Testing Balance Sheet Linkages Within The Spanish Savings Banks Industry: A Multivariate Approach

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Abstract: *This paper studies equilibrium and causality relationships between different aggregates in the Spanish savings banks balance sheet. The sample period covers the last decade, when some important institutional changes occurred. Empirical results using the Johansen's procedure and the Sims, Stock and Watson methodology for causality testing allow us to admit the null hypothesis of retail banking behaviour.*

Key words: Unit roots, Cointegration, Causality, Banking Theory, Savings Banks.

I. Introduction

During the last two decades an abundant literature has emerged which tries to describe and to explain the behaviour of banking firm in relation to its function of asset transformation. Most of the academic works published on this subject are theoretical studies which try to identify optimum holdings of assets and liabilities as well as the possible relationship between these aggregates. At the same time, empirical evidence is very limited and largely focused on the North American case.

This paper attempts to test the hypothesis of "retail banking behaviour" for the Spanish savings bank during the last decade. "Retail banking behaviour" refers to the provision of services to individuals and small businesses where the financial institutions are dealing with large volumes of low-value transactions. This is in contrast to wholesale banking where the customers are large, often multinational companies, governments or governmental enterprises, and the institutions deal with large-valued transactions, usually in small volumes. According to Lewis (1987), in practice it is difficult to identify purely retail banks. Perhaps the closest to retail-only establishments are the savings institutions, but even here Spanish savings banks have moved into universal banking in the last two decades.

The aim of this study is to identify and describe empirically the main relationships between assets and liabilities in Spanish savings banks during the period 1981-1990. In the first stage, empirical analysis is not focused on any particular theory. Instead, it aims to give an overall description of the inter-relations between assets' and liabilities' entries explained through a synthesis of the modern theories of the banking firm. In the second stage, an analysis of the direction of causality allows us to choose between "assets", "liabilities" and "integrated management" models.

The paper is structured as follows: in section II we give an overview of the empirical studies on banking firm behaviour. In section III the variables are described and the hypotheses about the relations between these variables are established. Section IV is devoted to testing empirically the validity of the different theories concerning savings banks. For that purpose, initially, an analysis is made to determine the order of integration of the variables. Later, the long run relationships are established by cointegration theory and both long run and short run possible causality relationships are studied. Finally, section V summarizes the most relevant conclusions.

II. Empirical Studies On Banking Firm Behaviour

Traditionally, the literature has considered three main approaches to the theory of the banking firm (Baltensperger, 1980, Santomero, 1984): a) asset management models, b) liabilities management models[1] and c) full or integrated management models. Between these three positions lies a variety of possible responses, the relative appeal of which will depend upon the structure of the bank's balance sheet, the nature of its deposit market, and thus the responsiveness of its deposit flows.

Lewis (1987) argues that in recent years there has been an apparent tendency for retail banks and other intermediaries to alter the nature of their portfolio behaviour from the end of the spectrum involving quantity responses towards behaviour based more upon price responses. Adopting the commonly used terminology, the tendency has been to move away from reserve asset management towards liability management policies. The reasons for this trend are complex. Factors quoted in the literature include deregulation, the growth of interbank markets, volatility in deposit flows, interest rate variability and competition for deposits. All of these factors have affected the behaviour of savings banks in the last decade. Nevertheless, it can be concluded from this brief review that this industry has in general continued to follow the approach suggested by asset management models.

Within the literature one can distinguish two major groups of studies, the older one being devoted to the description of banking liquidity management behaviour, and the more recent one which focuses on verifying theories of full banking firm behaviour.

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[1] More updated reviews of the literature, like Papademos and Modigliani (1990) or Pérez and Quesada (1992) consider the second group as a part of the third.

II.1. Studies using asset and liquidity management models

The earliest empirical studies on asset management are those made by Koyck (1954), Brunner and Meltzer (1964) and Pierce (1967). All of them try to find out the relationships between the rules of asset allocation in the banking firm system and the level of the money supply, based on the use of aggregated data. In an alternative way, the study by Hester and Pierce (1968), represents one of the first works in this field using microeconomic data. The results of this study allow us to describe the links between the origin and the assignment of resources according to a series of asset characteristics: liquidity, securities purchase facility and the variability of deposits.

