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THE UNIVERSITY OF SUSSEX
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**ESTIMATING DEMAND FOR MONEY IN
JAMAICA**

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1- INTRODUCTION

Estimation of demand for money performs a key role due to its importance in determining the effects of monetary policy in regulating the economic system. In a developing country such as Jamaica, this issue comes up to be even more important because it should provide the government with instruments able to guarantee stability and growth in the long run.

Jamaica is a small open economy and, after reaching independence in 1962, has operated a domestic currency (and a stock exchange since 1969). The authority responsible for monetary policy and price stability is the Jamaican Central Bank. Until the 1990's a fixed exchange rate regime was maintained, but in the context of a repressed financial system and low real interest rates, it failed to operate as an effective inflation anchor. By devaluation and after the consequent adoption of a floating rate in 1992, the financial system was liberalised and an explicit inflation targeting policy was adopted. The focus shifted to open market control of the operating targets provided by the monetary base and associated interest rates instruments.

It is important to stress the concept that, in a context like the Jamaican one, of a small open economy, characterised by a limited financial sector, domestic interest rates may not transmit in expected Keynesian way through output (Mishkin,1995), but rather transmit directly to demand and inflation. (Lattie, 1999). If such a monetary policy is to

offer an effective inflation strategy it is important that there is a stable long run relation between monetary conditions and behaviour of the public. This relationship is captured in the demand for money which provides important information for appropriate monetary actions.

Another fundamental feature is that of financial crises which could cause problems for monetary policy as they tend to destabilise money demand and limit the effectiveness and predictability of monetary policy. (Garcia- Herrero, 1997). Jamaica has been shaken by two major financial crises. The first arose in the 1980's within the context of the radicalised domestic politics and the international debt crisis. The second major financial crisis began in the mid 1990's and was associated with liberalisation and the speculative behaviour of weakly regulated financial institutions. In the second crisis the Jamaican government avoided IMF assistance and the requisite policies emphasising foreign exchange stabilisation and closure of troubled institutions. In contrast it sought to maintain liquidity by rescuing institutions and ensuring depositor protection

In the following analysis we shall investigate the dynamics of money demand, represented by real money balances, being a function of real income and nominal interest rates.

2- DATASET AND DATA EVOLUTION

The dataset is composed by annual data for Jamaica covering the period 1962 - 1997. In order to estimate demand for money we shall simply make use of three sets of variables:

1. Log of real money balances (henceforth M);
2. Log of Real income at constant 1995 Prices (Y)
3. Government of Jamaica Bond Yield in Percentage (R)

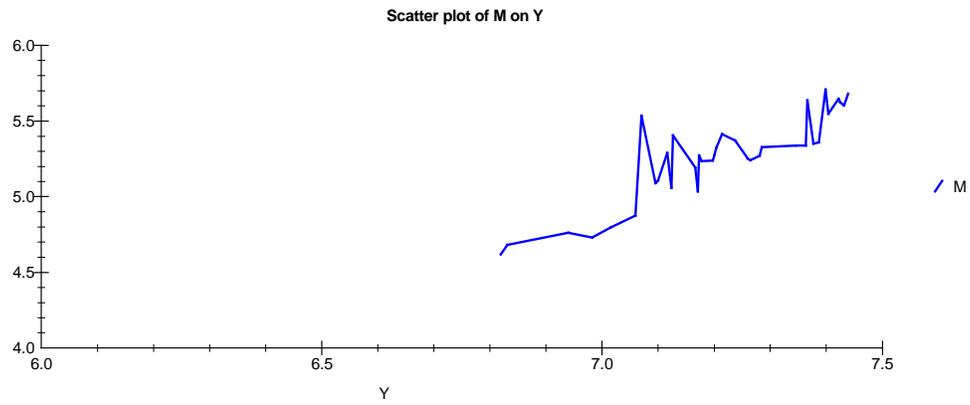
The following graphical analysis tries to go a bit further. Graph 1 plots the observed relationship between M and Y. As expected from economic theory, there seems to be a positive relationship between the two variables.

Graph 2 makes the same thing for R. We would have expected a negative correlation, while the data provide evidence of an upward sloping relationship between the rate of interest and money balances. This is an interesting point that we can keep in mind before looking at the estimates.

Finally, Graph 3 plots the three variables through time.

