

An aggregate import demand function for Yemen : An ARDL bounds testing approach

Essa Alhanom

*Assistant Professor of Economics, Faculty of Commerce and Administration Sciences
Ibb University - Yemen
eysa20@gmail.com*

Abstract

This paper analyses the determinants of aggregate import demand in Yemen. Due to the small size sample of the current study, the use of traditional co-integration techniques may be unreliable. Therefore, the recently developed bounds test for co-integration within ARDL modeling approach is applied to annual data covering the period 1990-2009. It is found that aggregate import demand and its determinants exhibit a long run equilibrium relationship. The long run income and relative prices elasticities are, respectively, 1.75 and -0.98. The ECM representation of the import demand function reveals a little bit higher income and relative prices elasticities and a moderate speed of adjustment to equilibrium.

1- Introduction

The study of import demand determinants is looked upon as a major macroeconomic relationship with various implications in formulating several policies among which trade, exchange rate, monetary and fiscal policies. The severe and permanent nature of the trade balance and current account deficits in developing and least developed countries give the study of import and export determinants further importance particularly in the context of policy making related to the achievement of both external and internal equilibrium.

During the past three decades a vast amount of research has been devoted to the study of import demand determinants either in developed or developing countries. This literature can be classified under two distinguished categories : the traditional studies and the modern and co-integration based studies. The traditional country specific studies, such as Khan(1975) for Venezuela , Salas(1982) for Mexico, Gafar(1988) for Trinidad and Tobago, and Giovannetti(1989) for Italy, used the standard OLS and partial adjustment approach which assume the existence of equilibrium relationship between the quantity of imports and the explanatory variables included in the used models. However, modeling the adjustment of import quantity to its long run equilibrium value, using the OLS would be invalid if the assumption of the existence of a long run relationship is false (Mah 1994 291). In addition, the use of OLS may lead to spurious regressions and thus unreliable statistical inference if the stationarity assumption is unsatisfied(see Granger and Newbold(1974) and Phillips(1986). Other studies such as Abbott and Seddighi(1996), Sinha(1997) ,Sinha and Sinha(2000), and Islam and Hassan(2004) used traditional univariate and multivariate co-integration methods (Engle-Granger 1987, Johansen 1988, Philips and Hansen 1990, , and Johansen and Juselius 1990) and error correction modeling which deal with the stationarity issue and enhance the

reliability of statistical inference about the long run equilibrium and short run dynamics. However, these co-integration techniques face the problem of the order of integration and require the data samples to be of large size (see Mah 2000 and Kremers *et al.* 1992). The ARDL bounds test developed by Pesaran and Shin (1999) and Pesaran *et al.* (2001) can be applied irrespective of whether the regressors are integrated of zero order, one, or mutually integrated. Furthermore, the bounds test is considered valid and suitable for small size samples studies (Narayan 2004).

As one of the least developed countries, With per capita income of 1141 US\$ and a population of 23.58 million in 2009, about 42% of Yemen population has been estimated to live below the poverty line of 2 US\$ / day in 2007 (UNDP 2010). Yemen economy faced with several structural constraints which are reflected in a weak and inflexible productive capacity for different sectors. In 2008 and as a share of GDP, agriculture, manufacturing, and oil and gas extraction contributed by 9.98 %, 5.62 %, and 31.7%, respectively (CSO 2010). As a result, the country imports most of its needs starting from food to machinery and equipments on the one hand and has a limited and concentrated base of export on the other. Imports as a share of GDP have been rising over decades and reached about 38.4% in 2008 (CSO 2010). The structural deficits of trade and current account balances represent, therefore, key challenges to the ambitions of economic stabilization and growth in the economy of Yemen.

To our knowledge, no econometric analysis of aggregate import demand in Yemen has been undertaken in general thus, this study attempts to fill in this gap. This paper aims at estimating the aggregate import demand function for Yemen over the period 1990 - 2009 using advanced econometric technique namely, ARDL bounds testing approach to co-integration. The paper is organized as follows : section 2 describes the model specifications, econometric methodology, and data employed in the study. Section 3 analyzes the empirical results of the estimations of import demand function for Yemen. The conclusions and policy implications drawn from this study are presented in section 4.