Nevertheless, the initial work of Hester and Pierce (1968) and the ones which followed the same line have been criticised in a number of respects. In the first place, the model assumes the acquisition of liabilities as something given, that is to say exogenous, which does not appear to be very realistic within the current financing innovation context of liability competition. In the second place, the model assumes that there is no substitution among the different types of liabilities when in practice the bank is combining different types of funds procurement. Finally, it is assumed that banks are operating under free competition, while the casual evidence suggests that banking markets are far from perfectly competitive.

II.2. Studies using integrated management models

The criticisms mentioned in the previous paragraph do not apply to this type of models. The initial effort in this area is due to Parkin, Gray and Barrett (1970) who studied British commercial banking. Following the same approach, but applied to the North-American case, it is possible to find several studies: Spindt and Tarhan (1980), Humphrey (1981) and Simonson, Stowe and Watson (1983), each using different empirical techniques to measure the connection between banking assets and liabilities. Spindt and Tarhan (1980) jointly estimate a system with seven equations. This work gives empirical evidence for the existence of relationships between liquid assets on both sides of the balance sheet. A wider description of the liabilities structure was attempted by Humphrey (1981). He found that asset composition is important in explaining the differences in liabilities structure. This suggests that the asset and liability composition relationship is not unidirectional. Hence, the analysis of the direction of causality is very relevant.

Simonson, Stowe and Watson (1983) enlarged Humphrey's work using a large banking sample. The empirical results led them to detect bidirectional interdependences between asset portfolio allocation and liability structure. The technique employed was canonical correlation, which allows one to relate the two parts of the balance sheet simultaneously. Canonical correlation is based on the covariation between asset positions within each one of the big aggregates in the banking balance as well as between the two parts of the balance itself. However, the study of Simonson, Stowe and Watson does not carry out replications using canonical correlation analysis, this being of special importance inasmuch as it is interesting to differentiate between the variability caused by sampling error and that related to a particular measure.

More recently, several banking behaviour theories have been tested for the case of Italy (Corradi et al., 1990) and for the U.K. (Barr and Cuthbertson, 1990) using the cointegration technique. A possible conclusion from these studies is that there has been asset management in Italian banking; however, the existence of quantitative credit restrictions during a part of the sampling period breaks the series cointegration. Evidence for the British case seems to show the existence of banking liability management, which is more in accordance with the operation of a modern bank.

In the Spanish case, empirical evidence is very scarce. However, a recent study applies cointegration techniques to the relationships between interest rates for assets and liabilities in the Spanish banking system (Sastre, 1991).

In this study it has been decided to apply the cointegration technique for measuring long run relationships using two different methods: ordinary least squares (OLS) and maximun likelihood in the error correction mechanism (Johansen's procedure).[2]

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[2] Recently, a study has compared such methods to the one of canonical correlations and it was proved that although all of them lead to super-consistent estimators, Johansen's method is the one which offers better characteristics to examine asymptotic distributions. On the other side, a Monte Carlo study proves that the characteristics in finite samples are consistent with asymptotic results (Gonzalo, 1989).

The results by OLS are used for the causality tests and are available from the author's upon request.

III. Long Run Relationships Between Aggregates In The Banking Balance Sheet

Cointegration techniques are applied in the present paper to analyze the relationships between the different components of bank balance sheet decisions. It is evident that cointegration is especially useful in analyzing the relations between non-stationary variables which economic theory and balance constraints predict may have an equilibrium relationship.

III.1. Variables

The variables used in the empirical analysis in this paper correspond to those items in the banks' balances which are outlined below. The data period is 1981/01-1990/12 due to the fact that records of some of the variables only appear from 1981. The variables have been transformed into real terms using as a deflator the consumer price index for the service sector. Data are taken from the Bank of Spain Statistical Bulletin on magnetic tapes, mainly from chapter III, and the sample therefore includes all of the savings banks. This allows us to assume that the results obtained correspond to those of a moderately large savings bank, due to the specific weight of these in the total for the sector.