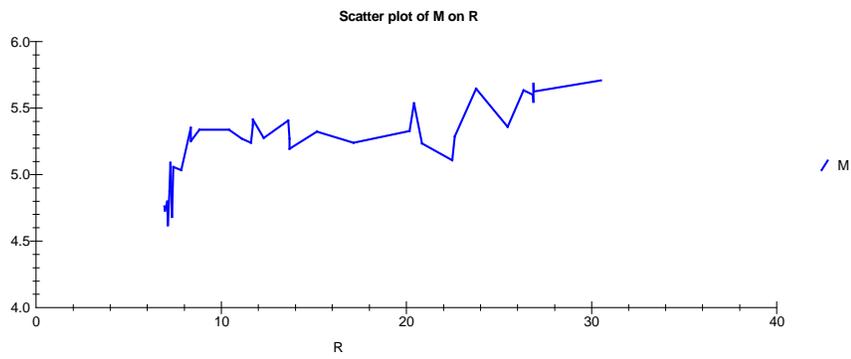
Graph 1

Relationship between M and Y



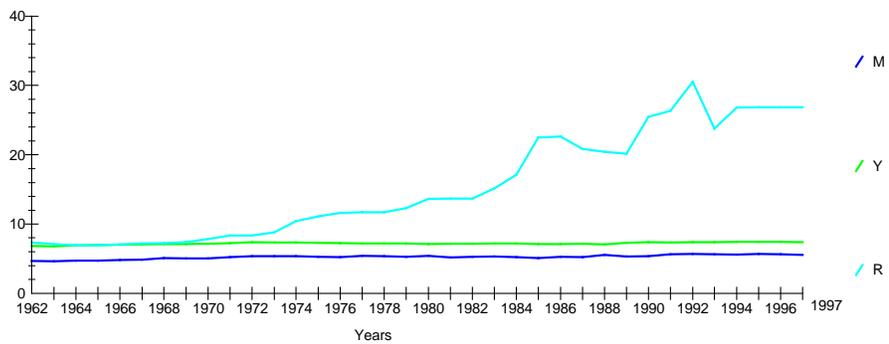
Graph 2

Relationship between M and R



Graph 3

M, Y and R (1962-1997)



Such a qualitative analysis is useful because it offers preliminary suggestions which however need to be further investigated through an appropriate econometric method.

The purpose of the analysis is to find out if there is any evidence of a stable relationship between money balances, GDP and interest rate and what are the relative contributions of the single variables.

Another important issue is to investigate any difference between short run and long run responses of money balances to variations in income and interest rate.

3- THE MODELISATION

The estimation of a demand for money in Jamaica is made up of five steps:

1. the first problem to be addressed is detecting the order of integration of the variables composing our dataset. As Griffiths, Hill and Judge (1993) and Greene (2003) rightly point out, time series representing non stationary processes (the grater majority of social and economic variables) are likely to generally deliver spurious regression results.
2. Once this first step will be accomplished the following long run model (Reilly, 2005) shall be evaluated:

$$M = \theta_1(Y) + \theta_2(R) + \varepsilon \quad (1)$$

where

- $\theta_1 =$ long run elasticity of M w.r.t. Y
- $\theta_2 =$ long run semi-elasticity of M w.r.t. R
- $\varepsilon =$ error term

If time series contained a unit root, this model would be very useful in order to test for cointegration (Dickey-Fuller test on the estimated error term).

3. An ARDL(1,1) model of the following form shall be evaluated (the subscript “-1” indicates one period lag):

$$M = \beta_1 + \beta_2(Y) + \beta_3(Y)_{-1} + \beta_4(R) + \beta_5(R)_{-1} + \beta_6(M)_{-1} + \varepsilon \quad (2)$$

where

$\beta_2 =$ short run elasticity of M w.r.t. Y

$\beta_4 =$ short run semi-elasticity of M w.r.t R

The ARDL(1,1) can be then rearranged in order to give information about long run elasticities. In the steady state ($(Y) = (Y)_{-1} = Y^*$ etc....):

$$M^* = \beta_1/(1-\beta_6) + (\beta_2+\beta_3)/(1-\beta_6)Y^* + (\beta_4+\beta_5)/(1-\beta_6)R^* \quad (3)$$

where

$(\beta_2+\beta_3)/(1-\beta_6) =$ long run elasticity of M w.r.t. Y

$(\beta_4+\beta_5)/(1-\beta_6) =$ long run semi-elasticity of M w.r.t. R

4. The framework of the ARDL(1,1) model shall be useful not just for highlighting both short and long run responses of M with respect to both GDP and interest rate, but also because it can help to further investigate the question about the existence of a “pure” and long run relationship among these three variables. If a “pure” relationship between money balances, GDP and rate of interest existed, then this relationship should to be “stable”: an Error Correction Mechanism able to adjust short run deviation with respect to this equilibrium has to be estimated (Greene, 2003, Reilly, 2005). An Error Correction Mechanism Model (henceforth ECM) able to give account for this adjustment process is derivable form the previous ARDL(1,1) model through a specific transformation (Reilly, 2005):

