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MONEY DEMAND IN A HIGH INFLATION ECONOMY: THE CASE OF ISRAEL

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Abstract—Money demand plays a central role in recent models of rapid inflation and stabilization which are highly relevant to the Israeli economy. This paper uses co-integration analysis to estimate money demand in Israel. We find that money demand shifted at the beginning of the 1980s, probably as a result of increased use of liquid indexed assets which provide protection against high inflation. In the previous two decades the equation was a fairly conventional "U.S.-type" logarithmic function. In the last decade the equation has had a lower constant and has exhibited less sensitivity to interest rate changes. In both periods the nominal rate of interest and real private consumption have been co-integrated with real M1 balances, and interest elasticity has been less than unity.

I. Introduction

The inflationary experience of Israel in the last decade has evoked a considerable amount of interest. Israel underwent a high inflation phase in the period 1978–1985, with CPI inflation running as high as 100% to 440% in annual terms. In July 1985 a stabilization policy was implemented which succeeded in bringing inflation down to around 20% annually. This experience led to the formulation of several theoretical models which try to explain either the high-inflation period or its stabilization or both. These models are also applicable to other small open economies such as the Latin American ones.

A central issue which is addressed by these models is whether or not the inflationary experience can be explained by the inflation tax. In this context money demand plays a crucial role. One approach, usually associated with Liviatan and Piterman (1986), claims that one cannot use the inflation tax argument in the Israeli context as empirical evidence shows that the elasticity of money demand with respect to inflation was higher than unity. A different approach, suggested by Bruno and Fischer (1990), claims that the inflation tax model is relevant but that it may imply two equilibria.

The money demand function has been frequently estimated in Israel. However, a summary of the results is quite inconclusive with respect to all parameters of interest and in particular the inflation elasticity. Moreover, it is plagued by the "missing money" and "shift points" phenomena, which have been extensively discussed in the literature on U.S. money demand (see in particular Goldfeld (1976)).

The purpose of this paper is to re-estimate this function for the Israeli economy in order to shed new light on both the theoretical debate and the empirical confusion. We do so employing the econometric method of cointegration. By using the largest possible data sample and cointegration analysis we hope to overcome some of the inherent weak points of the existing empirical literature.

The paper proceeds as follows: Section II briefly outlines some stylized facts and expounds the theoreti-

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cal hypotheses to be tested. Section III discusses the econometric methodology and the data. Section IV presents the empirical evidence on the co-integrating equations. Section V concludes with an interpretation of the evidence. The data are described in the appendix.

II. Stylized Facts and Hypotheses

In this section we present the main stylized facts concerning the behaviour of real money balances in Israel. We then briefly discuss theoretical explanations which form the basis of the hypotheses to be tested.

A. Stylized Facts

Figure 1 plots the monthly time series of real balances (M1 deflated by CPI) for the period 1965 : 01–1989 : 12.

Real balances exhibit a clear upward trend until 1973, a downward trend until 1985 and another upward trend since mid-1985. Also conspicuous is a particularly large decline in 1979.

B. Hypotheses

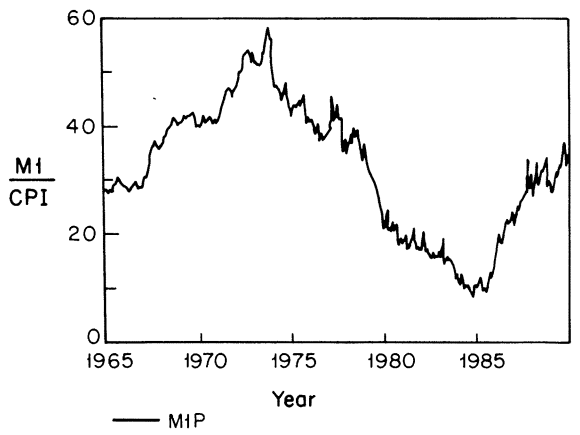
The time series of real balances as portrayed in figure 1 may be linked to several notable economic events by the following three hypotheses:

(i) The upward trend until 1973 may be explained by real income growth.

(ii) The decline since 1973, in particular that of the late 1970s, may be explained by increasing inflation, while the rise since the July 1985 stabilization plan may be explained by the decline in inflation.

(iii) The introduction of liquid indexed assets (in 1977 and 1982) may have caused a shift in the money demand function. This hypothesis was often mentioned in papers on the Israeli inflationary process, mainly with respect to the dollar-linked PATAM accounts.

