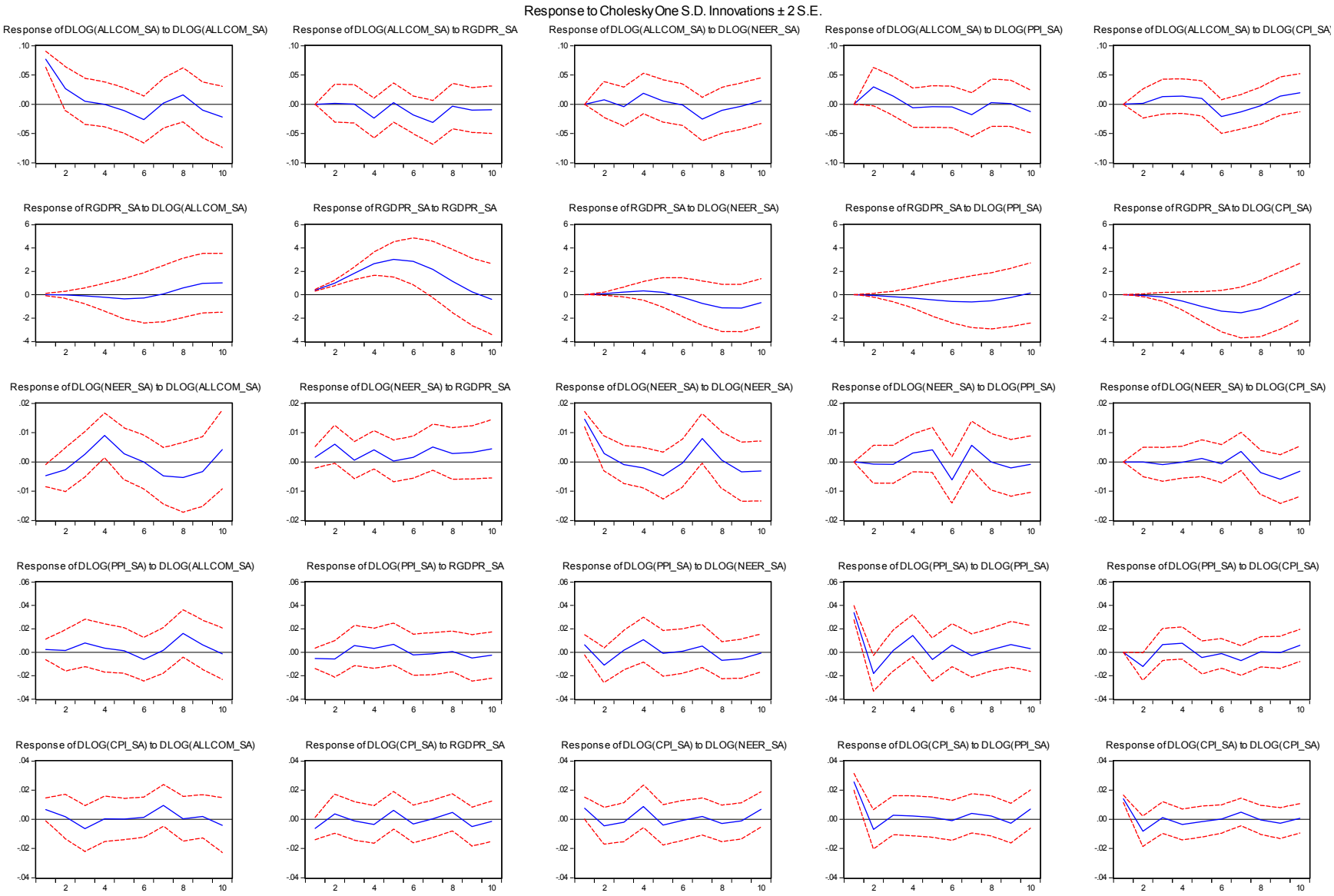
1/ All variables in log differences, except output gap

2/ Augmented Dickey Fuller Test for unit root, with trend and intercept. Selected lag length is one with minimum Schwartz Information Criterion. The maximum number of lags is truncated at 11.

