MODELLING THE DEMAND FOR M3 IN THE EURO AREA

by

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Index:

[A] Motivation

[B] Specification issues and statistical sources (*)

[C] The Area-wide model

[D] Single-country models & pooling

(*) Data and the corresponding definitions and methodological notes are both downloadable at: http://www.spbo.unibo.it/pais/golinelli/macro.html (data.xls, appendix.pdf)
The stability-oriented monetary policy strategy of the Eurosystem was defined in the ECB Monthly Bulletin of January 1999 (pp. 39-50):

**ECB target**: an annual inflation rate < 2% (HICP).

**ECB policy strategy** based on two “pillars”:
- announced reference value for M3 growth;
- outlook of price developments in the area.

The first “pillar” requires money M3 has a stable relationship with Euro area price level.

The stability of this relationship is typically assessed in the context of the money demand function.

From empirical literature (since the beginning of 90s): “Money demand functions at area-wide level have a very satisfactory performance (better than the corresponding single country functions)”, because the aggregate function:
- reduces potential determinants of mispecification;
- is less affected by currency substitution;
- enjoys statistical averaging effects.

This is a good news for the ECB, but ...
... previous benefits can be achieved at the risk of introducing parameter heterogeneity into the area-wide relationship [see: Kremers and Lane (1990), Artis, Bladen-Hovell and Zhang (1993), Cassard, Lane and Masson (1997), Wesche (1997b) and Fagan and Henry (1998)].

We will try to shed light on this old issue by using new econometric techniques and data. The steps we followed are:

- the construction of a consistent databank (quarterly data, period 1978q2-1997q4) for all the variables of interest (data homogeneity is necessary to test parameter homogeneity);
- the specification and estimation of a parsimonious equation for money demand at area-wide level, by using alternative techniques (cointegrated VARs and uniequational ARDL);
- the specification and estimation of the same equation for money demand at single-country level (ARDL approach);
- money demand pooled mean group estimation in a dynamic heterogeneous panel (where the Euro area countries are the panel individuals), and poolability tests of the long run parameters.
[B] SPECIFICATION ISSUES

The general long-run equation

\[ m = \alpha + \beta y + \gamma r + \delta \Delta p \]

raises a number of questions:

(i) how to measure \( m, y, r \) and \( \Delta p \) variables, and how to sum national data in the area?

(ii) what sample period, data periodicity, and seasonal adjustment?

(iii) how to model (possible) regime changes?

Different answers can be at the basis of alternative results.

The alternative answers (19 studies) are summarised in Table 1, page 4.

The possibly different results are in Table 2, page 6.
Table 1, page 4:
THE “ANSWERS” OF THE LITERATURE

(1) Choice of the money aggregate:
• broad and narrow money;
• simple sum and Divisia indexes;
• with or without cross border holdings;
⇒ simple sum M3 without cross border holdings.

(2) Sample period, periodicity, and (3) Seasonality:
• mainly, “EMS data” (1979);
• quarterly data (scale variable);
• seasonally adjusted;
⇒ sample period 1979q2-1997q4 (availability of coherent statistical sources and EMS regime data).

(4) Area definition and (5) Aggregation:
• Changing definition over time (sometimes “simplified”);
• Conversion rate: stock and flows by using market or PPP exchange rates (current or in a base year), indexes and rates by using weighted averages;
⇒ aggregation by using the 1st of January 1999 Euro exchange rate; weights were from GDP at 1995 prices.
(6) Cointegration approach:
• Engle and Granger (two steps);
• Dynamic model;
• Johansen;
⇒ Johansen and ARDL.

(7) Main institutional events (stability):
• German re-unification (1991);
• EMS establishing (March 1979); Delors’s Committee report (1989); Maastricht Treaty (December 1991); EMS crisis (August 1992);
• Financial innovation and deregulation;
⇒ we avoided dummy variables and/or segmented trends (problems with test distributions).
Table 2, page 6:
THE “RESULTS” IN THE LITERATURE

(1) Money
• prevalently logs of simple sums;
• deflated by using the consumer prices or the GDP deflator.

⇒ the parameter estimates are not heavily affected by the choice of the monetary aggregate.

(2) Scale variables
• mainly GDP at constant prices;
• the financial wealth is rarely used (see column 6 of Table 2, “Other”).

⇒ In general, the alternative estimates are quite similar: the money elasticity to GDP is > 1 [superior good? omission of other relevant variables (wealth, financial innovation and money own rate)?].

⇒ The inclusion of the financial wealth reduces the money demand elasticity to income.
(3) and (4) Own and alternative rates of return
• always in levels (never in logs);
• both rates only in 8 cases out of 31 (collinearity?)
• in 23 cases out of 31 just one rate of interest (10 long run, 13 short run) to measure the return of assets alternative to money (negative parameter).
⇒ Differently to the income elasticity estimates, rates of return parameter estimates are characterised by a large variability.