(4)

$$\Delta M = \beta_1 + \beta_2 \Delta Y + \beta_4 \Delta R - (1-\beta_6)(M - \theta_1 Y - \theta_2 R)_{-1} + \varepsilon$$

where

$\Delta =$ first difference

$\beta_2 =$ Short run elasticity w.r.t. Y

$\beta_4 =$ Short run semi-elasticity w.r.t R

$\theta_1 =$ $(\beta_2 + \beta_3)/(1-\beta_6) =$ Long Run elasticity w.r.t Y

$\theta_2 =$ $(\beta_4 + \beta_5)/(1-\beta_6) =$ Long Run semi-elasticity w.r.t R

$(1-\beta_6) =$ Error Correction Mechanism

By substituting $(M - \theta_1 Y - \theta_2 R)_{-1}$ with the residuals arising from the long run model (1) and after conducting an appropriate t-test about the significance of the error correction mechanism (Engle and Granger procedure), it will be possible to detect the presence of cointegration.

5. The last step of the analysis shall estimate an unrestricted version of the ECM, still based on the previous ARDL(1,1). The unrestricted ECM constitutes a simple “expansion” of the model (4) as follows:

(5)

$$\Delta M = \beta_1 + \beta_2 \Delta Y + (\beta_2 + \beta_3) Y_{-1} + \beta_4 \Delta R + (\beta_4 + \beta_5) R_{-1} + (1-\beta_6) M_{-1} + \zeta$$

where

$\beta_2 =$ Short run elasticity w.r.t. Y

$\beta_4 =$ Short run semi-elasticity w.r.t. R

An appropriate F-test on the unrestricted error correction mechanism (jointly determined by the coefficients attached to the lagged variables) shall be performed in order to gain further evidence about the presence of cointegration. Finally, transforming the unrestricted ECM in a long run equilibrium model (imposing, as

for model (3), $(Y) = (Y)_{-1} = Y^*$ we shall derive further estimations of long run elasticities.

4- RESULTS

In this section I will present the most important results arising from the steps described in the previous section. The details with the MICROFIT sheets will be shown in the attached appendix.

Step 1: DF and ADF

By plotting the correlograms (see the Appendix for the graphs) it seems reasonable to argue that the level variables are non stationary (M, Y, R) while the first differences are stationary ($\Delta M, \Delta Y, \Delta R$).

However, a more rigorous testing has to be performed. The following table shows the results of the univariate Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) test with respect both to the level variables and their first differences.

The modelled process includes both a drift and a time trend in order to reduce the possibility of bias in the coefficients because of omitted variables. The corresponding values of the Akaike Information Criteria (AIC) are also presented.

Table 1
DF and ADF tests

	<i>M</i>	ΔM	<i>Y</i>	ΔY	<i>R</i>	ΔR
DF	-2.9837	-7.5273	-2.3833	-5.3707	-3.1926	-7.2273
AIC	24.3165	20.7248	45.9065	42.2697	-69.5968	-71.5170
ADF(1)	-2.3618	-5.6094	-2.4362	-3.8420	-2.7109	-4.1151
AIC	23.7527	20.8577	45.1211	41.2749	-70.4247	-72.4967

95% critical value for the
 augmented Dickey-Fuller statistic = -3.5468 (ADF(1) on levels)
 augmented Dickey-Fuller statistic = -3.5514 (ADF(1) on first differences)

According to the results we cannot reject the null hypothesis of unit root as far as the level variables are concerned; it is instead possible to fully reject the null as far as the first differences are concerned. Therefore, it is possible to infer that the level variables of our dataset are I(1) processes.

The information prefers the choice ADF for ΔM , *R* and ΔR whilst DF is favoured for the other variables.

Step 2: long run relationship and first tests of cointegration

The results of the OLS regression are shown below:

$$M = -3.2239 + 1.1480(Y) + 0.013439(R) \quad (1^*)$$

$$R^2 = 0.84485$$

$$DW = 1.7580$$

A few points have to be stressed: first of all, the t-ratios arising from this model cannot be considered valid in order to perform inference because, being independent variables $\sim I(1)$, asymptotic properties of large samples do not hold (the variance of the independent variables does not converge to a finite value).