In order to distinguish more clearly between the various theories relating to banking firms, the balance sheet items have been divided into five main aggregated variables:

- (A) liquid assets = cash + deposits at the Bank of Spain.
- (B) earning assets = monetary assets + financial intermediaries + credit + portfolio.
- (C) capital = reserves + foundation capital + subordinated debentures
- (D) deposits = deposits + borrowed funds
- (E) liabilities = deposits + capital (D + C)

III.2. Testing Procedure

We assume that the savings bank industry in Spain is still primarily a retail banking industry in spite of the recent institutional changes. Therefore, we expect that the asset management models will be the most relevant ones. The strategy to determine whether or not this is correct is divided into two stages:

1) Cointegration relationships between different aggregates on both sides of the balance sheet are tested. These key relations will be compatible with different theoretical approaches.

2) Taking into account the equilibrium relationships found, the direction of causality is tested both in the short and in the long run. This will allow us to discriminate between asset and liability management models.

A common remark which emerges from the academic literature about banking firm behaviour is that it lacks a homogeneous theoretical core. However, in spite of this heterogeneity, it is possible to find a number of concepts or key relations which are repeated in the different theoretical approaches. Long run equilibrium relationships between variables are studied starting from the definition of the variables. Such relationships correspond to different hypotheses about banking firm behaviour. In relation to the balance sheet variables A, B, C, D and E identified above, the hypotheses about cointegration can be summarised as follows:

1) CI [A,B]
2) CI [A,D]
3) CI [B,D]
4) CI [B,E]
5) CI [A,E]
6) CI [A,B,D]

Hypothesis 1 refers to the relationship between reserve assets, which have a zero (or quasi zero) profitability, and earning assets (financial intermediaries, monetary assets and credit investments), which combine a degree of profitability with a variable liquidity, the relationship depending on the type of assets.

The decision to hold fully liquid assets or not, will depend on the volatility (uncertainty) in deposits determination and the development of the monetary market in the country. Of course, two other variables will also have a strong influence on the evolution of this ratio. These are first, legal regulation, and secondly, interest rates in the monetary market. However, it does not seem that Spanish banks have been obliged to hold additional reserves (Repullo, 1990), considering the high liquidity ratio.

Relationships 1 and 2/3, can be drawn from asset management models, particularly cash management and portfolio selection (Orr and Melon, 1961 or Markowitz, 1959).

Similarly, relationships 3 and 4/5 may be compatible with theoretical relationships from liability management models like monopoly models (Slovin and Shuska, 1983), real resources models (Sealey and Lindley, 1977) or with the customer relationship (Stiglitz and Weiss, 1981) or gap management models (Bierwag, Kaufman and Toews, 1982).

Finally, relationship 6 is compatible with cash management models like Baltensperger (1980) or Papademos and Modigliani (1990).

Once the equilibrium relationships have been found, the direction of causality is tested between both sides of the balance sheet. Following Corradi et al. (1990), banks will be divided into two main categories:

1) Banks which are non-sophisticated in their financing activity; these will follow asset allocation strategies, trying to invest funds obtained in the deposit market. They will be mainly concerned with raising deposits, even before having decided their strategy regarding earning assets. This strategy would be the most suitable one for retail banking.

2) Sophisticated banks. These will follow liability or integrated allocation strategies. As these banks are financed in competitive markets, investment decisions will occur in advance of, or simultaneously with, liability procurement strategies. This approach would be applied mainly by wholesale banking.

IV. Empirical Application To The Spanish Savings Banks Case

In this section, an analysis is made of long run relationships between the different entries on the banking balance sheet. The possible relationship between the variables is analyzed using the so-called cointegration theory (Engle and Granger, 1987 and Engle and Yoo, 1987). In addition, it is useful to check the possible causality relations, discriminating between the short and long run, according to the methodology developed in Sims, Stock and Watson (1990).

IV.1. Unit root tests[3]

The Phillips-Perron (1988) unit root test is used in this exercise for the sake of robustness. In making inferences the testing sequence suggested in Perron (1988) and modified in Dolado et al (1990) is followed (see table 1). As proposed by Dickey and Pantula (1987), we begin by testing for integration of order two [the null is I(3)] on the second difference of the variables and subsequently test for integration of order one [the null is I(2)] on the first difference of the variables and for integration of order zero [the null is I(1)] on the level of the variables.