FIGURE 1.—REAL M1 BALANCES



The first two hypotheses may be tested by estimating standard money demand equations, such as the Goldfeld (1973) log-log equation or the Cagan (1956) semi-log equation.

The third hypothesis should be viewed in the wider context of theoretical explanations of the inflation process. The central explanation for high inflation dynamics is the inflation-tax model. This model was used by Cagan (1956) to study European hyperinflation episodes in the 1920s and 1940s and by many authors to study the modern episodes in Latin America and Israel in the last two decades. Concerning this model there are two main views:

a. Looking at the space of inflation and real balances one can draw the money demand and the government budget deficit curves; their intersection yields the equilibrium rate of inflation. Bruno and Fischer (1990) have drawn special attention to the case whereby the demand function is of the semi-log type and there are two inflationary equilibria for a given deficit. The stability of these equilibria depends on an expectations-adjustment parameter and on the semi-elasticity of the demand function with respect to inflation. Note however that for a log-log function the equilibrium, if it exists, would be unique. If there occurred a shift in money demand then the equilibrium rate of inflation shifts as well.

b. A competing view claimed that introduction of substitute assets, for example liquid indexed assets, made money demand highly elastic with respect to inflation and that therefore the inflation tax model is not appropriate (Liviatan and Piterman (1986)). However a shift in the demand function may accommodate the increased use of indexed assets while interest elasticity remains smaller than unity.

By estimating the demand function we should therefore be able to answer the following questions:

(1) Is the interest (or inflation) elasticity of money demand bigger or smaller than unity? If the former is true then as approach *b* claims the inflation tax model is not very convincing.

(2) Which specification is more appropriate: a log-log one or a semi-log one? The former rules out multiple equilibria. If the latter obtains then the estimate of the semi-elasticity parameter is important for stability analysis.

(3) Was there a shift in the demand curve? The answer to this question may affect the responses to (1) and (2).

III. Econometric Methodology and the Data

The econometric methodology used in this paper is the co-integration method. In an important paper

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TABLE 1.—UNIT ROOT TESTS: DICKEY-FULLER & AUGMENTED DICKEY-FULLER TESTS

Variable	Test 1			Test 2			Test 3				
	$l = 0$	$l = 4$	$l = 13$	$l = 0$	$l = 4$	$l = 13$	$l = 0$	$l = 4$	$l = 13$	Period	n
log of real ml	−1.03	−0.98	−2.15	−1.00	−0.95	−1.83	0.05	0.05	−0.05	1965:01–1989:12	300
Δlog of real ml	−18.39[a]	−7.54[a]	−2.91	−18.42[a]	−7.55[a]	−2.92[a]	−18.45[a]	−7.56[a]	−2.91[a]	1965:01–1989:12	300
log of nominal interest	0.58	−1.24	−1.35	−1.00	−1.47	−1.52	−0.69	−0.53	−0.56	1965:01–1989:12	300
Δlog of nominal interest	−12.03[a]	−5.99[a]	−3.94[a]	−11.94[a]	−5.91[a]	−3.82[a]	−11.95[a]	−5.92[a]	−3.82[a]	1965:01–1989:12	300
inflation	−6.83[a]	−2.40	−2.29	−6.25[a]	−2.34	−2.22	−4.71[a]	−1.68	−1.53	1965:01–1989:12	300
Δinflation	−22.33[a]	−11.59[a]	−4.07[a]	−22.37[a]	−11.59[a]	−4.05[a]	−22.41[a]	−11.61[a]	−4.06[a]	1965:01–1989:12	300
nominal holding period yield	−8.76[a]	−2.93	−1.74	−8.70[a]	−3.04[a]	−1.95	−6.06[a]	−1.92	−1.18	1970:02–1989:12	239
Δnominal holding period yield (CPI-linked)	−23.78[a]	−11.00[a]	−4.52[a]	−23.82[a]	−10.48[a]	−4.42[a]	−23.87[a]	−11.00[a]	−4.43[a]	1970:02–1989:12	239
nominal holding period yield	−8.78[a]	−6.00[a]	−3.44[a]	−8.70[a]	−5.84[a]	−3.18[a]	−8.70[a]	−5.81[a]	−3.15[a]	1972:02–1989:12	215
Δnominal holding period yield (foreign currency-linked)	−16.74[a]	−10.46[a]	−6.49[a]	−16.79[a]	−10.48[a]	−6.51[a]	−16.83	−10.51[a]	−6.53[a]	1972:02–1989:12	215
log of real GDP	−0.57	−1.05	−0.79	−2.01	−1.90	−2.02	4.15	2.86	1.76	1965:01–1986:05	257
Δ log of real GDP (monthly)	−8.75[a]	−8.07[a]	−3.91[a]	−8.71[a]	−7.76[a]	−3.11[a]	−8.36[a]	−6.63[a]	−2.07[a]	1965:01–1986:05	257
log of real consumption	−2.13	−3.25	−2.12	−1.14	−1.15	−1.07	3.47	2.41	2.63	1965:01–1986:05	257
Δlog of real consumption (monthly)	−7.85[a]	−8.16[a]	−4.38[a]	−7.85[a]	−8.13[a]	−4.29[a]	−7.60[a]	−7.38[a]	−2.94[a]	1965:01–1986:05	257
log of real GDP	−2.03	−1.14		−0.91	−1.30		2.52	1.79		65.1–86.2	86
Δ log of real GDP (quarterly)	−12.83[a]	−3.09		−12.80[a]	−2.69		−10.80[a]	−1.51		65.1–86.2	86
log of real consumption	−3.92[a]	−2.09		−1.12	−1.08		1.94	2.73		65.1–86.2	86
Δ log of real consumption (quarterly)	−11.26[a]	−4.88[a]		−11.30[a]	−4.74[a]		−10.66[a]	−3.40[a]		65.1–86.2	86
Critical Values											
$n = 140$ 5%	−3.47	−3.41	−3.36	−2.90	−2.87	−2.82	−1.95	−1.95	−1.95		
$n = 444$	−3.44	−3.42	−3.40	−2.89	−2.88	−2.84	−1.95	−1.95	−1.95		