The sign on the coefficient of *R* is not negative, as we should expect according to economic theory: this specific result confirms the first evidence shown in the graph at

the beginning of this work (where we found out a positive relationship between money balances and the rate of interest). Probably this is due to particular characteristics of Jamaican Government Bond, whose value through the period was highly unstable (starting from 7,33% in 1962 and ending with 26,85% in 1997). An economic interpretation of the data should take into consideration this aspect.

If we perform a DF test on the residuals, the t-statistic is -5.1489. The 95% critical value for the test is -4.0001. We are then inclined to reject the null hypothesis of unit root in the residuals at 5% significance level and to infer about cointegration between the variables. We refer for this test to the AIC value of 24.4257, which is greater than its value for the ADF (23.4257). It is important to notice that the ADF result for the residuals provides a t-statistic of -3.7669, with which we wouldn't be able to reject the null. The choice of the AIC criteria, in this case, turns out to be decisive.

If we perform the Cointegrating Regression Durbin–Watson (CRDW) Test as Gujarati (2004) suggests, by confronting the d value obtained by the long run regression with the critical values (0.511, 0.386 and 0.311 for 1%, 5% and 10% levels of significance respectively), we get that $1.75 > 0.51$ and confirm the hypothesis of cointegration.

Step 3: ARDL(1,1) model

The regression line arising from model (2) is:

$$M = -2.4417 + 0.10743(Y) + 0.75984(Y)_{-1} - 0.0032977(R) + 0.012767(R)_{-1} + 0.25272(M)_{-1} \quad (2^*)$$

$$R^2 = 0.88823$$

The coefficients of Y and R represent short run elasticities (semi for R). Also in this case, because of non stationarity in the independent variable, inference based on the standard errors is not valid. The results of this model can be rearranged in order to derive long run elasticities:

$$(0.10743 + 0.75984)/(1 - 0.25272) = 1.160569 \text{ for } Y$$

$$(-0.0032977 + 0.012767)/(1 - 0.25272) = 0.012672 \text{ for } R$$

The reliability of these estimates, partially derived by the previous analytical step, is further investigated in the next two steps.

Step 4: Engle and Granger procedure

The empirical results of model (4) are the following:

$$\Delta M = 0.026575 + 0.10659\Delta Y - 0.0030762\Delta R - 0.74684(residuals)_{-1} \text{ (4*)}$$

$$R^2 = 0.45201$$

Table 2
Diagnostic tests, model (4*)

Diagnostic Tests	Statistic	Value	[Prob]
Serial Correlation	CHSQ(1)	0.28071	[0.596]
Functional Form	CHSQ(1)	0.56657	[0.452]
Normality	CHSQ(2)	1.8777	[0.391]
Heteroscedasticity	CHSQ(1)	1.0899	[0.296]

Being, in this case, independent variables stationary, inference based on the standard error should be valid. The model passes all the diagnostic tests and all the coefficients (included the error correction mechanism) have the expected signs. The coefficients on ΔY and ΔR represent short run elasticities (semi for R): it is really important to stress how both of them are clearly not significant, as if in the short run the influence of the variables on money balances was not relevant. The coefficient on $(residuals)_{-1}$ can be interpreted as the yearly speed of adjustment respect to short run disequilibria: we can read the data as if the 75% of any disequilibrium inherited from the last period is eliminated in the next period.

The restricted ECM provides a framework for further testing the presence of cointegration.

The critical values used in this test are derived beyond McKinnon following the equation below:

$$CV(T) = \beta_{\infty} + \beta_1 T^{-1} + \beta_2 T^{-2}$$

$$-4.11 + 1/34 * (-12.024) + 1/34^2 * (-13.13) = -4.47$$

A t-test on the error correction mechanism is performed giving a value of -4.99 . Being the non standard critical values -4.47 at 95% (sample size = 34, $k=3$) we reject the null hypothesis of no cointegration.

Step 5: unrestricted ECM

The regression line arising from model (5) is:

$$\Delta M = -2.4417 + 0.10743(\Delta Y) - 0.0032977(\Delta R) + 0.8677727(Y)_{-1} + 0.0094692(R)_{-1} - 0.74728(M)_{-1} \quad (5^*)$$

$$R^2 = 0.45282$$

Table IV.III
Diagnostic tests for model (5*)

Diagnostic Tests	Statistic	Value	[Prob]
Serial Correlation	CHSQ(1)	0.30776	[0.579]
Functional Form	CHSQ(1)	0.63028	[0.427]
Normality	CHSQ(2)	1.9623	[0.375]
Heteroscedasticity	CHSQ(1)	0.98312	[0.321]

Also in this case the model passes all the diagnostics. As before, the coefficients on ΔY and ΔR represent short run elasticities (semi for R) and they appear to be identical to those derived in the third step: as a matter of fact, the unrestricted ECM is nothing more than a re-parameterisation of the standard ARDL. Both the lagged values of Y and R are significant at the 1% level, Y with the expected positive correlation while R has a positive sign (but the magnitude of the coefficient is really not relevant).