The results (see table 2) show that for all of the series, the null hypotheses of I(3) and I(2) processes are rejected at the 1% level of significance. In testing the null hypothesis of one unit root we also found that also for all of the series, the null hypothesis can be rejected at the 1% level of significance using the $Z(\phi)$ statistics. However, when using $Z(t_{\alpha})$ statistics, this hypothesis cannot be rejected for any of the variables.

In evaluating these findings, one must bear in mind that any existing test of the unit root hypothesis has quite a low power against relevant stationary alternatives with a root close to unity. This would imply that mean reversion occurs over very long periods of time.

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[3] The ROOTINE and RATS v 3.1 econometric programmes have been used to implement the Phillips-Perron and Boero-Burridge test respectively.

Again, this highlights the importance of the span of the available data rather than the number of observations per se. More observations do not necessarily lead to tests having higher power if there is a change in the sampling interval. A long span of annual data is to be preferred to a shorter span with, say, quarterly or monthly data even if the latter affords a greater number of observations. Moreover, the Phillips-Perron procedure has been found to suffer from serious size distortions and very low power when errors are autoregressively correlated, so this test performs poorly against trend-stationary alternatives (DeJong et al., 1992). As we are working with monthly data and the evidence is mixed for these series, it does not tend to support the view that they are stationary (Perron, 1988).

An alternative approach is provided by the recent Boero-Burridge test. This is a simple non-parametric test based on the number of sign changes of a random walk, with the appealing property of having a sampling distribution independent of nuisance parameters (Boero-Burridge, 1991). The performance of the B-B test has been compared with that of the Dickey-Fuller test using Monte-Carlo methods and it exhibits a superior power.

The critical values for the B-B test are shown in table 3 for the Spanish savings banks data and the results appear in the graphs at the end of the paper. As can be seen, for each of the variables the number of sign changes doesn't allow us to reject the null hypothesis of a random walk. The B-B test therefore allows us to draw the much stronger conclusion from the univariate analysis that all of the variables considered appear to be integrated of order one I(1).

IV.2. Cointegration relationships among entries of the savings banks balance sheet

Once the integrability order of the series has been determined, the result can be used to estimate cointegration relationships. According to Escribano (1990), the components x_{jt} of a vector X_t, which represents a determined stochastic process are cointegrated in a weak sense or in variance if:

a) all of the components are integrated of the same order, I(d) in a weak sense, being d>0 and,

b) there is a linear combination of them $z_t^* = \alpha'(x_t - \mu)$, that is I(d-b), b>0, in a weak sense. Matrix α' of order r x N is called the cointegration matrix.

The method of estimation used in this paper is the one developed by Johansen (1988, 1989) and Johansen-Juselius (1990). This is based on the estimation of the group of cointegrating vectors in a vector autoregressive process by the maximum likelihood procedure. This method has several advantages over the 2-step regression procedure suggested by Engle and Granger. It relaxes the assumption that the cointegrating vector is unique and it takes into account the error structure of the underlying process.

The Johansen estimation method is based on the error correction representation of the VAR(p) model with Gaussian errors:

$$\text{(IV.1)} \qquad \Delta x_t = \mu + \Gamma_1 \Delta x_{t-1} + \Gamma_2 \Delta x_{t-2} + \ldots + \Gamma_{p-1} \Delta x_{t-p+1} + \Pi x_{t-p} + B z_t + u_t$$

where x_t is an m x 1 vector of I(1) variables, z_t is an s x 1 vector of I(0) variables, Γ_1, Γ_2, ..., Γ_{p-1}, Π are m x m matrices of unknown parameters, B is an m x s matrix, and u_t N $(0, \Sigma)$. The Johansen procedure estimates (IV.1) subject to the hypothesis that Π has a reduced rank, $r < m$. This hypothesis can be written as:

$$\text{(IV.2)} \qquad H(r)\colon \Pi = \alpha\beta'$$

where α and β are m x r matrices. Johansen (1989) shows that, under certain conditions, the reduced rank condition (IV.2) implies that the process Δx_t is stationary, x_t is non-stationary (i. e. has unit roots), and that $\beta' x_t$ is stationary. The stationary relations $\beta' x_t$ are referred to as the cointegrating relations.