Source: Schwert (1987, Table 7) for test 1; Schwert (1987, Table 7) for test 2; Fuller (1976, Table 8.5.2 Part I) for test 3.
Notes: (1) Test 1: H_0: $\Delta Y_t = \epsilon_t + \gamma$

$$H_1: \Delta Y_t = -\alpha Y_{t-1} + \sum_{i=1}^{l} \beta_i \Delta Y_{t-i} + \gamma(time) + constant + \epsilon_t$$

Test 2: H_0: $\Delta Y_t = \epsilon_t$

$$H_1: \Delta Y_t = -\alpha Y_{t-1} + \sum_{i=1}^{l} \beta_i \Delta Y_{t-i} + constant + \epsilon_t$$

Test 3: H_0: $\Delta Y_t = \epsilon_t$

$$H_1: \Delta Y_t = -\alpha Y_{t-1} + \sum_{i=1}^{l} \beta_i \Delta Y_{t-i} + \epsilon_t$$

(2) Values reported are t values for the α coefficient.
(3) Critical values from Schwert (1987) pertain to an MA coefficient equal to zero.
[a] Significant at 5%. When significant one rejects H_0, i.e. rejects the unit-root hypothesis.

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Engle and Granger (1987) introduced an estimation and testing methodology which we follow here.

The sample begins in 1965 and ends in August 1989. There are two reasons for the relatively late starting date: the National Accounts series, including GDP and consumption, are available in the quarterly frequency only from 1964 (before that date the data are annual); nominal interest rate data are available only from January 1965. The estimation is done at two frequencies: quarterly and monthly (except in one subperiod where the quarterly frequency yields too few observations). Full definitions of the series are elaborated in the appendix.

IV. The Empirical Results

A. *Unit Root Tests*

Table 1 reports Dickey-Fuller and Augmented Dickey-Fuller tests for the individual time series. Three different tests are used and they are formally described in the table's notes.

We find that all monthly series examined are $I(1)$ except for the holding period yield on foreign-linked bonds (which is stationary). The quarterly series tests yield the same outcome.

B. *Co-Integration Tests*

In this study we estimate log-log and semi-log money demand equations. This is done for several reasons: first and foremost these are the appropriate specifications to answer the theoretical questions posed in Section 2. Second, these are the prevalent specifications in the empirical literature, including the literature on Israeli money demand. Therefore the results of the present study are directly comparable to the "standard" results.

1. *The Functional Form and the Variables*: The money demand equation was estimated in the following forms:

$$\ln m = \text{constant} + \alpha \ln X + \beta \ln Z \qquad (1)$$

$$\ln m = \text{constant} + \alpha \ln X + \beta Z \qquad (2)$$

where

m = real balances (M1)
X = income or scale variable
Z = cost of money variable.

