Exchange Rate Pass Through, the Case of Iceland 2003-2011

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Abstract

This paper investigates the exchange rate pass through into production prices and consumer prices in Iceland for the time period 2003-2011. The exchange rate pass through is examined with impulse response functions for a standard VAR in first differences. Exchange rate pass through in Iceland is found to be large and swift both for production prices and consumer prices. Furthermore, variance decomposition analyses show, that the exchange rate is a major contribution variable to forecast variance of the production price index and consumer price index with and without housing prices.

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1 Introduction

When referring to exchange rate pass through the general conception is that exchange rate pass through stands for the effect of a one percent change in exchange rates on import prices. In this paper we extent the definition of exchange rate pass through, just a little, and refer to it as the effect of a one percent change in the exchange rate on production prices and consumer prices.The topic of exchange rate pass through is important to study for two reasons other than a curious mind.

Firstly, the exchange rate pass through is of great importance for central banks when it comes to monetary policy because in a world of free capital flows the interest rate decisions of central bankers can have a influence on exchange rates, through capital flows, and hence consumer inflation, which in many cases is the main goal of central banks. The estimation of exchange rate pass through therefore gives policy makers further information to base their decisions on. Secondly the exchange rate pass through within an economy has a direct influence on the consumer's wallet through the prices of goods and services.

This paper investigates the exchange rate pass through in Iceland, according to our broader definition, on the production price index (PPI) and the consumer price index (CPI) both with and without housing prices in Iceland. The size and speed of the exchange rate pass through in Iceland is observed by implementing a standard VAR framework, similar to the one put forward by McCarthy (2000), using a Cholesky decomposition to identify exchange rate shocks in the model. The impulse response functions are estimated for orthogonalized one standard deviation shocks in the exchange rate for the production price index and the consumer price index with and without housing prices, results are then presented as a 1% exchange rate shock and discussed.

The variance decomposition, also known as forecast error variance decomposition, are then analyzed to allow us to better understand the contribution of the exchange rate to the n-step[1] forecast error variance of production prices and the contribution of the exchange rate and production prices to consumer prices with and without housing prices. For our models we use data for oil prices in US dollars, output gap in Iceland and the exchange rate of the Icelandic Krona derived from the macroeconomic model database of the Central Bank of Iceland and data for production price index, consumer price index and consumer price index excluding housing prices taken from Statistics Iceland. Both datasets are taken directly form the Central Bank of Iceland and Statistics Iceland homepage and are quarterly data from Q4 2003 to Q1 2011. It was of interest to view as long a period as possible and as close in time as possible to span a longer time period and to get a larger sample for our VAR estimation. However, when it came down to it the choice of a period was constrained by the availability of the data for the production price index which has only been gathered since 2003. Moreover, in McCarthy's (2000) paper import

[1] n=time

prices are included in the model which would have been interesting but in the case of Iceland that index or one familiar to it is not gathered.

Estimations of impulse response functions for the production price index and consumer price indexes we revealed a large and swift pass through of a exchange rate depreciation into prices in Iceland, we also find that the pass through to consumer prices is larger when excluding housing prices from the index. Furthermore, we find that the exchange rate is a major factor in explaining the forecast variance of the three price indexes, production price index, consumer price index and consumer price index excluding housing prices.

This paper is organized as follows: Section 2 gives a short review of the relevant literature on exchange rate pass through and is followed by section 3 which better explains why two separate consumer price indexes are used in light of Iceland's special circumstances. In section 4 we go over the tests we preform in order to specify our model to the best of our abilities and section 5 presents our VAR and methodology. A description of the data is given in section 6 and results are finally presented and discussed in section 7. Conclusions then wrap the paper up in section 8.

2 Review of the literature

The literature on exchange rate pass through is often said to broadly categorize into two segments, the impact of exchange rate fluctuations on specific segments of the industries in the economy of interest (e.g. studies such as Kardasz and Stollery (2001) and Olivei (2002)) and the impact of exchange rate fluctuations on aggregate price indexes. Our paper focuses on the latter and, hence, we will emphasize on studies done at the macro level.

McCarthy's (2000) study, which this one is largely based on, is a comprehensive study of exchange rate pass through on the aggregate level for a number of industrialized economies. McCarthy's findings are that the exchange rate pass through to consumer prices are modest in most of his analyzed economies and correlation between the exchange rate pass through and the openness of the economy is shown to be positive. McCarthy's method of estimating the exchange rate pass through along a distribution chain of prices has been widely adopted by researchers, e.g. Hyder and Shah (2004) and Gueorguiev (2003).

Hyder and Shah (2004) estimate a VAR framework suggested by McCarthy (2000) on monthly data in Pakistan from January 1988 to September 2003. Their main findings where, a) a moderate effect of exchange rate fluctuations on domestic price inflation and b) that the impact of the pass through is mostly felt in the first 12 months with the effect more pronounced in the first four months. Gueorguiev (2003) estimated and quantified the size and speed of the exchange rate pass through in Romania based on McCarthy's (2000) methodology. In his study he found a relatively large and fast exchange rate pass

through in Romania for monthly observations between June 1997 and January 2003. The exchange rate pass through ranged from 60 to 70 percent for producer prices and 30 to 40 percent for consumer prices with most of the effect being felt after 12 to 15 months.

Some research has been done, mainly by the Central Bank of Iceland, on the exchange rate pass through in Iceland but never with the McCarthy (2000) framework. The exchange rate pass trough has been estimated by Petursson (2010) where he finds that the exchange rate pass through in Iceland has been just short of 40% before the adoption of inflation targeting in Iceland and in excess of 40% after the adoption in 2001 until 2010.

3 Motivation for picking both CPI's

Steinsson (2005) pointed out that the three most important uses for the CPI in Iceland have been:

1. The indexation of loans
2. The use as a benchmark in labor market wage negotiations
3. Monetary policy

Due to the fact that the CPI is used in the calculation of indexed loans and the fact that it is the common index when referring to inflation in Iceland, we measure the impulse response function with housing prices. Furthermore, housing is obviously a part of the consumption of the average family and since Iceland has historically had a much greater proportion of families living in their own housing than renting, housing prices are in the CPI. Furthermore, it is very likely that rent prices and housing prices are highly correlated.