(5) The inflation rate
Used in few cases, should measure deviations from long run price homogeneity of money demand: again, possible collinearity problems with interest rates.

(6) “Other” relevant variables
• US dollar against Ecu exchange rate (positive sign, currency substitution)
• Financial wealth (See column “Income” above)

(7) Speed of adjustment (loading parameter)
• Close relationship between cointegration and ECM models;
• Relevance of the significance of the loading estimates.
⇒ In general, slow dynamics of adjustment, slightly faster for narrow money balances.
**Putting things together:**

**THE LIST OF THE VARIABLES OF INTEREST**

All 5 variables were first obtained at country level, and then aggregated (see Data Appendix).

\( m = \text{logs of real M3}, \text{ deflated by the GDP deflator} \)

\( y = \text{logs of real GDP} \)

\( RL = \text{average yields on the Government long term bonds} \)

\( RS = \text{average yields on Government short term bills} \)

*note: we used \( r = \log(1+RL) \) and \( s = \log(1+RS) \) to be coherent with our definition of annual rate of inflation:*

\( \Delta p = 4 \times \{p - p(-1)\} \), where \( p = \text{logs of HICP} \)

At area wide level, we made a comparison with Coenen e Vega (1999) results (obtained by using the ECB “official” database): our data deliver similar historical path, cointegration properties and parameter estimates, if used in the context of their analyses.
Dickey-Fuller tests show the 5 \((m, y, r, s, \Delta p)\) variables of interest are I(1) \(\Rightarrow\) the inferences are conducted in the field of Johansen (1995) reduced rank cointegration: an Unrestricted VAR(2), with unrestricted intercept and seasonal dummies, is always enough to ensure vector white noise residuals.

The “specification trade-off”:
• the inclusion in money demand of a large number of variables should increase the probability of finding cointegrated relationships (see Wickens, 1996);
• critical values of Johansen’s rank tests are inaccurate when the number of variables is large with respect to the cointegration rank (see MacKinnon, Haug and Michelis, 1999).

\(\Rightarrow\) Money demand equations with a large number of explanatory variables (probably larger than the correctly specified model would require, see the literature above mentioned) are likely to be cointegrated but pose both parameter identification and statistical inference problems.
The concept of *Irreducible Cointegration* (IC) can be helpful to draw the picture of the whole system of structural relationships (see Davidson, 1998): “a set of I(1) variables is called irreducibly cointegrated (IC) if they are cointegrated, but dropping any of the variables leaves a set that is not cointegrated”. In addition, if an IC relation contains a variable which appears in no other IC relation, it is structural.

In Table 3 (page 10) all possible subset of \((m, y, r, s, \Delta p)\) are tested for cointegration (on the whole, 25 subsets), starting from each pair of variables; once one set is found to be cointegrated, all supersets can not be ICs.

We detect **three** ICs:

(i) \(r\) and \(\Delta p\) (is interpreted as a Fisher equation with not rejected over-identification restrictions to \((1, -1)\) cointegrating vector);

(ii) \(m, y\) and \(r\) and

(iii) \(m, y\) and \(s\) (are interpreted as alternative structural money demand relationships with different - and heavily collinear - measures of yields on the assets outside money).
Since the IC among \((m, y \text{ and } r)\) variables is characterised by significant and robust results (they remain almost the same even by adding other variables and suitable parameter restrictions) we retain \((ii)\) as the structural money demand equation.

The parameter constancy is also evidenced by the plot of the recursive long run parameter estimates in the cointegrated VAR, with \(y\) and \(r\) weak exogeneity restrictions imposed (and never rejected).

As suggested by Gonzalo and Lee (1998), previous results from Johansen’s approach are compared with alternative methods:

**Table 4 – Alternative long run estimates (page 12)**

<table>
<thead>
<tr>
<th></th>
<th>Johansen</th>
<th>ARDL</th>
<th>FM-OLS</th>
<th>OLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>(y)</td>
<td>1.373</td>
<td>1.373</td>
<td>1.420</td>
<td>1.422</td>
</tr>
<tr>
<td></td>
<td>0.051</td>
<td>0.057</td>
<td>0.048</td>
<td>-</td>
</tr>
<tr>
<td>(r)</td>
<td>-0.680</td>
<td>-0.681</td>
<td>-0.385</td>
<td>-0.374</td>
</tr>
<tr>
<td></td>
<td>0.316</td>
<td>0.366</td>
<td>0.228</td>
<td>-</td>
</tr>
</tbody>
</table>

- Money elasticity to income estimates are very similar and significantly greater than one;
- Money semi-elasticity to interest rates estimates have a larger variability (lack of precision).
The results are not sensitive to the approach chosen because (as seen from Johansen’s method results) the explanatory variables are weakly exogenous for money demand parameter estimates and the cointegration rank is one.