2- Model, Econometric Methodology, and Data

The most widely used specification of import demand function considers the quantity of import demanded as a function of real domestic income and relative prices (ratio of import prices to domestic prices). This specification is given by the following equation:

$$M_t = f [Y_t, (P_{mt}/P_{dt})] , \quad (1)$$

where M_t is the quantity of imports demanded at period t, Y_t is the real GDP at period t, P_{mt} is the import price at period t, and P_{dt} is domestic price level at period t. Equation (1) can be rewritten as :

$$M_t = f(Y_t, RP_t) , \quad (2)$$

where RP_t stands for the ratio of import prices P_{mt} to domestic prices P_{dt} .

The log linear transformation of equation (2) can be formulated asⁱⁱ:

$$\ln M_t = \beta_0 + \beta_1 \ln Y_t + \beta_2 \ln RP_t + u_t , \quad (3)$$

Where \ln is the natural logarithm and u_t is error term. The signs of explanatory variables are expected to be : $\beta_1 > 0$; $\beta_2 < 0$.

It is true that bounds test does not require the variables of the regression to be integrated of the same order but there is a need to make sure that no variable is integrated of more than one before starting the implementation of ARDL bounds test. Therefore, ADF (augmented dickey-Fuller) Dickey and Fuller(1981) and Phillips-Perron(1988) unit root tests are performed.

The ARDL bounds testing procedure to co-integration will be conducted through two stages. At the first stage, the existence of long run co-integration relationship between import demand and its determinants real GDP and relative prices is tested by estimating a conditional ARDL representation of equation (3) as follows:

$$\Delta \ln M_t = b_0 + \sum_{i=0}^n b_{1i} \Delta \ln Y_{t-i} + \sum_{i=0}^n b_{2i} \Delta \ln RP_{t-i} + \sum_{i=1}^n b_{3i} \Delta \ln M_{t-i} + b_4 \ln M_{t-1} + b_5 \ln Y_{t-1} + b_6 \ln RP_{t-1} + \varepsilon_t, \quad (4)$$

Where Δ refers to the first difference operator and n is the maximum lag length. The parameters b_1 , b_2 , and b_3 stand for the short run dynamics whereas b_4 , b_5 , and b_6 present the long run relationship. Therefore, a joint significance test of no co-integration relationship between the variables is implemented with the null hypothesis ($H_0: b_4 = b_5 = b_6 = 0$) as against the alternative hypothesis ($H_1: b_4 \neq b_5 \neq b_6 \neq 0$).ⁱⁱⁱ

The bounds test procedure of Pesaran *et al.*(2001) depends on the Wald test (F statistics) with an asymptotic non standard distribution. Pesaran, Shin and Smith(1996) established two bounds of critical values for different model specifications. If the computed F statistic, at a chosen significance level, exceeds the upper critical bound value, the null hypothesis of no co-integration is rejected. Similarly, if the lower computed F statistics falls below the lower critical bound value, the null hypothesis of no co-integration is not rejected. When the computed F statistics falls between the two critical bound values, the result is considered inconclusive.

Once a long run relationship (co-integration) is established, the long run coefficients are estimated using the following long run model^{iv}:

$$\ln M_t = \phi_1 + \sum_{i=0}^n b_{1i} \ln Y_{t-i} + \sum_{i=0}^n b_{2i} \ln RP_{t-i} + \sum_{i=1}^n b_{3i} \ln M_{t-i} + \varepsilon_t \quad (5)$$

The selection of the appropriate specification (optimal lag length for each variable)of the above model can be made depending on different criteria such as AIC (Akaike Information Criterion), SBC (Schwarz Bayesian Criterion). Modern econometric softwares, such as Microfit, estimate $(p + 1)^k$ regressions and select the appropriate specification according to the chosen criterion, where p is the maximum lag length to be used and k is the number of variables included in the equation.

The second step of ARDL bounds test involves the estimation of the ARDL short run dynamics by formulating the error correction representation associated

with the above long run equation (5). It estimates the short run dynamics and the speed of adjustment of import quantity demanded to changes in the explanatory variables before converging to its equilibrium level. The error correction model can be formulated as:

$$\Delta \ln M_t = \delta + \sum_{i=0}^n \alpha_{1i} \Delta \ln Y_{t-i} + \sum_{i=0}^n \alpha_{2i} \Delta \ln RP_{t-i} + \sum_{i=1}^n \alpha_{3i} \Delta \ln M_{t-i} + \gamma ECM_{t-1} + \varepsilon_t \quad (6)$$

where γ is the speed of adjustment parameter and ECM is the residuals that are obtained from the estimation of equation (5).