Deciding whether the financial system should use the CPI with or without housing prices in the indexation of loans has been an ongoing debate in Iceland. Where labor unions, political parties and individuals have complained considerably because of the inflationary pressure that rising housing prices put on the economy. In the paper's sample housing prices rose from 2003 - 2008, which in turn means that indexed loans increased more than they would have, during that period, in the absence of housing prices in the CPI. Most indexed loans in Iceland are housing loans, therefore including housing prices in the CPI when determining the increase on loans due to inflation makes a lot of sense from a risk management point of view. The reason is that individuals are in a stronger financial position when housing prices increase and should therefore be better able to pay their mortgage payments. The argument that most individuals already own their houses and are therefore not as adversely affected by the rise in housing prices as the rise of other goods and services is however a good argument for labor wage negotiations as pointed out by Steinsson (2005).

We therefore carry on with our analysis by looking at the impulse response function for CPI to estimate the effect on peoples net wealth, through increasing loans and diminishing purchasing power, and CPI without housing prices to estimate the effect on consumer goods and services to gouge into what, in Steinsson's (2005) opinion, should be the benchmark for labor wage negotiations.

4 Model specification tests

In this section we will start by discussing results from the unit root tests and determine whether or data is stationary or not. It is important for our data to be stationary since if the mean, variance and covariance of the time series do not remain constant over time the time series do not satisfy the assumptions required for VAR estimation Thomas(1997). We then carry on and have a look at the Granger causes within our models since it is of importance to set the most endogenous variable in the models last in the distribution chain. Lastly we test for cointegration to view if there are any long term equilibrium relationships between the variables.

4.1 Stationarity and lag length

Depending on the outcomes of unit root tests we decide whether we take the first differences of our variables or not. The number of lags in our unit root tests are found by performing a univariate Ljung-Box test. Regarding the lag length of or VAR models, choosing the right number of lags, is important since too few lags will diminish the model's explanatory power and increase the risk of autocorrelation. Moreover, autocorrelation in autoregressive models results in biased point estimates. Hence enough lags need to be included to remove residual autocorrelation. On the other hand, too many lags will give away degrees of freedom and can have an adverse effect on the model's forecasting. In theory the optimal choose of lags is the one that turns the residuals into white noise in the shortest amount of lags Thomas (1997).

After deciding the appropriate number of lags for the test, results from the Augmented Dickey-Fuller (ADF) test revealed a unit root for all time series. According to the ADF test all time series, excluding the consumer price index, had an order of integration of one, therefore the first difference was taken of all time series except the consumer price index. In the case of the consumer price index we found the order of integration to be two and we therefore took a look at the results from a Phillips-Perron test (PP test). Results from the PP test showed that CPI was integrated of order one and we therefore carried our work on with that assumption[2]. Furthermore, the logarithm of all time series,

[2]The results from the tests can be found in Appendix A.

excluding output gap, was calculated in order to observe the percentage impact in the impulse response function.

In order to select the number of lags for our VAR estimations we took a look at Akaike Information Criterion, Schwarz-Bayesian Criterion, Hannan-Quinn Criterion and Final Prediction Error[3]. For our VAR estimation, where we estimate the impulse response function for CPI, the Final Prediction Error recommends a lag length of three, whereas all other criterion recommend a lag length of four. For our second model, where we estimate the impulse response function for CPI w/o housing prices, all information criteria recommend a lag length of four. Therefore, we selected the lowest recommended lag length for the VAR with CPI, since we have a very short sample and therefore cannot afford to have too many lags. In our VAR estimation of our second model we go against the recommended lag length of four and choose the lag length of three, also because of our short sample, but also since the lag length of four yields a non positive definite Cholesky matrix which makes it impossible to estimate our impulse response function. By choosing a lower lag length we are risking under-fitting the model. In order to feel more comfortable with dropping one lag, we took a look at the residuals from our VAR estimations and found that all lagged residuals were statistically significant with 95% confidence or higher.

4.2 Granger causality

A VAR framework constructs the error terms in each regression equation to be uncorrelated with the error in the preceding equations. Therefore, placing the most endogenous variable last is of great importance since the result depends on the order of the variables. Altering the order changes the VAR equations, coefficients, and residuals, Stock and Watson (2001).Tests reveal the following Granger causes between the variables:

1. Oil → Production price index and consumer price index
2. GAP → No variable
3. Exchange rate index → Production price index
4. Production price index → Oil
5. Consumer price index → Oil
6. CPI excluding housing prices → No variable

Table 1: Granger causes between variables

The results from the Granger test do strengthen the argument for the ordering of the

[3]The VARselect command in R project was used for the information criteria estimation

equations in the exchange rate pass through models. Oil prices seem to provide statistically significant information about future values of PPI and CPI and the the exchange rate hold the statistically significant information for PPI. However, the output gap does not Granger cause any variable we use in the model. Since the Granger causality test does not prove or disprove a definite causal relationship, and due to the presumption that output gap helps explain demand fluctuations, we keep the variable in our model. In the same sense, although the Granger causality test does not show that PPI Granger causes CPI, we do not exclude PPI from our model since it is still our believe that PPI helps explain CPI. That conclusion is drawn from the fact that higher domestic production prices are highly likely to raise consumer inflation through higher prices of inputs for all firms purchasing domestically produced good and services. In the end, the main conclusion to by drawn from the Granger causality test is that the ordering of the variables does not only make intuitive sense but is also somewhat strengthened by the test. However, a very strange observation appears in the Granger causality test. CPI and PPI seem to provide statistically significant information on oil prices. Although the findings are statistically significant, common sense must at least take them as highly unlikely, because, although Icelanders might sometimes think so, Iceland's economy is not that big, that movements in inflation will impact global oil prices. We therefore presume that the endogenous relationship is only one way from global oil prices to domestic inflation but not vice versa.

4.3 Cointegration

Cointegration means that there is a long term relationship between some variables being estimated. In the presence of cointegration, the standard properties of VAR can become invalid and regressions can read to spurious results, Heij, de Boer, Franses, Kloek and van Dijk (2004).

Co-integration	Test	10%	5%	1%
$r \leq 4$	2.86	6.50	8.18	11.65
$r \leq 3$	9.91	12.91	14.90	19.19
$r \leq 2$	25.24	18.9	21.07	25.75
$r \leq 1$	34.34	24.78	27.14	32.14
$r \leq 0$	40.56	30.84	33.32	38.78

Table 2: Johansen cointegration, CPI

From table 2 a cointegration rank of three becomes apparent. We therefore have a three long run equilibriums relationships in the model including CPI. This equilibrium can be between two or possibly all variables in the model.