The maximum eigenvalue test (maximum rank of cointegration) assumes under the null hypothesis that the number of cointegrating vectors is $r = \bar{r} \geq m$, where m is the number of regressors in the cointegrating relation. In every case, the null hypothesis is compared to the alternative of $r = \bar{r} + 1$, using the following test:

$$\xi MAX = -2 \log Q = T \log (1 - \hat{\lambda}_{T+1})$$

where $\hat{\lambda}$ are the estimated eigenvalues of the cointegration matrix and T is the number of observations used in the estimation.

Alternatively, the trace test uses the same null hypothesis against the maintained one $r \geq \bar{r} + 1$. The statistic is as follows:

$$\xi\text{TRACE} = -2\log Q = -T \sum_{i=\bar{r}+1}^{n} \log (1-\hat{\lambda}_i)$$

By using the tests of the trace and the maximum rank of cointegration it is possible to assess the presence of a maximum of r cointegration relationships, versus the non-existence of any of them, and to test later which of them correspond to the existing long run relationships. This method is based on the number of possible stationary linear combinations among trend variables, giving support to the fact that these series have one or several common trends.

IV.2. Long run estimations by Johansen's procedure[4]

The results of the test for the key relations stated in section III.2 are reported in table 4. It can be noted from the table that either the test based on the maximum eigenvalue of the stochastic matrix or the one based on the trace of this matrix, allows us to accept a cointegrating vector for each relationship.

In the first column the relationship between the variables for liquid assets (A) and earning assets (B) is analyzed. The parameters have the expected signs according to asset management models. Hence, a rise in liquid assets is expected when there is a fall in holdings of earning assets. The best result is obtained with a VAR of order one.

The second column is devoted to the analysis of the relationship between liquid assets (A) and deposits (D). This relationship is also compatible with the functioning of asset management models. In this case, there is a lag in the relationship, so a VAR of order four is needed.

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[4] The econometric results in this section were obtained using MICROFIT v.3.0.

The relationship between the variables for earning assets (B) and deposits (D) and between these ones and liabilities (E) is reported incolumns three and four. The theoretical support for this can be found in liability models, the customer relationship or gap management models. Similarly, the relationship between liquid assets (A) and liabilities (E) (column five) can be placed in this group of theories. All three cases are modeled by a VAR of order three.

Finally, a long run equilibrium relationship is found between liquid assets (A), earning assets (B) and deposits (D). This is reported in column six, where there is a negative relationship between A and B, but a positive one between A and D. This relationship is compatible with cash management models.

Once the equilibrium relationships have been tested, the next step is to test for the direction of causality. This will allow to distinguish between asset and liabilities management models.

IV.3. Empirical evidence about short and long run causality[5]

Following Granger (1988), if X_t and Y_t are both I(1) variables but they are cointegrated, then they are generated by an "error correction model" (Z_t). As a consequence of this, either ΔX_t or ΔY_t (or both) must be caused by Z_{t-1} (which is in itself a function of X_{t-1} and Y_{t-1}). Therefore, if there exists cointegration, there must be causality between them in at least one direction in order to provide them with enough dynamics to reach the equilibrium. If Z_t is not used, the model will be misspecified and, in some cases, the causality will not be detected. This problem only appears when both series are cointegrated. That is why we consider two alternative situations (Corradi et al,1990):

i) the existence of a cointegrated vector.
ii) the absence of cointegration.

[5] The causality tests have been implemented in RATS v.3.1.

If the series I(1) are cointegrated the relevant regression is the following one:

$$X_t = \alpha_0 + \gamma_1 (X_{t-1} - \alpha Y_{t-1}) + \sum_{i=1}^{m} \alpha_{1i} \Delta X_{t-i} + \sum_{i=1}^{n} \alpha_{2i} \Delta Y_{t-i} + \alpha_{1i} X_{t-1} + \varepsilon_{1t}$$

The same representation would be valid for Y_t. The two null hypothesis to test are the following ones:

$H_0 : \gamma_1 = 0$. (absence of long run causality).
$H_0 : \alpha_{2i} = 0$. (absence of short run causality),$\forall_i$ / i = 2....n.

Therefore, if the series are cointegrated, the standard F test can be used to test for causality in the short and long run.