To ascertain the goodness of the selected ARDL specification, diagnostic tests of serial autocorrelation, functional form, normality and heteroskedasticity are performed. In addition, the structural stability of the parameters of import demand is tested using the CUSUM (cumulated sum of recursive residuals) and CUSUMSQ (cumulated sum of squares of recursive residuals) suggested by Brown et al., (1975).

Annual time series data for the period 1990-2009 are used. The variables used in this study are defined as follows: M_t is real aggregate import calculated as import value at current prices divided by the import unit value index, and both were taken from the United Nation statistics database. Y_t is real income calculated as GDP at current prices divided by consumer price index, and both were taken from International Financial Statistics CD ROOM 2010. RP_t is relative prices calculated as the ratio of import unit value index divided by consumer price index. Except unit root tests, Microfit 5 software is used in different stages of the ARDL bounds test.

3- Empirical Results

Before the implementation of the ARDL bounds test, it is important to investigate the univariate properties of data series to identify the degree to which they are integrated to make sure they are not $I(2)$ or higher. The augmented Dickey-Fuller (ADF) and Phillips-Perron tests are conducted and the results of both tests, displayed in Table(1), show that $\ln M_t$ and $\ln Y_t$ are $I(1)$, whereas $\ln RP_t$ is $I(0)$. This result lends support to the implementation of bounds test procedure.

Our empirical ARDL bounds test begins with testing the existence of long run co-integration among the import demand, real income, and relative prices via performing F test to equation (4) as explained above. Table (2) shows that the computed F statistic (5.439) is higher than the upper bound critical value (4.85) and consequently the null hypothesis of no co-integration can be rejected at the 5% significance level.

Table(1)

	Unit Root Tests for Stationarity					
	ADF Test			Phillips-Perron Test		
	intercept	intercept & trend	non	intercept	Intercept& trend	non
Ln M	-0.72	-2.11	0.87	-0.72	-2.11	0.87
ΔLn M	-3.77**	-3.61***	-3.54*	-3.71**	-3.35***	-3.54*
Ln Y	-2.45	-4.67*	-0.84	-9.54*	-10.32*	-4.01*
ΔLn Y	-3.85**	-1.92	-4.13*	-9.96*	-4.45**	-12.42*
Ln RP	13.77*	-4.88*	-15.75*	-40.7*	-23.8*	-17.68*
ΔLn RP	-3.09**	-3.76*	-1.49	-4.87*	-3.69**	-6.18*

Notes: (1) *, **, *** indicate 1%, 5%, and 10% significance level, respectively. (2) the lag length Chosen for ADF test was selected automatically depending on Schwarz Bayesian Information. (3) the bandwidth for Phillips-Perron test was selected automatically depending on Newy-West using Bartel-Kernel. (4) tests performed using eviews 7 software.

As the long run relationship between import demand and its determinants is found, we now estimate the long run elasticities of income and relative prices through the estimation of ARDL equation (5). But we need first to determine the optimal lag length of the three variables using AIC and SBI criteria.

Table(2)

Bounds Test For co-integration analysis

Computed F statistic	5.439
Critical bound values at 5%	Lower = 3.79 upper = 4.85
K (number of regressors)	2
intercept and no trend in the model	

Note: critical values are from Pesaran *et al.* (2001), p.300.

Table (3) shows the estimated long run elasticities of income and relative prices of two selected models: ARDL(1,0,1) according to AIC and ARDL(0,0,1) according to SBI. The resulted signs of the coefficients are as expected, positive Income elasticity and negative relative price elasticity. Additionally, in the long run, import demand proved to be elastic to real income (1.745 according to AIC ARDL(1,0,1) model and 1.68 according to SBI ARDL(0,0,1) model), and inelastic to relative prices (-0.0976 according to AIC ARDL(1,0,1) model and -0.0954 according to SBI ARDL(0,0,1) model). Table(3) also presents diagnostic tests of both models and suggests the absence of serial correlation, misspecification error, heteroscedasticity, and non normality of residual. It can be seen that ARDL model of lag lengths (0,0,1) may be better than the other ARDL(1,0,1) model as it shows higher values for t ratio for all variables and thus higher levels of significance. Besides, the value of F statistic of the same model is also higher compared to the other model. However, the absence of the $\Delta \ln M$ as a regressor in this model means that we have no choice other than depending on the other model based on AIC in establishing ECM representation of the long run model as formulated in equation(6).