Co-integration	Test	10%	5%	1%
$r \leq 4$	2.34	6.50	8.18	11.65
$r \leq 3$	9.88	12.91	14.90	19.19
$r \leq 2$	17.28	18.9	21.07	25.75
$r \leq 1$	30.97	24.78	27.14	32.14
$r \leq 0$	35.52	30.84	33.32	38.78

Table 3: Johansen cointegration, CPI w/o housing prices

From table 3 one can then observe a cointegration rank of two. Normally, one should proceed and estimate an error correction model to incorporate the long-run relations between the variables in our models. Despite stressing the presence of cointegration in the models we do proceed with our models as McCarthy (2000) points out it should have little effect on the results given the very short time horizon studied in this paper. Results of cointegration are presented to stress that we have cointegration in our models and highlight possible shortcomings of this paper, despite McCarthy (2000) not using an error correction model in the presence of cointegration.

5 Model and Methodology

To examine the pass through of exchange rate to producer price and consumer price inflation, this paper utilizes a VAR approach developed by McCarthy (2000). In the model, inflation at a particular distribution stage − producer and consumer in period t is assumed to comprise several different components. The first component is the expected inflation at that stage based on the available information at the end of period t - 1. The second and third components are the effects of period t domestic supply and demand shocks on inflation at that stage. The fourth component is the effect of external exchange rate shocks on inflation at a particular stage. Next are the effects of inflation shocks at the previous stages of the distribution chain. Finally, there is the inflation shock at that particular stage.

The inflation shocks at each stage are simply that portion of that stage's inflation, which cannot be explained using information from period t - 1 plus information about domestic supply and demand variables, exchange rates, and period t inflation at previous stages of the distribution cycle. One other feature of the model, worth mentioning, is that there is no contemporaneous feedback in the model. As an example, consumer inflation shocks affect inflation at the import and producer stages only through their effect on expected inflation in future periods. Under these assumptions, the model can be written as:

$$\pi_{it}^{oil} = E_{t-1}(\pi_{it}^{oil}) + \epsilon_{it}^{\delta} \tag{1}$$

$$\hat{y}_{it} = E_{t-1}(\hat{y}_{it}) + a_{1i}\epsilon_{it}^{\delta} + \epsilon_{it}^{d} \tag{2}$$

$$\Delta e_{it} = E_{t-1}(\Delta e_{it}) + b_{1i}\epsilon_{it}^{\delta} + b_{2i}\epsilon_{it}^{d} + \epsilon_{it}^{e} \tag{3}$$

$$\pi_{it}^{w} = E_{t-1}(\pi_{it}^{w}) + \beta_{1i}\epsilon_{it}^{\delta} + \beta_{2i}\epsilon_{it}^{d} + \beta_{3i}\epsilon_{it}^{e} + \beta_{4i}\epsilon_{it}^{m} + \epsilon_{it}^{w} \tag{4}$$

$$\pi_{it}^{c} = E_{t-1}(\pi_{it}^{c}) + \gamma_{1i}\epsilon_{it}^{\delta} + \gamma_{2i}\epsilon_{it}^{d} + \gamma_{3i}\epsilon_{it}^{e} + \gamma_{4i}\epsilon_{it}^{m} + \gamma_{5i}\epsilon_{it}^{w} + \epsilon_{it}^{c} \tag{5}$$

Where π_{it}^{oil}, $\hat{y}_{it}$, Δe_{it} ,π_{it}^{w} and π_{it}^{c} are oil prices, output gap, exchange rate, PPI and CPI inflation respectively. ϵ_{it}^{δ}, ϵ_{it}^{d} and ϵ_{it}^{e} are the supply, demand and exchange rate shocks respectively. ϵ^{w} and ϵ^{c} are the PPI and CPI inflation shocks. Furthermore, $E_{t-1}(.)$ is the expectation of a variable based on the information set at the end of period t$-$1. The shocks are assumed to be serially uncorrelated as well as uncorrelated with another within a period.

The external shocks we investigate in the paper are identified from the dynamics of an exchange rate shock after taking into account the contemporaneous effects of the supply and demand shocks. The reason for this particular ordering of the equations in our model is what (McCarthy, 2000) calls the distribution chain of pricing, where the identified shocks affect their corresponding variables and those variables that are ordered at a later stage. However, they do not affect those variables that are ordered before them, which is why it is important to order the most exogenous variable first. Since oil price may affect all other variables in the system, we chose oil prices first, additionally oil prices are not affected by any other variables in the system. The next variables in the system are output and exchange rate. The price variables are ordered next and are therefore affected by all the before mentioned variables. Following the distribution chain of pricing, producer price index (PPI) comes first and then consumer price index (CPI), since PPI affects CPI though e.g. mark ups of production firms that spill over to CPI because of higher wholesale prices for retailers. The ordering of the variables makes a lot of intuitive and theoretical sense, but is also to some extent confirmed by the Granger causality tests shown in section 4.2.

McCarthy (2000) assumes that the conditional expectations in equations 1 to 6 can be replaced by linear projections of the lags of the six variables in the system. Under these assumptions, the model can be estimated as a VAR using a Cholesky decomposition. The impulse responses of PPI and CPI inflation to the orthogonalized one standard deviation shock of the exchange rate then provides estimates of the effect of the variable on domestic

inflation. In addition, we analyze the variance decompositions of PPI and CPI inflation help us to determine the importance of the exchange rate for domestic inflation.

6 Data

The data used in the analysis are quarterly data obtained from the Central bank of Iceland's macroeconomic model database and from Statistics Iceland. Specifically oil prices, output gap and the exchange rate index are obtained from the Central Bank of Iceland's quarterly macroeconomic model database[4] and the producer price index[5], consumer price index and the consumer price index without housing prices[6] are obtained from Statistics Iceland. Specifically the time series are:

1. **Oil prices**: Petroleum (spot prices), US dollars per barrel.
2. **Output gap**: Obtained as the Solow residual from a Cobb-Douglas production function using trend employment and capital.
3. **Exchange rate index of foreign currency**: Official trade-weighted exchange rate index for the Icelandic krona, using trade and services weights from previous year bilateral trade.
4. **Production price index**: Measures prices of production inputs produced domestically as the are sold.
5. **Consumer price index**: Measures inflation based on measurements by Statistics Iceland on consumption patterns of consumers.
6. **Consumer price index without housing prices**: Measures inflation based on measurements by Statistics Iceland on consumption patterns of consumers excluding housing prices.

The producer price index was available from Q4 2003 to Q4 2006 and from Q1 2006 to Q1 2011. In order to have as long a time series as possible for the production price index, the two were combined with the index set as Q4 2003=100. Since the two series intersected the calculation of a single time series was straight forward, the newer time series was calculated forwards using the percentage change in the index from Q1 2006. The consumer price indexes were set as Q4 2003=100, other time series were not tempered with in any way.