The ARDL($p$,$p$) approach (Pesaran and Shin, 1998) deserves deeper analyses since it will be used in the single country & poolability approaches:

$$\Delta m_t = \mu + \phi m_{t-1} + \pi' x_t + \sum_{i=1}^{p-1} \lambda_i^* \Delta m_{t-i} + \sum_{i=1}^{p-1} \psi_i^* \Delta x_{t-i} + \epsilon_t$$

where $\mu$, $\phi$, $\pi$, $\lambda$ and $\psi$ are parameters; $x_t = (y_t, r_t)'$ and $\epsilon_t$ is the error term. Under standard assumptions on $\epsilon_t$ and if $\phi < 0$ a stable relationship exists in the long run between $m_t$ and $x_t$ and can be defined as:

$$m_t = \theta' x_t + \eta_t$$

where $\theta = -\pi/\phi$ and $\eta_t$ is I(0).

Our ARDL(2,2) model for $m$, $y$ and $r$ can be simplified in the final model for the Euro area:

$$\Delta m_t = -0.16 + 0.52 \Delta m_{t-1} - 0.31 \Delta r_{t-1} - 0.11 (m - 1.37 y + 0.68 r)_{t-1}$$

$$\begin{array}{cccccc}
(0.04) & (0.08) & (0.10) & (0.03) & (0.06) & (0.37)
\end{array}$$

• very parsimonious model
• data congruent
• stable parameter estimates
• forecasting ability 98q1-99q3: p-value 20.1%
We study the money demand functions for all the 11 countries in the Euro area, by specifying an ARDL model for each country with $m$ as dependent variable and $y$ and $r$ as explanatory variables.

For national models, we increase the ARDL lag length ($p = 4$, instead of $p = 2$), to capture specific aspects characterising disaggregated money demand relationships: lagged regressors may act as proxies for some other omitted short run explanatory variables.

The results are in Table 6, page 16. The comparison between the results from aggregate and disaggregated models shows the better properties of the first. The main findings are:

• the regression standard error of the national models is at least double w.r.t the area model;
• the diagnostic tests for national models signal some specification problems;
• a long run relationship is hardly ever detected;
• almost always the estimates of long run elasticity of income are $> 1$, while the elasticity to the long rate are much more dispersed (they spread from $-4$ to $5$).
This worsening in performance when shifting from the area to the national model can depend on two causes:

- specification problems at country level (our national models are too simplified);
- the disturbing effect of shocks and outliers on the estimation of national money demands (sampling error).

⇒ In the latter case, it is common practice to pool the long run parameters of money demand relative to different sampling units, in order to increase model performance.

Following the Pesaran, Shin and Smith (1999) procedure, it is possible to test the poolability of long run parameters in an ARDL panel data model (long run parameter homogeneity test).

Table 7 at page 18 reports the estimates of the long run parameters under the hypothesis of poolability: $\theta_h = \theta \ \forall h$ for four subset of countries in the Euro area (see below). The $\theta$ estimates are obtained either by averaging the national results (MGE, Mean Group Estimator) or by imposing the pooling constraint (PMGE, Pooled Mean Group Estimate). Under the null of poolability, both estimators are consistent, but PMGE is also efficient.
The null can be tested by using two approaches:

- an Hausman-type test statistic (note that in small samples it is not said that the difference of the variances is positive definite);
- a likelihood ratio test, from the comparison of the constrained log-likelihood (under the pooling hypothesis) and the unconstrained one (the sum of the log-likelihood in the national models); in small samples this test tends to over-reject the null.

We made pooled estimates for 4 groups of countries:
1. Euro area without Luxembourg;
2. Core area (Austria, Belgium, France, Germany, Netherlands);
3. Core plus Italy;
4. Core plus Spain.

The results can be summarised as follows:

1. Euro area without Luxembourg:
   - long run parameter poolability Hausman test is not rejected; the likelihood ratio test is rejected;
   - previous results can be due to the huge dispersion of the unrestricted estimates;
   - the fitting of the pooled model is slightly worse than the unrestricted, and we have no worsening in diagnostic tests;
2. Core area
- long run parameter poolability Hausman test can not be computed; the likelihood ratio test is not 5% rejected;
- the fitting of the pooled model is broadly the same as the unrestricted (results not reported);

3. and 4. Core + Italy, and Core + Spain
- the purpose is not to verify the possibility of coexistence of Italy and Spain in a monetary union with the countries of the “core”;
- the Hausman test can not be computed; the likelihood ratio test 5% rejects the poolability in the core + Italy subset (but does not reject at 1%) and does not 5% reject in the core + Spain subset.
CONCLUSIONS

• Further evidence on the superiority of the area-wide money demand with respect to national relationships;
• the area equation parameter estimates are stable and precise (mainly the money elasticity to income);
• diagnostic checks stress the benefits from statistical averaging;
• the forecasting ability of the aggregate relationship is very promising;
• the national parameter estimates are very imprecise, probably due to shocks and outliers effects;
• possible long run homogeneity of the national parameters;
• smaller countries parameters tend to be less homogeneous;
• relevance of the cross sectional information to improve the efficiency of long run estimates.