Table(3)

Long run coefficients for ARDL(1,0,1) and ARDL(0,0,1)

Dependent variable Ln M				
Model selection criteria				
AIC ARDL(1,0,1)			SBI ARDL(0,0,1)	
Regressor	Coefficient	t-ratio [prob]	Coefficient	t-ratio [prob]
Ln Y	1.745	9.63(0.000)	1.68	11.49(0.000)
Ln RP	-0.976	-12.9(0.000)	-0.954	-15.99(0.000)
INPT	-4.196	-2.79(0.051)	-3.79	-3.05(0.009)
Diagnostic tests	LM=0.105[0.746] F(1,12)=0.07[0.796] RESET=0.48[0.487] F(1,12)=0.33[0.576] *Normality Test=0.144[0.488] **Heteroscedacticity=0.71[0.399] F(1,16)=0.657[0.429]		LM=0.601[0.438] F(1,13)=0.449[0.515] RESET=1.67[0.196] F(1,13)=1.33[0.268] Normality test=0.973[0.615] Heteroscedacticity=0.702[0.402] F(1,16)=0.649[0.432]	

* based on skewness and kurtosis of residuals.

** based on regression of squared residuals on squared fitted values.

The estimation results of short run elasticities showed in Table(4) which reveals that income elasticity of import demand in the short run is 1.79 which is a little bit higher than that of the long run (1.75) whereas, import demand showed to be elastic (-1.314) with relation to relative prices. The error correction term ECM_{t-1} is statically significant (at 5%) and its coefficient shows the appropriate (negative) sign with a value of -0.42. This value indicates that import demand shows a moderate speed (42% a year) of adjustment to changes in the explanatory variables before converging to its equilibrium value. The diagnostic tests of the above mentioned major regression problems are performed on the ECM, as displayed in table(4) and the results suggest the absence of these problems.

Table(4)

Error Correction Model Representation of ARDL(1,0,1)		
Dependent variable $\Delta \ln M$		
regressors	coefficient	T-ratio [prob]
INPT	-0.005	-0.113(0.912)
$\Delta \ln M_{t-1}$	0.037	0.249(0.807)
$\Delta \ln Y$	1.792	6(0.000)
$\Delta \ln RP$	-1.314	-6.06(0.000)
$\Delta \ln RP_{t-1}$	0.392	2.405(0.035)
ECM_{t-1}	-0.415	-2.89(0.015)
	$R^2 = 0.836$ $\bar{R}^2 = 0.762$ F(5,11)= 11.25[0.000] Equation log likelihood= 14.93	S.E of regression = 0.125 Residual Sum of Square=0.172 D.W=1.982
Diagnostic tests	LM=0.215[0.643] RESET=0.088[0.766] Normality=0.239[0.887] Heteroscedasticity=0.717[0.397]	F(1,10)=0.127[0.728] F(1,10)=0.522[0.824] ----- F(1,15)=0.661[0.429]

To test the stability of the import demand function's parameters, as presented in the above ECM, we apply the CUSUM and CUSUMSQ which reveal that our model appears to be stable and correctly specified as is clear from the graphical presentation of these two tests in figures (1) and (2).

Figure (1)