[4] http://cb.is/?PageID=722

[5] http://hagstofa.is/Hagtolur/Verdlag-og-neysla/Visitala-framleidsluverds

[6] http://hagstofa.is/Hagtolur/Verdlag-og-neysla/Visitala-neysluverds, applies for both consumer price indexes

7 Results

In this section we will discuss the findings of our impulse response functions on the Icelandic economy. The variance decomposition analysis, also known as the forecast error variance decomposition, is also analyzed. The estimation results from the VAR go unreported since they are very hard to interpret by themselves and, furthermore, because they are already depicted in the impulse response functions. Before viewing the impulse response functions it should be noted that the bootstrapped confidence intervals are very asymmetric. This is a relatively well known problem for bootstrapped confidence intervals for impulse response functions in a short sample VAR, see Kilian (1998). Our sample is very short and has few observations and therefore this problem arises.

7.1 Exchange rate pass through on the production price index

In figures 1-3 we view the cumulative orthogonal impulse response functions derived from the VAR regressions. This means that the impulse total effect up to the quarter depicted in the figures is shown, e.g. if the effect is 0.05% for the first quarter after the shock and 0.15% for the second quarter, the cumulative (total) effect shown at quarter 2 in the figure is 0.2% . Orthogonal means that all other shocks are held constant, we are therefore tracing out the shock to the exchange rate no other shock.

At first glance we see from figure 1 the intuitive results of raising domestic inflation from a negative shock in exchange rates, specifically a 1% depreciation of the ISK. The effect is both large and very quick, the shock increases PPI by about 0.76% in the first year and sails onwards ranging between approximately 0.85% and 0.65%. The large pass through is of interest, however, drawing strong conclusions from the impulse response function would be ill advised. The 95% confidence interval is huge, ranging from no impact at all to 1.6% for one year. Going further on, the difference becomes even more extreme.

Despite the considerable lack of precision in our forecast, something that is well know e.g. in inflation forecasting, we can draw some conclusions. The first one would be that the impact of an exchange rate depreciation is most likely very large on Icelandic production prices and the second one would be that the depreciation is felt by domestic producers very quickly. Because of Iceland's geographical position not only are most goods imported but most inputs into domestic production are also imported. The roughly close to one against one relationship between PPI and the exchange rate depicted be the impulse response function on PPI can be better understood by giving thought to Iceland's extreme dependence on imports even in domestic production. Domestic producers are likely to buy their production inputs directly from abroad and since the Icelandic krona (ISK) is far from being a global currency all trade is most likely done in some foreign currency. Therefore, since the PPI measures the costs of those exact inputs, the one against one

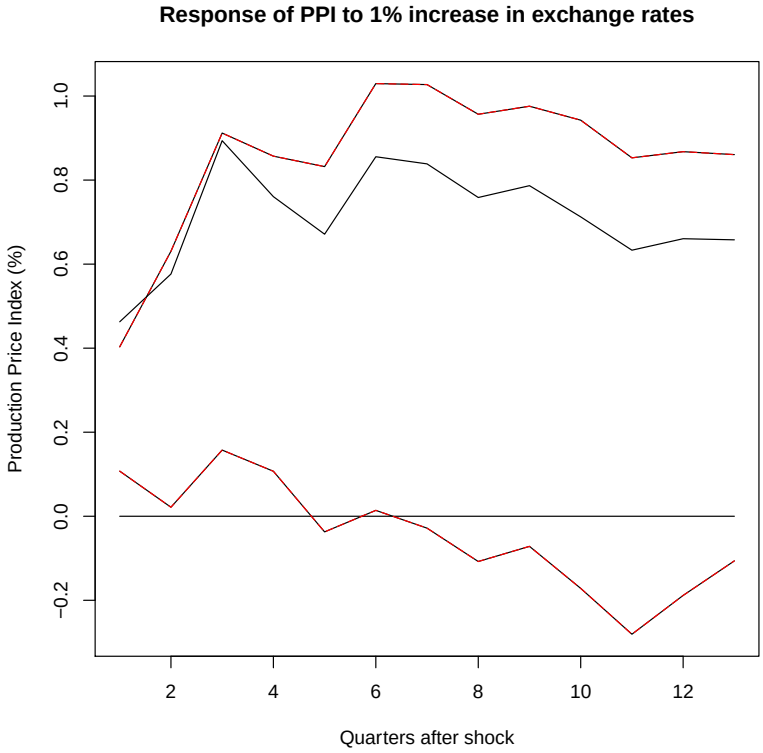

Figure 1: Cumulative Orthogonal Impulse Response Function, black line. The red lines are bootstrapped 95% confidence intervals

relationship is less surprising as e.g. a producer of beer who has a contract of buying one ton of hops for USD 2,000 will feel the full depreciation of the ISK on his wallet. These results are interesting to compare to the ones found in studies for other small economies, although relatively big compared to Iceland. Naug and Nymoen (1996) and Menon (1995) showed for Norway and Australia that foreign producers responded to market conditions in the importing country and that the exchange rate change was not fully passed on the import prices. Our findings do not show much of that tendency for import prices affecting the PPI, giving even more raise to the extreme price taking position of Icelandic companies.

7.2 Exchange rate pass through on consumer price indexes

From observing data from Statistics Iceland, the large portion of foreign goods in the typical basket of the Icelandic household becomes apparent. The data for Q1 2011 shows that 34.3% of the consumer bundle that Statistics Iceland used to measure CPI is foreign goods or services[7]. However, as Kaupthing bank's Research (2007) points out the effect of imports is larger than that number alone suggest since domestic industries use foreign

[7] http://www.hagstofa.is/Hagtolur/Verdlag-og-neysla/Visitala-neysluverds

inputs in their production and thereby affecting the remaining 65.7%. The fluctuation of the exchange rate therefore affects domestic prices through both the domestically produced goods and directly trough imported goods and services. They go on and point out that it is generally believed that the extent of exchange rate pass through should roughly reflect the ratio of foreign goods and services in the CPI. If Iceland fits into that generalization, the exchange rate pass through to consumer inflation should be around 0.34%[8].

From observing figure 2, one can see that the CPI's 95% confidence intervals are narrower than that of the PPI's impulse response function so drawing some stronger conclusions is more comfortable. However, our impulse response is not within the confidence interval up to one year and is therefore strictly not significant. However, we can draw some conclusions from the impulse response. The most interesting part is how quick the pass through is, in four quarters it has almost leveled off at 0.3%. Another interesting observation is that after one year we are very close to the ratio of imports into Iceland, the cumulative affect is 0.323% and according to the imports ratio we would have expected around 0.34%. Moving forward up to three years the affect of the shock has subsided somewhat and the one percentage shock has yielded a 0.27% pass through onto CPI.

