ECONOMICS BULLETIN

Empirical Analysis of the Money Demand Function in Sub-Saharan Africa

Shigeyuki Hamori
Kobe University

Abstract

This paper empirically analyzed the money demand function in the Sub-Saharan African region using a nonstationary panel data analysis. We conducted the analysis on 35 countries based on annual data from 1980 to 2005. The empirical results revealed that there exists a cointegrating relationship of the money demand function in the Sub-Saharan African region. In other words, there is a close relationship between the money supply and the real economy over the long term, and monitoring money supply promises to play an important role in stabilizing the level of prices in this region.

This research is partly supported by the Grant-in-Aid of the Japan Society for the Promotion of Science (21st Century COE program).
Citation: Hamori, Shigeyuki, (2008) "Empirical Analysis of the Money Demand Function in Sub-Saharan Africa." *Economics Bulletin*, Vol. 15, No. 4 pp. 1-15
Submitted: January 30, 2008. **Accepted:** March 6, 2008.
URL: http://economicsbulletin.vanderbilt.edu/2008/volume15/EB-08O10003A.pdf

1. Introduction

The purpose of this paper is to conduct an empirical analysis on the stability of the money demand function in the region of Sub-Saharan Africa. Considering the economic progress of developing nations, economic growth and inflation are important indices that should be monitored through policy. Even if rapid economic growth can be achieved, it is still possible that the lives of the people will lack stability in the event that strong inflation occurs at the same time. Accordingly, the governments of developing nations need to give due consideration to achieving rapid growth and low inflation by appropriately adjusting the fiscal and monetary policies.

In the Sub-Saharan African region, inflation reached a high annual average of 9.46% over the period from 1980 to 2005, when calculated based on the GDP deflator. The trend in the inflation rate is graphically illustrated in Figure 1. Monetary policy is arguably effective as a means of controlling inflation. If the money demand function is stable over the long run, money supply changes are closely related to prices and income, and it is possible for policy authorities to control inflation appropriately through adjustments made to the money supply. If, on the other hand, the money demand function is unstable over the long run, changes in the money supply are not closely related to prices and income, and it is not possible for policy authorities to appropriately control inflation through adjusting the money supply. Thus, the fundamental issue is to examine whether there exists the equilibrium relation of money demand. The concept of cointegration has been widely used to test this relation. Suppose variables that consist of money demand relation, such as real money balances, real income, and interest rates, are nonstationary variables with a unit root. When a linear combination of these nonstationary variables is stationary, then any deviation from the relation is temporary and the relation holds in the long run. If such a linear combination exists, the variables are said to be cointegrated (Engle and Granger, 1987). Hence, the issue of cointegration in the money demand function has attracted the attention of many researchers, especially in developed countries (Hafer and Jansen, 1991; Miller, 1991; Friedman and Kuttner, 1992; Hansen and Kim, 1995; Wesche, 1997; Spencer, 1997; Fase and Winder, 1998; Fagen and Henry, 1998; Hayo, 1999; Coenen and Vega, 2001). However, the body of literature on the stability of the money demand function in the Sub-Saharan African region has in fact been limited; the exceptions include Nachega (2001), Rother (1999), and Jenkins (1999).

The contribution of this paper is twofold. This is the first attempt to empirically analyze the money demand function in the Sub-Saharan African region as a whole. To our knowledge, there has been no comprehensive research on the money demand function of Sub-Saharan Africa, suggesting that it is meaningful to conduct an analysis of this region. Second, we employ a nonstationary panel data analysis as a method to analyze the issue of the money demand function. The empirical research on the money demand function using the unit root and cointegration techniques is widely known to be problematic when the sample size is small. Indeed, this is applies to the Sub-Saharan African region since only annual data is available in many cases. However, we overcome this problem through the application of a nonstationary panel data analysis, which has recently undergone remarkable advances.

Our empirical results confirmed the cointegrating relationship of money demand in the Sub-Saharan African region. In other words, there is a close relationship between money supply and the real economy over the long run, and the control of money supply by the authorities (central banks) promises to play an important role in stabilizing the price levels in this region.