Inference about cointegration requires this time testing for the joint significance of the lagged variable of the model (jointly determining the error correction mechanism) and this can be performed through a variable deletion test. The F-test gives a value of 7.6934. Under the null hypothesis (no cointegration) the non standard critical values ($k = 2$) are ($F_L = 3.793$ $F_U = 4.885$) at 95% and ($F_L = 3.182$ $F_U = 4.126$) at 90% significance level.

As expected, we are able to reject the null and confirm our results about the presence of cointegration between the variables.

Summary

In the following table the empirical findings as for elasticities are summed up.

Table

Short run and long elasticities

	Y		R (semi-elasticity)	
	Short Run	Long Run	Short Run	Long Run
Long Run OLS		1.1480		0.013439
ARDL(1,1)	0.10743	1.160569	-0.0032977	0.012672
Restricted ECM	0.10659		-0.0030762	
Unrestricted ECM	0.10743	1.160569	-0.0032977	0.012672

The results are very close to each other and, in some cases, identical: a 10% increase in Y entails a short run increase of M by 1% and a long run increase by 11,6%. The same increase in the rate of interest is almost irrelevant both in the short and in the long run. With regards to the reliability of these estimates, we got consistent results through cointegration testing procedures.

According to our findings, evidence about the existence of a cointegrating relationship among money balances, income and government bond yield is really strong.

Obviously, further investigation should be helpful but we are partially comforted by the findings of previous literature (see for example Garthey, 1998).

5- POLICY IMPLICATIONS AND CONCLUSIONS

The elasticity values emerging from the presented econometric exercise directly involve a strong and clear support for the presence of cointegration between the variables.

The irrelevance of R in affecting changes in M is probably due to the particularity of Jamaican context: we already pointed out the great instability and variability of government bond yield throughout the dataset period.

While the relationship in the long run seems to be confirmed by the data, in the short run the correlation between money balances and income appears less significant: this is probably connected with the specificity of the context and the instability generated by the two financial crisis which should have an impact in affecting the effectiveness of monetary policy.

Another important element can be the role of IMF in tightening hands of Jamaican government.

A final test was conducted in MICROFIT in order to test the goodness of our specification: the predictive failure test.

Basically, we dropped two observations out of the sample (1996 and 1997) in order to forecast the predicted values of money balances for these years with the actual ones.

The results are shown in the following table:

```

Single Equation Static Forecasts
*****
*****
Based on OLS regression of DM on:
DY          DR          Y(-1)          R(-1)          M(-1)
CONST
33 observations used for estimation from 1963 to 1995
*****
*****
Observation      Actual      Prediction      Error      S.D.
of Error
1996             -.010038      .0082886       -.018327
.020264
1997             -.013668      .013960        -.027628
.020288
*****
*****

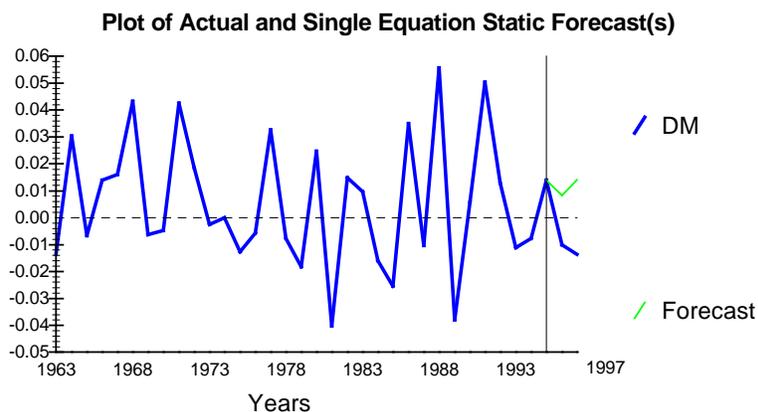
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Summary statistics for single equation static forecasts
*****
*****
Based on 2 observations from 1996 to 1997
Mean Prediction Errors      -.022977      Mean Sum Abs Pred Errors
.022977
Sum Squares Pred Errors     .5496E-3      Root Mean Sumsq Pred Errors
.023443
Predictive failure test     F( 2, 27)= 1.1970[.318]
*****
*****

```

Since it is a log form equation, it is possible to interpret the Error term as direct percentage errors. The predictions are quite good (difference of 1 and 2%).



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