A very interesting observation from the impulse response functions is how quick the pass though is although a relatively quick pass through was to be expected given Iceland's openness and size of the economy. It is noteworthy to stress again that the cumulative impulse response for a 1% depreciation in the Icelandic Krona almost exactly reflects the ratio of foreign imports in the consumer bundle that the CPI estimations are based upon, it does give us confidence in our findings although the findings are a bit lower than Pertursson (2010). It is plausible that the difference in results are due to different methodologies and different data sets.

By comparing figures 2 and 3 we see that the exchange rate pass through is larger when excluding housing prices than when we include them or 0.49% for one year and around 0.55% moving onwards. It does make intuitive sense that the negative shock to the exchange rate would have a greater impact on CPI when excluding housing prices than when including them. The reason is that we have housing prices in general in the consumer bundle that is the basis for consumer price inflation calculations and already built houses are not directly affected by the change in exchange rate in the way that other goods in the consumer bundle are. Lets take a short example:

When the Icelandic Krona depreciates, imported food and cars become more expensive to import, domestically produced beer becomes more expensive since the inputs into the beer production are to a large extent imported, however, houses are there and they are

[8]Since the ratio is 34.3% for foreign goods and services and we are estimating a 1% exchange rate shock

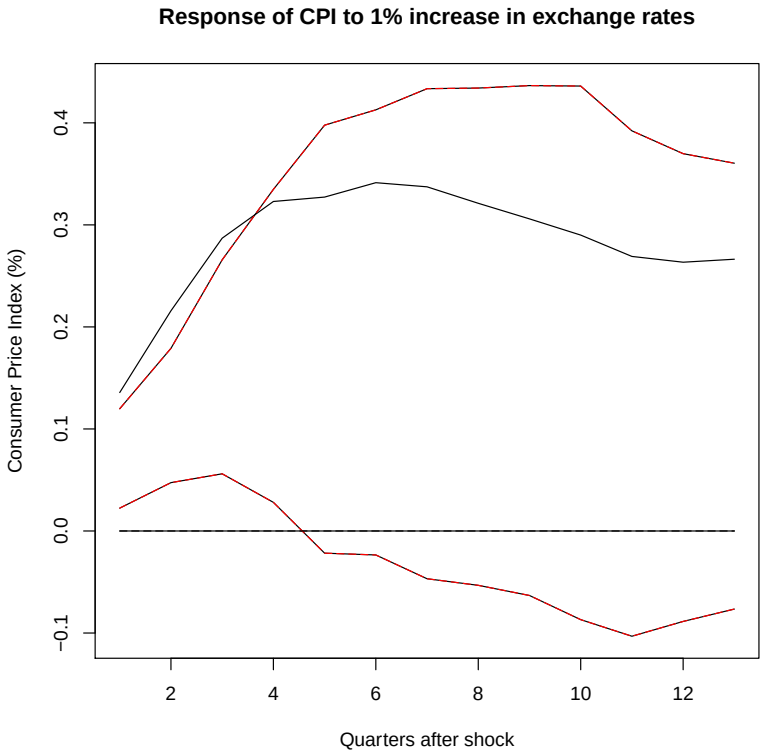

Figure 2: Cumulative Orthogonal Impulse Response Function, black line. The red lines are bootstrapped 95% confidence intervals

already built (produced). Houses in construction, on the other hand, do cost more if the exchange rate depreciates and one can also argue that it is unlikely that housing prices would lag much behind the general price level. The point is, that it is not surprising that the pass through to CPI when excluding housing prices is greater than the one to CPI since the portion of goods that are more exposed to the exchange rate is higher when excluding housing prices. When considering the effect of a one percent raise in import prices on inflation in the economies presented in McCarthy (2006) a similar trend appears, where a raise in import prices has a big effect on CPI in most economies. The reason for comparing the change in import prices in those countries to the change in exchange rate in Iceland is the often mentioned price taking issue with small economies, an issue where Iceland must be an extreme case. A 1% change in the exchange rate has very little effect on CPI in e.g. the USA since importers in the USA are most likely doing there business in US dollars and also since a lot of goods used in domestic production are also domestically produced. With other words, the United States of America are a much more self sustainable economy, with a much greater global currency. Therefore, the large pass through from exchange rates to consumer inflation in Iceland relative to larger economies emphasizes Iceland's extreme price taking position. Now, when looking at the impact of a 1% change in import prices on consumer inflation in McCarthy (2000) the economies look

more like Iceland. Hence, Icelandic companies are most likely not getting any discounts from foreign suppliers the way a larger market zone may very well get. The reasons are twofold, extremely little foreign trade is done in the Icelandic krona whereas Euro zone countries do a lot of theirs in the Euro and the Icelandic market is so small that the supplier most likely has less incentive for making special deals to dampen the shock.

Another reason for the pass through to be higher when excluding housing prices is that since the potion of goods and services is higher, the PPI influences it to a greater extent.

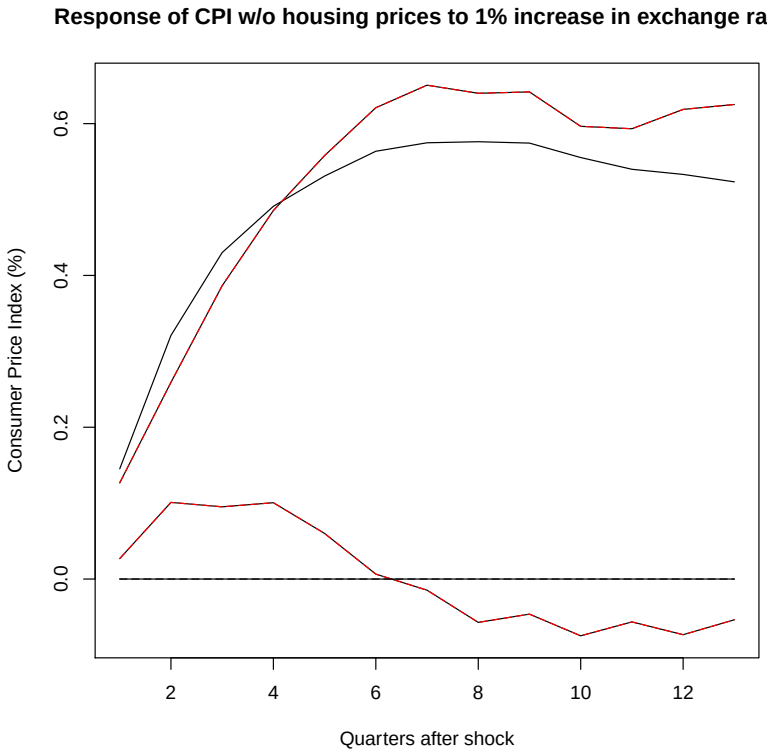

Figure 3: Cumulative Orthogonal Impulse respose function, black line. The red lines are bootstrapped 95% confidence intervals