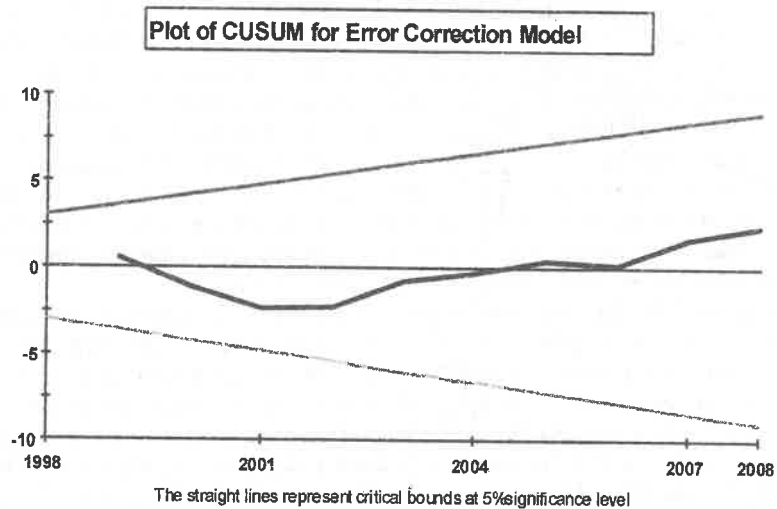
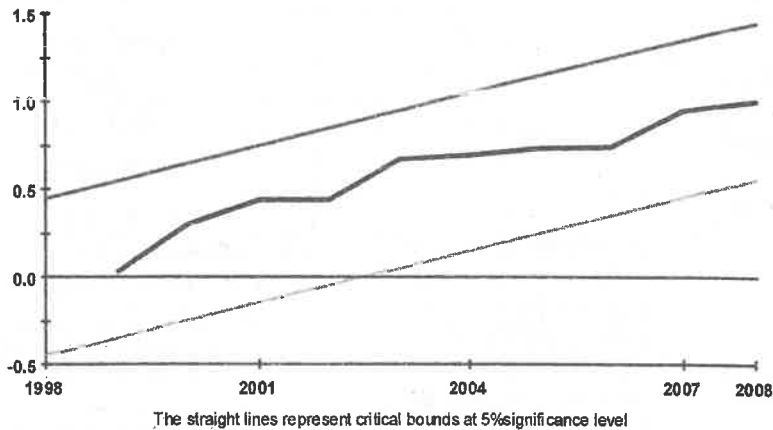


Figure (2)

Plot of CUSUMSQ for Error Correction Model



4- Conclusion and Policy Implications

This study is motivated by the need to estimate aggregate import demand function for Yemen using the recently developed ARDL bounds test approach to co-integration. The long run relationship between import demand, real income and relative prices, using annual data for the period 1990-2009, is investigated. We found evidence of a level long run relationship between the variables, and therefore the long run and short run elasticities estimation is performed. It is found that, in the long run, real income has an elastic and positive (1.75) impact on import demand whereas, relative prices have a negative, but inelastic, impact (-0.98 according to AIC and -0.95 according to SBI). These results are in line with theoretical prediction and empirical range of Goldstein and Khan(1985). The positive and elastic real income impact suggests that import demand is growing faster than income growth and unless exports grow faster than imports, economic growth will cause the trade balance and current account deficits to continue. The major implication of this result for policy making is that the Yemen government should concentrate and encourage the development of domestic industries of low import content.

In spite of the fact that relative prices variable is significant at 1% and its elasticity is closer to unity but it is still in the inelastic range. This indicates that import demand is negatively affected by import prices and positively affected by domestic prices level but is less responsive to their changes which can be traced to the fact that Yemen depends highly on import to meet most of its needs either necessary or luxury ones. From the view point of policy making, this does not lend support to the use of exchange rate policies to curtail imports and thus to correct trade and current account disequilibrium in the case of Yemen. Another policy

implication is that using monetary policy to affect Import demand via controlling domestic inflation might not improve the trade balance but there is still a need to keep domestic inflation within the acceptable levels.

The short run dynamics of the ECM representation of import demand function reveal that import demand elasticity of income in the short run (1.79) is higher than that of the long run (1.75) and the elasticity of relative prices (-1.31) is higher than the same in the long run and more than unity. The estimated error correction term is statically significant with the appropriate (negative) sign and a moderate value (-0.42) which indicates a moderate speed of adjustment to equilibrium value of import demand.

References :