2. Model

There are various theories on the money demand function. For example, Kimbrough (1986a, 1986b) and Faig (1988) put forth the following money demand function by explicitly considering transaction costs.

(1) $$\frac{M_t}{P_t} = L(Y_t, R_t) \qquad L_Y > 0, \; L_R < 0$$

In this formula, M_t represents nominal money supply for period t; P_t represents the price index for period t; Y_t represents the output for period t; and R_t represents the nominal interest rate for period t. Increases in output yield increases in money demand, and increases in interest rates lead to decreases in money demand.

We use two models corresponding to formula (1) in order to conduct an empirical analysis.

(2) Model 1: $\ln(M_t) - \ln(P_t) = \beta_0 + \beta_1 \ln(Y_t) + \beta_2 R_t + u_t, \quad \beta_1 > 0, \beta_2 < 0$

(3) Model 2: $\ln(M_t) - \ln(P_t) = \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(R_t) + u_t, \quad \beta_1 > 0, \beta_2 < 0$

Model (2) uses the interest rate levels, and model (3) uses the logarithm value of the interest rates.

3. Data

We used annual data over the sample period from 1980 to 2006. The analysis covered the following 35 nations belonging to the Sub-Saharan African region:

Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Congo, Rep., Cote d'Ivoire, Equatorial Guinea, Ethiopia, Gabon, Gambia, Ghana, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Niger, Nigeria, Rwanda, Senegal, Seychelles, Sierra Leone, South Africa, Swaziland, Togo, Uganda, Zambia, Zimbabwe.

The data used are as follows: $lrm1$ = logarithm value for real money balances (M1); $lrm2$ = logarithm value for real money balances (M2); ly = logarithm value for real GDP; r = interest rate; lr = logarithm value for interest rates. The data were obtained from the World Development Indicators published by the World Bank.

Tables 1 and 2 present the results of the panel unit root test on each variable—$lrm1$, $lrm2$, ly, r, and lr. Further, Table 1 indicates the results of the unit root test on the level of each variable and Table 2 indicates those on the first difference of each variable.

Four types of tests were used: the Levin, Lin, and Chu t-test; the Im, Pesaran, and Shin W-test; the ADF–Fisher chi-square test; and the ADF–Choi Z-test (Levin, Lin and Chu, 2002; Im, Pesaran and Shin, 2003; Choi, 2001; Maddala and Wu, 1999). For each test, the exogenous variables were subject to two types of specification—with the first including individual effects and individual linear trends and the second including only individual effects. As shown in Tables 1 and 2, each variable has one unit root in almost all the cases. These results are robust to the test method and the exogenous variable specification.

4. Empirical Results

4.1 Money Demand Function for M1

First, we analyzed the money demand function in relation to the use of M1. For this analysis, we conducted panel cointegration tests for the money demand function of the 35 countries. Three types of panel cointegration tests were conducted. The first was the residual-based panel cointegration test developed by Pedroni (1999, 2004). He proposes several tests for cointegration that allow for heterogeneous slopes coefficients across cross-sections. This consists of seven component tests: the panel v-test, panel rho-test, panel PP-test, panel ADF test, group rho-test, group PP-test, and group ADF test. In the null hypothesis, the residuals are nonstationary (i.e., there is no cointegrating relationship). In the alternative hypothesis, the residuals are stationary (i.e., there is a cointegrating relationship among the variables). However, for the first four tests, it is assumed that the residuals of the alternative hypothesis have common AR coefficients; however, for the remaining three tests, it is assumed that the residuals of the alternative hypothesis have individual AR coefficients.

The second text conducted is the residual-based panel cointegration test developed by Kao (1999). The Kao test follows the same approach as the Pedroni tests, but it specifies cross-section specific intercepts and homogeneous coefficients on the first-stage regressors. In the null hypothesis, the residuals are nonstationary (i.e., there is no cointegration). In the alternative hypothesis, the residuals are stationary (i.e., there is a cointegrating relationship among the variables).