Figure 3 depicts a very informative picture, the exchange rate pass through is much higher which means that the influence of the exchange rate on that index is much greater. Comparing our results for exchange rate pass through into consumer prices to the ones found in Petursson (2010) we find that the pass through is higher in Iceland than the average of emerging market economies on an inflation target. It should be of no surprise that it is much higher than for industrialized economies on an inflation target. In the Central Bank of Iceland's Report on Monetary Policy in Iceland after Capital Controls (2010) two reasons are given for Iceland's high exchange rate pass through:

1. It is relatively more costly for foreign suppliers to analyze market conditions in Iceland than in most other countries, which leads to more widespread use of producer-

currency pricing that tends to exacerbate the impact of exchange rate fluctuations on domestic prices.

2. Importers of goods to Iceland often do not have to compete with domestic producers of similar products. Their competition is limited to other importers of the same goods, which are subject to the same exchange rate shocks.

In general these arguments are of similar essence as the ones put forwards in this paper. That is, Iceland's small economy makes it a price taker in global trade.

7.3 Comparing exchange rate pass through for PPI and CPI

The difference between the exchange rate pass through to production prices, on the one hand and consumer prices on the other, are large. Between the PPI and the CPI the difference varies around the mean of 0.43% during the forecast period for CPI where as it fluctuates around the mean of 0.24% for the CPI excluding housing prices. The reason for the large difference between the production price index and the consumer price indexes could be that firms/retailers are not rolling the price increases fully over on the consumer. The firms/retailers have to pay more for their imports and domestically produced goods that use foreign inputs but take some of the cost on themselves by lower profit margins. Furthermore, it seems that firms that produce domestic goods are also not rolling the full amount of the adverse exchange rate movement on to the consumer. The same most likely applies for the case of the krona appreciating, that is the consumer does not gain the total strengthening of the currency in lower prices, Kaupthing Bank Research (2007).

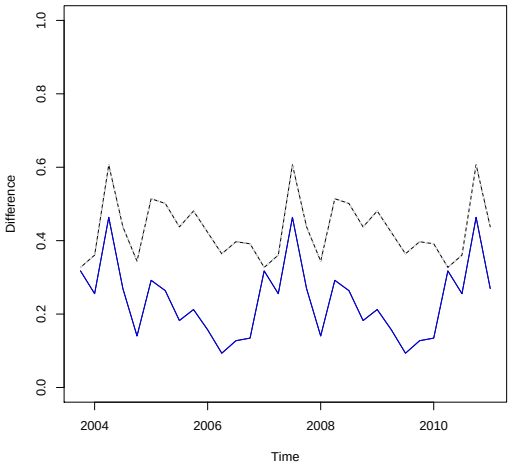

Figure 4: The difference between the PPI's and CPI(blue line) and CPI w/o housing prices (dashed line) Impulse Response Functions

For all price variables we see a swift exchange rate pass through. Compared to other economies the exchange rate pass through into consumer prices is especially swift. A plausible reason for the pass through being faster in Iceland than in larger economies is that in Iceland a larger proportion of inputs in domestic production are imported from abroad. This is defiantly the case when comparing Iceland to USA but there are also strong arguments for it also being the case when comparing Iceland to another small economy such as Denmark or Norway, Kaupthing bank Research (2007).

7.4 Variance decomposition analysis

From the impulse response functions we were able to draw conclusions regarding the size and pace of the exchange rate pass through. However, in order to find information on the importance of exchange rate fluctuations on domestic inflation we need to have a look at the variance decomposition of the price variables. As for each variable, variance decompositions show the ratio of the forecast error variance that is attributable to its own shocks and to shocks stemming from other variables.

Quarters	Q4	Q8	Q12
Exch. rate	27.4%	23%	22.7%

Table 4: Percentage of PPI forecast variance attributed to exchange rate shocks

From table 4 one can observe that the percentage of PPI forecast variance attributed to the exchange rate shock are in excess of 27% for one year and declines to around 23% for the forecast horizon of two and three years. This is a very large ratio and the importance of the exchange rate fluctuations on the PPI, when compared to McCarthy's (2000) variance decomposition tables it would be the largest, almost double the size of Belgium which would come second.

Estimating the importance of PPI and exchange rate shocks on the forecast variance of CPI we turn to table 5.

Quarters	Q4	Q8	Q12
Exch. rate	46.8%	35.7%	35.6%
PPI	15.7%	26.9%	26.8%
Total	62.5%	62.6%	62.4%

Table 5: Percentage of CPI forecast variance attributed to exchange rate and PPI shocks

The numbers from the variance decomposition for CPI are in line with our believe that the exchange rate is a major factor in explaining the forecast variance of the CPI. The percentage attributed to the exchange rate directly and PPI (some indirect exchange rate effects) are in excess of 62% over the three years. The percentage of CPI attributed to the exchange rate and PPI are very high compared to the values for countries in McCarthy's (2000) study. For the exchange rate the value is much higher than that of Belgium's and the Netherlands, which are the highest in the study, however, as we add the PPI, Iceland is closer to the sample in McCarthy's study, but still the highest.

Quarters	Q4	Q8	Q12
Exch. rate	59%	46.8%	46.1%
PPI	12.9%	23.6%	23.8%
Total	71.9%	70.4%	69.9%

Table 6: Percentage of CPI without housing prices forecast variance attributed to exchange rate and PPI shocks

Comparing table 5 to table 6 we see that the percentage of forecast variance attributed to PPI and the exchange rate increases when including housing prices. An interesting trend becomes apparent in the two tables, one observes that the role of exchange rate in explaining the forecast variance of the two consumer price indexes declines at the same time as the role of producer prices increases. An attempt towards explaining that trend would be the plausibility that the producer prices have an affect later in the timespan since the products being produced domestically lag more in price increases than imported ones. The logic being, that as the exchange rate depreciation becomes more permanent as the producer of a domestic good, that uses foreign inputs, rolls more of the negative exchange rate movement over to the consumer. The conclusion from that would be that with regards to inflation it is important whether the producers regard the exchange rate

movement as permanent or temporary. Another more practical reason could be that the process is longer for the producer of domestic beer to realize the effect of higher hop prices before producing the beer, compared to a retailer importing clothes.