Equation (1) is a logarithmic function of the type estimated by Goldfeld (1973, 1976) while equation (2) is of the semi-log (with respect to the cost of money) form proposed by Cagan (1956).

Two variables were tested as alternatives for the income or scale variable: real GDP and private consumption. Although the former is widely used in the literature, we tested the latter aggregate as well following several recent studies, which argued that this variable reflects the scale of transactions better than GDP and that it yields superior results.

Several alternatives were used as the cost of money variable: the nominal debitory rate of interest (widely known as HAHAD), the rate of inflation, the holding period yields on CPI-linked and foreign-linked bonds, and in sub-periods where data was available, the rate of exchange rate depreciation and the yield to maturity on 5 year CPI-linked bonds. In what follows we present those specific formulations of equations (1) and (2) which were found to be cointegrated.

We use actual values rather than estimates of expected values for all variables. This is justified in the cointegration context as deviations of expected values from actual ones are stationary for prevalent expectations-formation mechanisms. Thus their omission does not affect the cointegrating equation which studies the relationship of non-stationary $I(1)$ variables.

2. *The Main Results*: We find no co-integration for the entire sample period. However, when we subdivide the sample into the periods 1965:01–1980:12 and 1983:01–1989:08 (i.e., omitting the intervening period 1981–1982), we find cointegrating equations which are reported in table 2 for the monthly frequency. It should be remarked that when trying to extend the first period sample into the 1980s, the residuals become non-stationary and the R^2 of the regression falls. This is so even when running the equation only till the July 1985 stabilization program.[1]

The results for the quarterly frequency are almost identical and are available from the author on request.

As may be seen from the table the main findings are:

(i) *For the first period*—In this period only equation (1) is cointegrated. This is true for both GDP and private consumption as the scale variable. Interest elasticity ranges between -0.67 to -0.75 while income elasticity ranges between 1.05 to 1.27.

(ii) *For the second period*—In this period three equations are cointegrated: equation (1) with the log of private consumption and the log of nominal debitory interest; equation (2) with the log of private consumption and the holding period yield on CPI-linked bonds; and equation (2) with the log of private consumption and the holding period yield on foreign-linked bonds.[2] In this period equation (1), with the log of GDP, is not

[1] As the sample was subdivided into two periods, we checked the order of integration of the individual series in each period. Results are available from the author.

[2] The stationarity tests of table 2 indicate that the holding period yield of foreign-linked bonds is $I(0)$ in the sample period. However, the tests conducted for the subperiod 1983–1989 indicate that it is $I(1)$ and therefore it is included in the results reported here. If the series is nonetheless $I(0)$ its coefficient has the usual properties of an OLS estimator.

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TABLE 2.—CO-INTEGRATING EQUATIONS (MONTHLY DATA)
DEPENDENT VARIABLE: NATURAL LOG OF REAL BALANCES

1. The Logarithmic Function (Equation 1) Scale Variable (in natural logs)	Constant	Interest Rate[1]	Scale Variable	R^2	DF	ADF	Z_α
A. First Period 1965:01–1980:12 n = 192							
GDP	−2.03	−0.67	1.05	0.93	−5.13[b]	−3.99[b]	−44.23[b]
	(0.12)	(0.01)	(0.03)				
Consumption	−2.34	−0.75	1.27	0.91	−4.50[b]	−4.19[b]	−35.87[b]
	(0.15)	(0.02)	(0.04)				
Critical Values[2] (10%)					−3.47	−3.51	−27.58
(5%)					−3.78	−3.78	−32.06
B. Second Period 1983:01–1989:08 n = 80							
GDP	−11.55	−0.46	1.42	0.93	−3.29	−1.89	−16.57
	(2.90)	(0.03)	(0.32)				
Consumption	−15.53	−0.32	1.99	0.96	−4.34[b]	−3.51[a]	−29.98[a]
	(1.92)	(0.03)	(0.23)				
Critical Value[2] (10%)					−3.59	−3.32	−27.58
(5%)					−3.93	−3.62	−32.06
2. The Semi-Log Function (Equation 2) The Period 1983:01–1989:08 n = 80 Cost of Money Variable	Constant	Cost of Money	Scale[3] Variable	R^2	DF	ADF	Z_α
Inflation	−27.55	−1.36	3.48	0.92	−4.29[b]	−3.93[a]	−24.40
	(1.73)	(0.33)	(0.19)				
Holding Period Yield	−29.47	−0.90	3.68	0.91	−4.34[b]	−4.33[b]	−32.46[b]
(CPI-linked bonds)	(1.67)	(0.29)	(0.19)				
Holding Period Yield	−30.11	−0.75	3.75	0.91	−8.00[b]	−4.60[b]	−31.35[a]
(foreign-linked bonds)	(1.59)	(0.26)	(0.18)				
Critical Values[2] (10%)					−3.59	−3.32	−27.58
(5%)					−3.93	−3.62	−32.06