The third test is the Johansen-type panel cointegration test developed by Maddala and Wu (1999). They use Fisher’s result to propose an alternative approach to test for cointegration in panel data by combining tests from individual cross-sections to obtain a test statistic for the full panel. There are two kinds of Johansen-type tests: the Fisher test from the trace test and the Fisher test from the maximum eigenvalue test. In the Johansen-type panel cointegration test, we chose the lag order to be one.

Table 3 shows the results of the cointegration tests for Model 1. As is evident from Table 3, the null hypothesis (in which there is no cointegrating relationship) is rejected in eight of the ten cases at the 5% significance level.

Table 4 indicates the results of the cointegration tests for Model 2. In this case as well, it is evident that the existence of a cointegrating relationship is supported in eight of the ten cases at the 5% significance level.

As the existence of the cointegrating relationship was supported, we estimated the money demand function using the fully modified ordinary least squares (FMOLS) method developed by Pedroni (2001). Table 5 shows the estimation results for Models 1 and 2. As is evident from this table, the sign condition of the money demand function holds for the

Sub-Saharan African region. The output coefficient was estimated to be significant at the positive values of 0.86 and 0.89 for Models 1 and 2, respectively, while the interest rate coefficient was estimated to be significant at the negative values of –0.02 and –0.38 for Models 1 and 2, respectively.

From the above results, it is evident that when panel data for the Sub-Saharan African region is used, a cointegrating relationship was supported and that the existence of a money demand function with respect to M1 was statistically supported.

4.2 Money Demand Function for M2

Next, we considered the money demand function when using M2 as the money supply component. Table 6 indicates the results of cointegration tests for Model 1. As evident from Table 6, the null hypothesis (in which there is no cointegrating relationship) is rejected in eight of the ten cases at the 5% significance level. Table 7 indicates the results of the cointegration tests for Model 2. In this case as well, it is similarly evident that the existence of a cointegrating relationship was supported.

As the existence of a cointegrating relationship was supported, we estimated the money demand function using FMOLS. Table 8 presents the estimation results with respect to Models 1 and 2. As is evident from this table, the sign condition of the money demand function holds for all the cases. The output coefficient was estimated to be significant at the positive values of 1.00 and 1.02 for Models 1 and 2, respectively, whereas the interest rate coefficient was estimated to be significant at the negative values of –0.01 and –0.28 for Models 1 and 2, respectively.

From the above results, it is clear that when panel data for the Sub-Saharan African region is used, a cointegrating relationship was supported and that the existence of a money demand function with respect to M2 was statistically supported as well.

5. Concluding Remarks

In developing countries, maintaining prices at a stable level—together with promoting economic growth—is an important policy issue. The price issue is closely related to the stability of the money demand function. If an equilibrium relation exists in the money demand function, it is possible to maintain inflation at an appropriate level through the appropriate control of the money supply.

This paper empirically analyzed the money demand function using the recently advanced method of panel unit root and panel cointegration. A nonstationary panel data analysis is an appropriate method of analysis in regions, such as Sub-Saharan Africa, where it is difficult to collect a sufficiently a large sample size. The empirical results revealed that there exists a cointegration relation with respect to money demand in the Sub-Saharan African region over the period from 1980 and 2006, regardless of whether M1 or M2 is used as the money supply measure. Accordingly, the evidence has some important policy implications. Money supply (M1 or M2) is a reliable policy variable from the intermediate-target perspective. Due to the existence of a stationary relationship between money supply, output, and price level, in attempting to control the price level (or output), the reliability of money supply as a target variable holds. This region exhibits an annual inflation of nearly 10%, but it may be possible to overcome this level of inflation in the long run provided central banks implement policies appropriately.

References

Choi, I. (2001). Unit root tests for panel data. *Journal of International Money and Finance*, *20*, 249–272.

Coenen, G., & Vega, J. L. (2001). The demand for M3 in the Euro area. *Journal of Applied Econometrics*, *16*, 727–748.

Engle, R. F., & Granger, C. W. J. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica*, *55*, 251–276.

Fagen, G., & Henry, H. (1998). Long run money demand in the EU: Evidence for area-wide aggregates. *Empirical Economics*, *23*, 483–506.