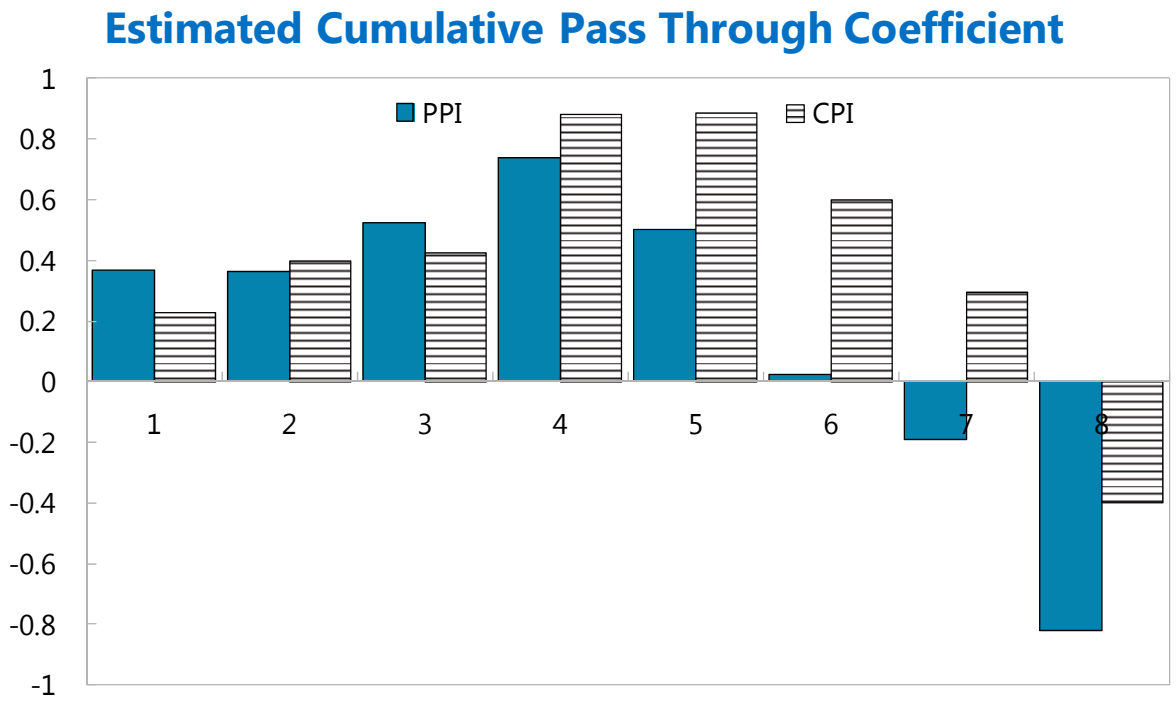
Appendix III: Impulse Response Functions (Output gap model)



Appendix IV: Impulse Response Functions (Real GDP growth model)



Appendix V. Estimated Cumulative Pass through coefficient



Sources: IMF Staff calculations.

Appendix VI. Variance Decomposition of Producer and Consumer Price Indexes

Percentage change in forecast variance of PPI attributable to changes in:

	All Commodity Price Index	Output gap	NEER	PPI	CPI
1	5.4	0.0	2.6	92.0	0.0
2	12.2	5.8	2.1	76.7	3.2
3	24.5	4.9	2.1	65.8	2.7
4	30.5	8.0	1.9	54.7	5.0
5	37.0	8.8	2.1	47.0	5.1
6	39.0	8.3	3.6	43.6	5.5
7	40.3	8.9	3.7	41.6	5.4
8	48.5	8.3	5.3	33.5	4.4

Percentage change in forecast variance of CPI attributable to changes in:

	All Commodity Price Index	Output gap	NEER	PPI	CPI
1	3.8	0.7	1.4	59.8	34.3
2	5.2	1.8	1.9	53.8	37.2
3	5.3	4.0	1.8	53.4	35.5
4	8.1	3.8	5.6	49.0	33.4
5	15.1	3.8	4.9	45.1	31.1
6	20.5	5.5	5.6	40.5	27.9
7	27.3	8.7	5.7	33.1	25.2
8	28.2	9.1	10.1	28.8	23.7

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