To summarize, from tables 4-6 it becomes apparent that exchange rate fluctuations and the change in production prices are a major factor in explaining the forecast variance of consumer inflation. It further strengthens the view put forward in this paper that consumer prices in Iceland whether measured with or without housing prices are extremely vulnerable to changes in the exchange rate and production prices. The impulse response functions presented in figures 1-3 showed the size and speed of the exchange rate pass through and the variance decomposition analysis underlines that the exchange rate is a major contributor even bigger than in all other economies studied by McCarthy (2000), Gueorguiev (2003) and Hyder and Shah (2004).

7.5 Effects on monetary policy

Based on the results presented in this paper, it is obvious that the Central Bank of Iceland needs to pay close attention to the movements of the Icelandic Krona. From the analysis of the exchange rate pass through in Iceland we have a pass through of 0.32% for CPI and 0.49% CPI when excluding housing prices within one year of a 1% depreciation of the ISK. For a central bank trying to fight inflation the common practice is to raise interest rates to dampen demand and consumption. When raising interest rates the central bank makes it more appealing (rewarding) to invest in the local currency, not just for domestic investors and savers but also for foreign investors. By hiking the interest rate and thereby, holding other things constant, increasing the interest spread with other economies the central bank increases the inflow of money, strengthens the currency, relative to other currencies, and most likely lowers inflation by lowering import prices. This story is especially true for a small economy like Iceland because of the large proportion of imports in the consumer bundle relative to the larger economies e.g. the United States.

Another interesting thing to contemplate is Petursson's (2010) view that the size of an economy's exchange rate pass through can be viewed as a monitor of the confidence in the country's monetary policy. In light of the exchange rate pass through observed in this paper, relative to findings in other papers, there is some indication of a lack of creditability in the monetary policy of the Icelandic Central Bank due mainly to poor inflation performance. As pointed out by Petursson (2010) this can be a vicious cycle that is difficult to break out of. This high exchange rate pass through also diminishes the power of the central bank to pursue an independent inflation targeting policy.

8 Conclusions

Despite some draw backs in the modeling, such as asymmetric confidence intervals stemming from a very short data sample and some insignificant values, informative conclusions were drawn from our results. The investigation of impulse response functions showed a large and swift exchange rate pass through in Iceland both to production prices and consumer prices. Furthermore, the exchange rate seems to account for a larger part of the forecast variance of the price indexes examined in this paper than in similar research for other economies of all sizes, albeit no economy smaller than Iceland. We find an especially high exchange rate pass through to production prices that we explain by Iceland's extreme price taking position in the global economy. It is clear from the results of this paper that the Icelandic public lives within an economy where exchange rate fluctuations have a large influence on their well being. A one percent depreciation of the Icelandic Krona was found to have an impact of roughly 0.3% on CPI and 0.5%. within one year. This does hit the wallet of Icelanders hard, as most housing loans are indexed to the CPI and will therefore increase substantially. The exchange rate pass through to CPI excluding housing prices, which was argued to reflect the price of goods and services better, was found to increase by 0.49% for one year. That emphasized the effect the exchange rate has on the purchasing power of consumers if wage increases negotiated by the labor unions do not follow.

A plausible lack of confidence in the monetary policy regime and/or implementation in Iceland can also be drawn from the papers findings. If a lack of confidence persists, then that is a very serious thing for the Central Bank of Iceland as the implementation of monetary policy becomes much harder as inflation expectations could remain higher than they needed to be.

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A Appendix

Results from Ljung-Box tests used to pick the number of lags in the unit root tests are shown in figures 7 -12. The results from Ljung-Box test[9] revealed that it took one lag to get rid of autocorrelation in the residuals for all variables excluding the output gap, where it took two. The results from the Augmented Dickey Fuller and Phillips-Perron tests are shown in figures 5 -11 and table 10. The results from the unit root tests are that all time series are I(1) and therefore the first difference was taken in all cases before the estimation of the model.

In these estimations we see that we cannot reject the presence of a unit root. We do find random walk with a drift for consumer prices without housing prices. One cannot think of a special reason why the time series should drift when excluding housing prices

[9]Used a function written by Pedro Brinca Soares, a PhD student at Stockholm University

but not when including them and by visual inspection of the time series, figure 12, we cannot see either a upwards nor a downwards drift. The VAR model is therefore estimated without drift.