Faig, M. (1988). Characterization of the optimal tax on money when it functions as a medium of exchange. *Journal of Monetary Economics*, *22*, 137–148.

Fase, M. M. G., & Winder, C. C. A. (1998). Wealth and the demand for money in the European Union. *Empirical Economics*, *23*, 507–524.

Friedman, B. M., & Kuttner, K. N. (1992). Money, income, prices, and interest rates. *American Economic Review, 82*, 472–92.

Hafer, R. W., & Jansen, D. W. (1991) The demand for money in the United States: Evidence from cointegration tests. *Journal of Money, Credit and Banking, 23*, 155–68.

Hansen, G., & Kim, J. R. (1995). The stability of German money demand: Tests of the cointegration relation. *Weltwirtschaftliches Archiv*, *131*, 286–301.

Hayo, B. (1999). Estimating a European demand for money. *Scottish Journal of Political Economy*, *46*, 221–244.

Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics, 115*, 53–74.

Jenkins C. (1999). Money demand and stabilization in Zimbabwe. *Journal of African Economies*, *8*, 386–421.

Johansen, S. (1988). Statistical analysis of cointegrating vectors. *Journal of Economic Dynamics and Control*, *12*, 213–54.

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration – with application to the demand for money. *Oxford Bulletin of Economics and Statistics*, *52*, 169–210.

Kao, C. (1999). Spurious regression and residual-based tests for cointegration in panel data. *Journal of Econometrics*, *90*, 1–44.

Kimbrough, K. P. (1986a). Inflation, employment, and welfare in the presence of transaction costs. *Journal of Money, Credit, and Banking*, *18*, 127–40.

Kimbrough, K. P. (1986b). The optimum quantity of money rule in the theory of public finance. *Journal of Monetary Economics*, *18*, 277–284.

Levin, A., Lin, C. F., & Chu, C. S. J. (2002). Unit root tests in panel data: Asymptotic and finite-sample properties. *Journal of Econometrics*, *108*, 1–24.

Maddala, G. S., & Wu, S. (1999). A comparative study of unit root tests with panel data and a new simple test. *Oxford Bulletin of Economics and Statistics*, *61*, 631–52.

Miller, S. M. (1991). Monetary dynamics: An application of cointegration and error

correction modeling. *Journal of Money, Credit and Banking*, *23*, 139–154.
Nachega, J. (2001). Financial liberalization, money demand, and inflation in Uganda, IMF Working Paper 01/118.
Pedroni, P. (1999). Critical values for cointegration tests in heterogeneous panels with multiple regressors. *Oxford Bulletin of Economics and Statistics*, *61*, 653–70.
Pedroni, P. (2001). Purchasing power parity tests in cointegrated panels, *Review of Economics and Statistics*, *83*, 727–731.
Pedroni, P. (2004). Panel cointegration: Asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis. *Econometric Theory*, *20*, 597–625.
Rother P. C. (1999). Money demand in the west African economic and monetary union – the problems of aggregation. *Journal of African Economies*, *8*, 422–447.
Spencer, P. (1997). Monetary Integration and currency substitution in the EMS: The case for a European monetary aggregate. *European Economic Review*, *41*, 1403–1419.
Wesche K. (1997). The stability of European money demand: An investigation of M3H. *Open Economies Review*, *8*, 371–391.