- Abbott, A.J., and H.R. Seddighi (1996), " Aggregate Imports and Expenditure Component in the UK: An Empirical Analysis, " *Applied Economics*, 28, 1119-1125.
- Brown, R. L., J. Durbin, and J. M. Evans (1975), " Technique for testing the constancy of regression relationships over time, " *Journal of the Royal Statistical Society Series*, B37, 149-163.
- Dickey, D.A., and Wayne A. Fuller (1981), " Likelihood ratio statistics for autoregressive time series with a unit root, " *Econometrica*, 49(4), 1057-1072.
- Engle, R.F., and C.W.J. Granger (1987), " Cointegration and Error Correction: Representation, Estimation and Testing, " *Econometrica*, 55, 251-76.
- Gafar, J.S. (1988), " The Determinants of Import Demand in Trinidad and Tobago: 1967-1984, " *Applied Economics*, 20, 303-13.
- Giovannetti, G. (1989), "Aggregated Imports and Expenditure Components in Italy: An Econometric Analysis, " *Applied Economics*, 21: 957-971.
- Goldstein, M. and M. Khan (1985), " *Income and Price Effects in Foreign Trade*, " in R. W. Jones and P. Kenen (eds), *Handbook of International Economics II*, Amsterdam: North Holland.
- Granger, C.W.J., and P. Newbold (1974), " Spurious Regressions in Econometrics, " *Journal of Econometrics*, 2, 111-20.
- Islam, Anisul, and M. Kabir Hassan (2004), "An econometric estimation of the aggregate import demand function for Bangladesh: some further results," *Applied Economics Letters*, 11(9), 575-580.
- Johansen, S. (1988), " Statistical Analysis of Cointegration Vectors, " *Journal of Economic Dynamics and Control*, 12, 231-254.
- Johansen, S. and K. Juselius (1990), " Maximum Likelihood Estimation and Inference on Cointegration-With Applications to the Demand for Money, " *Oxford Bulletin of Economics and Statistics*, 52, 169-210.
- Khan, M. (1975), " The structure and behavior of imports of Venezuela, " *Review of Economics and Statistics*, 57, 221-224.
- Kremers, J. J. M., N. L. Ericsson, and J. Dolado (1992), " The power of cointegration tests, " *Journal of Econometrics*, 52, 389-402.
- Mah, J. S. (1994), " Japanese import demand behaviour: the cointegration approach, " *Journal of Policy Modeling*, 16, 291-298.

- Mah, J. S. (2000), " An empirical examination of the disaggregated import demand of Korea: the case of information technology products, " *Journal of Asian Economics*, 11, 237-244.
- Narayan, P.K. (2004), " Reformulating Critical values for the bounds F-statistics approach to cointegration: an application to the tourism demand model for Fiji, " Department of Economics Discussion Papers No.02/04, Monash University, Melbourne.
- Pesaran Bahram and M. Hashim Pesaran (2009), *Time series econometrics using Microfit 5*, (Oxford: Oxford University Press,).
- Pesaran, M. H. and Y. Shin (1996), " Cointegration and Speed of Convergence to Equilibrium," *Journal of Econometrics*, 71, 117-143.
- Pesaran, M.H., Y. Shin, and R.J. Smith (2001), "Bounds Testing Approaches to the Analysis of Level Relationships, " *Journal of Applied Econometrics*, 16(3), 289-326.
- Pesaran, M. H. and Y. Shin (1999), "*An autoregressive distributed lag modelling approach to cointegration analysis.*" In S. Strom (Ed.), *Econometrics and Economic Theory in 20th Century: The Ragnar Frisch Centennial Symposium*, Chapter 11, pp. 371-413. Cambridge: Cambridge University Press.
- Phillips, P. C. B. (1986), "Understanding Spurious Regressions in Econometrics, " *Journal of Econometrics*, 33, 311-334.
- Phillips, P. C. B. and B. E. Hansen (1990), " Statistical Inference in Instrumental Variables Regression with I(1) Processes, " *Review of Economic Studies*, 57, 99-125.
- Phillips, P. C. B. and P. Perron (1988), " Testing for a Unit Root in Time Series Regression," *Biometrika*, 75, 335-346.
- Salas, J. (1982), " Estimation of the Structure and Elasticities of Mexican Imports in the Period 1961-1979," *Journal of Development Economics*, 10, 297-311.
- Sinha, D. (1997), " Determinants of import demand in Thailand, " *International Economic Journal*, 11(4), 73-83.
- Sinha Dipendra, and Tapen Sinha (2000), "An aggregate import demand function for Greece," *Atlantic Economic Journal*, 28(2), 196-209.

ⁱ Oil export represent more than 90% of total goods export and the rest dominated by other primary products.

ⁱⁱ Employing the log linear formulation allow us to obtain import elasticities of income and relative prices directly from equation (3).

ⁱⁱⁱ The null hypothesis test for import demand is performed by estimating equation (4) without the lagged level variables $\ln M_{t-1}$, $\ln Y_{t-1}$, and $\ln RP_{t-1}$ and then performing a variable addition test in order to test the joint significance of these variables see, Pesaran and Pesaran, (2009).

^{iv} Before the above model is estimated the maximum lag length is specified.