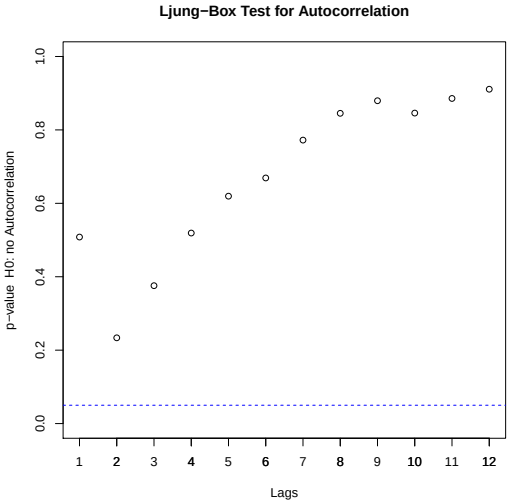

Figure 5: Ljung-Box test for oil prices, lag=1

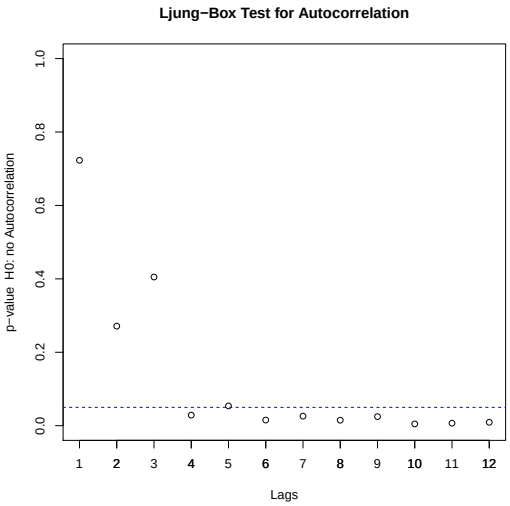

Figure 6: Ljung-Box test for output gap, lag=1

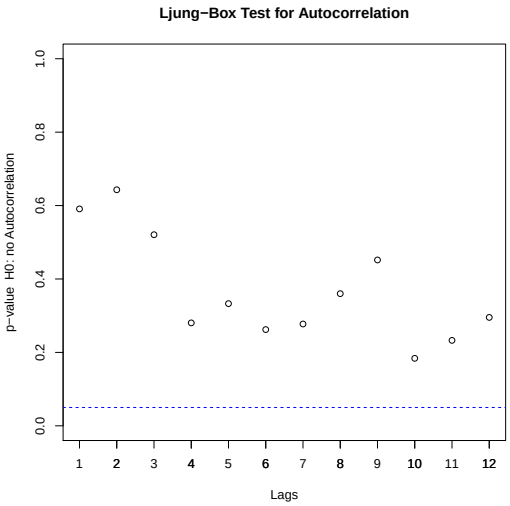

Figure 7: Ljung-Box test for output gap, lag=2

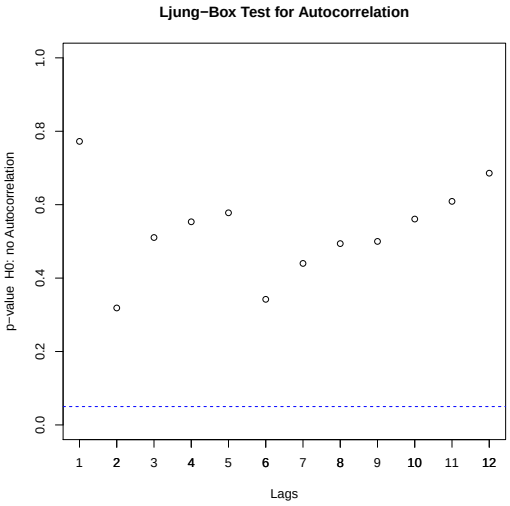

Figure 8: Ljung-Box test for the exchange rate, lag=1

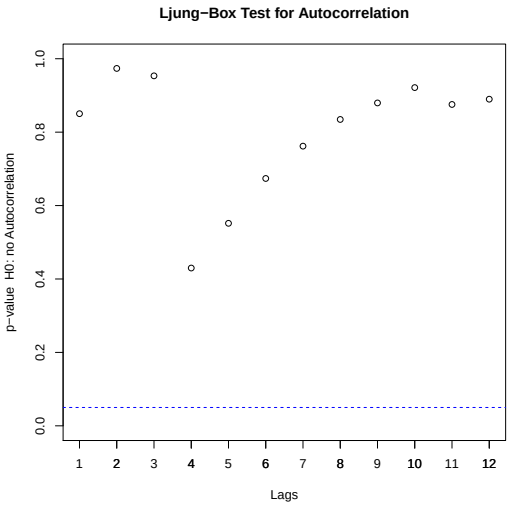

Figure 9: Ljung-Box test for the production price index, lag=1

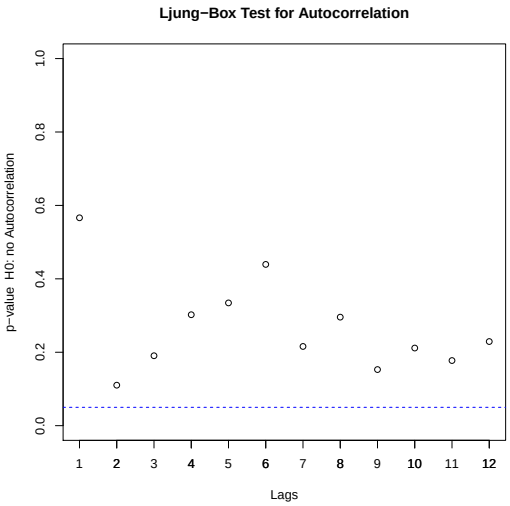

Figure 10: Ljung-Box test for the consumption price index, lag=1

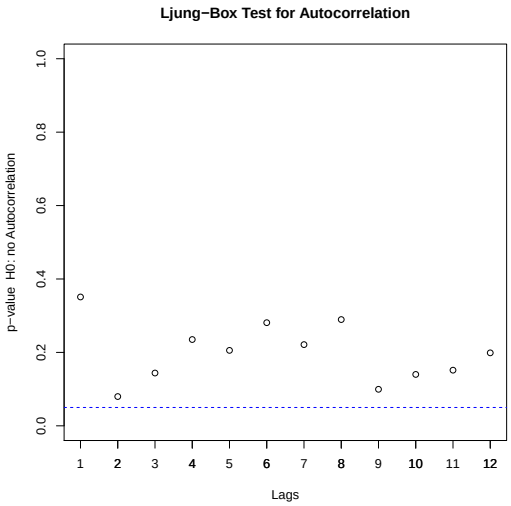

Figure 11: Ljung-Box test for the consumption price index excluding housing prices, lag=1

Test statistic	$\tau 3$	$\phi 2$	$\phi 2$
Oil prices	-3.497	4.43	6.16
Output gap	-2.81	3.59	5.36
Exchange rate	-1.86	1.78	1.91
PPI	-2.65	3.96	3.82
CPI	-1.73	4.72	1.53
CPI w/o housing prices	-1.78	3.26	2.04
Critical value, $\alpha = 0.05$	-3.5	5.13	6.73

Table 7: Augmented Dickey Fuller test results for unit root with trend

Test statistic	$\tau 2$	$\phi 1$
Oil prices	-2.5	3.54
Output gap	-1.12	0.64
Exchange rate	-0.44	0.79
PPI	-0.09	1.69
CPI	-0.06	5.13
CPI w/o housing prices	0.29	2.58
Critical value, $\alpha = 0.05$	-2.93	4.86

Table 8: Augmented Dickey Fuller test results for unit root with drift

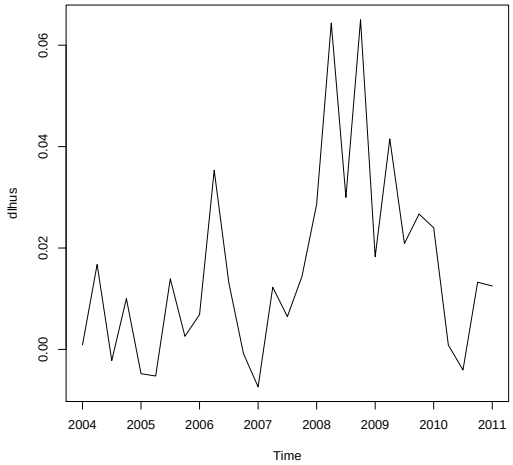

Figure 12: Plot of the first difference in logarithm of CPI w/o housing prices

Test statistic	$\tau 1$
Oil prices	-0.08
Output gap	-1.16
Exchange rate	0.44
PPI	1.86
CPI	3.25
Critical value, $\alpha = 0.05$	-1.95

Table 9: Augmented Dickey Fuller test results for unit root

Dickey-Fuller Z(alpha)=-24.6106	Truncation lag parameter=2
p-value < 0.01	
alternative hypothesis:	stationary

Table 10: Phillips-Perron test for unit root for CPI