Table 1 Panel Unit Root Tests: Level

		Exogenous variables: F and Tr		Exogenous variables: F	
$lrm1$	Levin, Lin, and Chu *t*-test	–0.381	(0.352)	1.516	(0.935)
	Im, Pesaran, and Shin *W*-test	–0.391	(0.348)	3.276	(1.000)
	ADF–Fisher chi-square test	79.309	(0.209)	49.991	(0.966)
	ADF–Choi *Z*-test	–0.253	(0.400)	3.319	(1.000)
$lrm2$	Levin, Lin, and Chu *t*-test	1.375	(0.915)	0.139	(0.555)
	Im, Pesaran, and Shin *W*-test	0.378	(0.647)	3.174	(0.999)
	ADF–Fisher chi-square test	77.834	(0.244)	58.258	(0.841)
	ADF–Choi *Z*-test	0.661	(0.746)	3.063	(0.999)
ly	Levin, Lin, and Chu *t*-test	–0.832	(0.203)	–1.072	(0.142)
	Im, Pesaran, and Shin *W*-test	–0.432	(0.333)	8.403	(1.000)
	ADF–Fisher chi-square test	94.938	(0.025)	40.934	(0.998)
	ADF–Choi *Z*-test	0.044	(0.518)	8.530	(1.000)
r	Levin, Lin, and Chu *t*-test	3.757	(1.000)	1.161	(0.877)
	Im, Pesaran, and Shin *W*-test	0.817	(0.793)	0.424	(0.664)
	ADF–Fisher chi-square test	65.007	(0.646)	62.763	(0.718)
	ADF–Choi *Z*-test	1.237	(0.892)	0.526	(0.701)
lr	Levin, Lin, and Chu *t*-test	2.910	(0.998)	0.337	(0.632)
	Im, Pesaran, and Shin *W*-test	0.534	(0.703)	0.239	(0.595)
	ADF– Fisher chi-square test	67.096	(0.576)	59.638	(0.807)
	ADF–Choi *Z*-test	0.957	(0.831)	0.437	(0.669)

Note:
F and Tr denote the individual effects and individual linear trend, respectively.
Numbers in parentheses are *p*-values.
The *P*-values for the Fisher tests are computed using an asymptotic chi-square distribution. All the other tests assume asymptotic normality.

Table 2 Panel Unit Root Tests: First Difference

		Exogenous variables: F and Tr		Exogenous variables: F	
$\Delta lrm1$	Levin, Lin, and Chu *t*-test	–19.283	(0.000)	–23.233	(0.000)
	Im, Pesaran, and Shin *W*-test	–19.665	(0.000)	–22.717	(0.000)
	ADF–Fisher chi-square test	418.791	(0.000)	527.578	(0.000)
	ADF–Choi *Z*-test	–16.321	(0.000)	–19.138	(0.000)
$\Delta lrm2$	Levin, Lin, and Chu *t*-test	–19.255	(0.000)	–20.992	(0.000)
	Im, Pesaran, and Shin *W*-test	–18.842	(0.000)	–21.646	(0.000)
	ADF–Fisher chi-square test	403.391	(0.000)	501.226	(0.000)
	ADF–Choi *Z*-test	–15.409	(0.000)	–18.287	(0.000)
Δly	Levin, Lin, and Chu *t*-test	–16.836	(0.000)	–16.188	(0.000)
	Im, Pesaran, and Shin *W*-test	–16.957	(0.000)	–16.741	(0.000)
	ADF–Fisher chi-square test	367.707	(0.000)	388.747	(0.000)
	ADF–Choi *Z*-test	–14.062	(0.000)	–14.632	(0.000)
Δr	Levin, Lin, and Chu *t*-test	–8.088	(0.000)	–13.832	(0.000)
	Im, Pesaran, and Shin *W*-test	–12.890	(0.000)	–14.824	(0.000)
	ADF–Fisher chi-square test	378.392	(0.000)	443.980	(0.000)
	ADF–Choi *Z*-test	–13.244	(0.000)	–15.017	(0.000)
Δlr	Levin, Lin, and Chu *t*-test	–9.308	(0.000)	–15.359	(0.000)
	Im, Pesaran, and Shin *W*-test	–11.784	(0.000)	–15.360	(0.000)
	ADF–Fisher chi-square test	335.105	(0.000)	432.104	(0.000)
	ADF–Choi *Z*-test	–11.989	(0.000)	–15.153	(0.000)

Note:
F and Tr denote the individual effects and individual linear trend, respectively.
Numbers in parentheses are *p*-values.
The *P*-values for the Fisher tests are computed using an asymptotic chi-square distribution. All the other tests assume asymptotic normality.