Notes: (1) In the logarithmic function the interest rate is always the log of the nominal interest rate (HAHAD).
(2) The critical values for the DF and ADF tests are taken from Engle and Yoo (1987) while those for the Z_α test are taken from Phillips and Ouliaris (1990).
(3) In the semi-log equation (with respect to the cost of money) the scale variable is the log of private consumption.
(4) Standard errors are in parentheses.
[a] Significant at 10%.
[b] Significant at 5%.

cointegrated; equation (2) with the rate of inflation, fails the Z_α test.

The equation displays marked changes between the two periods: the constant is substantially lower, the interest elasticity is more than halved (in absolute value), and income elasticity is higher in the second period relative to the first period.

D. Implications

The finding of a "break" in the sample period is consistent with the cited hypothesis about a possible shift in the demand for money. When inflation accelerated there was a shift in the patterns of money and assets holding: the private sector shifted from money to other liquid assets which provided inflationary protection (first to the PATAM and later to short-term deposits). However when the rate of inflation was stabilized on a much lower level, these patterns did not change. Once firms and individuals learned to use computerized instruments to move swiftly and at low cost from money to liquid assets and back again, and the fixed costs associated with these mechanisms were made, it cannot be expected that the use of "narrow" money will return to its pre-shift levels.

There is a difference between the two periods in all the parameters estimated. This difference may be interpreted as follows: the decline in the constant expresses the decline in money demand following the cited financial changes. Given this decline the demand for money becomes less sensitive to the interest rate and more sensitive to the scale of transactions. The intuition is that once firms and individuals hold less money, because they hold more indexed bonds which offer protection against inflation, then the speculative motive (the cost of money) weakens while the transactions motive gains weight.

V. Conclusions

The picture which emerges, both from the stylized facts presented in section II and the econometric tests

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in section IV, may be summed up as follows:

a. The demand for money in Israel was characterized, until the end of the 1970s, by a "U.S.-type" logarithmic function.

b. Following the acceleration of inflation at the end of the 1970s and the early 1980s, and the introduction of liquid, interest-bearing or indexed assets there occurred a shift (albeit somewhat delayed) in the demand function.

c. The new function is characterized by lower money demand (a lower constant) and places greater weight on changes in income rather than changes in the interest rate as determining changes in money demand.

d. In both periods the elasticity of money demand with respect to the interest rate is smaller than unity in the logarithmic function. In the semi-log function (in the second period) the elasticity is smaller than unity for the actual inflation rates which prevailed at the time.[3] These results enable us to answer the questions posed in section II which were derived from the theoretical debate on the inflationary process:

(i) The inflation tax is indeed a credible explanation as the estimate for interest elasticity is less than unity.

(ii) The evidence favours a log-log formulation (at least for the first period). This implies a unique equilibrium as for this specification there is only one intersection of the money demand curve with the government budget deficit curve.

(iii) There indeed occurred a shift in the demand function.

APPENDIX

The Data

1. Sources

All the series used were taken from the Bank of Israel Data Bank except for the following:

a. Nominal interest rates charged by banks for the period 1965–1971 were taken from Minsly (1979).

b. Real yields on bonds for the period were drawn from various issues of the Monthly Bulletin of Statistics published by the Central Bureau of Statistics.

2. Definitions

Money—Currency in circulation and checking deposits (defined as M1).

Prices—CPI index.

Nominal Interest Rates—Debitory nominal interest rates charged by the banks on short-term loans.

Real Bonds Yield—Yield to maturity on indexed bonds (with 5 year maturity) traded on the Tel Aviv Stock Exchange.

Holding Period Bond Yields—Nominal changes in market indices of the price of bonds traded on the Tel Aviv Stock Exchange.

Real GDP and Consumption Measures—Non seasonally adjusted data measured quarterly by the Central Bureau of Statistics. These were transformed to monthly series by fixing the quarterly number as that of the second month in the quarter and calculating the geometric growth rate for the months in between.

[3] The elasticity for the semi-log specification is computed by multiplying the coefficient on inflation, which is the semi-elasticity, by the actual rate of inflation.

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