Table 3 Panel Cointegration Tests: (Model 1 for M1)

Model 1: $lrm1 = \beta_0 + \beta_1 \ln y + \beta_2 r$	Test Statistic	*p*-value
(a) Pedroni Residual Cointegration Tests		
Panel v-stat	–0.563	(0.341)
Panel rho-stat	0.699	(0.313)
Panel PP-stat	–4.534	(0.000)
Panel ADF stat	–5.050	(0.000)
Group rho-stat	3.622	(0.001)
Group PP-stat	–3.047	(0.004)
Group ADF stat	–4.144	(0.000)
(b) Kao Residual Cointegration Tests		
	–9.352	(0.000)
(c) Johansen Fisher Panel Cointegration Test		
Fisher Statistic from the trace test	145.100	(0.000)
Fisher Statistic from the maximum eigenvalue test	139.500	(0.000)

Table 4 Panel Cointegration Tests: (Model 2 for M1)

Model 2: $lrm1 = \beta_0 + \beta_1 \ln y + \beta_2 \ln r$	Test Statistic	*p*-value
(a) Pedroni Residual Cointegration Tests		
Panel v-stat	–0.345	(0.376)
Panel rho-stat	0.872	(0.273)
Panel PP-stat	–4.277	(0.000)
Panel ADF stat	–4.961	(0.000)
Group rho-stat	3.623	(0.001)
Group PP-stat	–2.983	(0.005)
Group ADF stat	–4.056	(0.000)
(b) Kao Residual Cointegration Tests		
	–3.677	(0.000)
(c) Johansen Fisher Panel Cointegration Test		
Fisher Statistic from the trace test	142.700	(0.000)
Fisher Statistic from the maximum eigenvalue test	136.500	(0.000)

Table 5 Panel FMOLS Results: M1

	Explained Variable	Explanatory Variables	
Model 1	$lrm1$	ly	r
		0.86	–0.02
		(32.79)	(–6.63)
Model 2	$lrm1$	ly	lr
		0.89	–0.38
		(32.95)	(7.02)

Note:
Numbers in parentheses are *t*-statistics.

Table 6 Panel Cointegration Tests: (Model 1 for M2)

Model 1: $lrm2 = \beta_0 + \beta_1 \ln y + \beta_2 r$	Test Statistic	*p*-value
(a) Pedroni Residual Cointegration Tests		
Panel v-stat	0.685	(0.315)
Panel rho-stat	0.862	(0.275)
Panel PP-stat	–4.211	(0.000)
Panel ADF stat	–4.756	(0.000)
Group rho-stat	3.671	(0.001)
Group PP-stat	–2.786	(0.008)
Group ADF stat	–4.291	(0.000)
(b) Kao Residual Cointegration Tests		
	–9.971	(0.000)
(c) Johansen Fisher Panel Cointegration Test		
Fisher Statistic from the trace test	148.500	(0.000)
Fisher Statistic from the maximum eigenvalue test	137.600	(0.000)

Table 7 Panel Cointegration Tests: (Model 2 for M2)

Model 2: $lrm2 = \beta_0 + \beta_1 \ln y + \beta_2 \ln r$	Test Statistic	*p*-value
(a) Pedroni Residual Cointegration Tests		
Panel v-stat	0.706	(0.311)
Panel rho-stat	0.886	(0.269)
Panel PP-stat	–4.215	(0.000)
Panel ADF stat	–4.614	(0.000)
Group rho-stat	3.597	(0.001)
Group PP-stat	–2.911	(0.006)
Group ADF stat	–3.754	(0.000)
(b) Kao Residual Cointegration Tests		
	–3.817	(0.000)
(c) Johansen Fisher Panel Cointegration Test		
Fisher Statistic from the trace test	147.400	(0.000)
Fisher Statistic from the maximum eigenvalue test	135.700	(0.000)

Table 8 Panel FMOLS Results: M2

	Explained Variable	Explanatory Variables	
Model 1	$lrm2$	ly	r
		1.00	–0.01
		(40.37)	(–2.76)
Model 2	$lrm2$	ly	lr
		1.02	–0.28
		(40.82)	(–3.13)

Note:
Numbers in parentheses are *t*-statistics.

Figure 1 Inflation in Sub-Saharan Africa