The following causality relationships can be observed from the cointegration found between the different pairs of variables studied: (see table 5).

1. It is possible to distinguish a short run causation flowing from liquid assets (A) to earning assets (B). Alternatively, when studying the long run, the causality relationship found is the opposite. From an economic point of view, it seems quite logical that the need for liquidity obliges the banks to readjust assets in the short run, while the long run trend may be explained by the factors which determine the profitability of investments, as portfolio management models seem to point out.

2. With regard to the relationship between liquid assets (A) and deposits (D), the short run causality runs only from deposits to liquid assets. Thus, reserve management models would explain banking operations.

3. In the case of the relationship between earning assets (B) and deposits (D), there is causality from the second to the first one, both in the short and in the long run. Nevertheless, the empirical evidence shows that there is a bidirectional causality relationship in the long run. It can be concluded that, in the short run, the management of the savings banks generally follows the traditional approach of first attracting savings and then transforming them into assets. However, in the long run the variables that determine financial investments have an influence on the take up of liabilities by savings banks.

4. The relationship between earning assets (B) and liabilities (E) has a one-way causality: from liabilities towards earning assets both in the short and the long run. This result allow us to define the management of savings banks as classic.

5. Finally, with regard to the existing relationship between liabilities (E) and liquid assets (A), the existence of causality from the first one to the second has been shown. This results strengthens the conclusion obtained from the second relationship in the sense of finding the existence of liquidity management in savings banks as the reason for this causality relationship.

V. Conclusions

Two principal models of banking firm behaviour have been suggested in the literature, one based on asset management, the other on liabilities management. The empirical evidence is mixed: for example, in the case of Italy, there is support for the former approach, whereas for U.K. analysis suggests that behaviour corresponds more closely to the liabilities management model. This paper examines the evidence for the behaviour of the Spanish savings banks during the 1980's using cointegration techniques. The starting point is the finding that all of the variables considered appear to be integrated of order one I(1). Next, the major equilibrium relationships [for liquid assets, earning assets, deposits and liabilities] have been found using the Johansen's procedure for multivariate-cointegration. According to Granger's Representation Theorem, these equilibrium relationships will allow us to state that there must be causality in each of them in at least one direction. This will permit to discriminate between asset and liability models.

In general the results confirm the hypothesis that Spanish savings banks follow a "classic" asset management behaviour which is appropriate for retail banking. Specifically the direction of causation in the short run was found to go from deposits and liabilities to liquid and earning assets, and in the long run also from deposits and liabilities to earning assets.

However two other findings are worth highlighting: first, it appears that in the short run the direction of causation runs from liquid assets to earning assets whereas the reverse causality is found in the long run. From an economic point of view, it seems feasible that liquidity constraints can force rapid readjustments in the portfolio while the trend in the long run will be explained by the investment's profitability determinants, as the portfolio selection models seem to state. Secondly, in the case of deposits and earning assets, there is causality from the former to the latter, both in the short and the long run. Nevertheless, empirical evidence shows that in the long run there is a bidirectional causality relationship. The conclusion could be that in the short run the savings banks' management, in general, follows traditional schemes of transformation of saving into assets. However, in the long run, variables influencing investment earnings have an influence on the structure of and demand for liabilities.

To sum up, as can be seen from table 5, the major causality relationships go from the liability side of the balance sheet to the asset side. This seems to imply that the Spanish saving banks during the 80's followed an asset management strategy typical of a traditional retail banking industry in spite of the important changes in the Spanish financial system.

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References

Baltensperger, E. (1980) Alternative Approaches to the Theory of the Banking Firm. *Journal of Monetary Economics* 6, 1-37.

Barr, D.G. & K. Cuthbertson (1990) Modeling short term asset holdings of U.K. banks. *Discussion Papers, Technical Series* 34. Bank of England.

Bierwag, G. O., Kaufman, G. G. & Toevs, A.L. (1982) Single Factor Duration Models in a Discrete General Equilibrium Framework. *Journal of Finance*, 37, 325-338.

Boero, G. & Burridge, P. (1991) A simple non-parametric test for a unit root, *Discussion Paper* 91/10, University of Nottingham.

Brunner, K. & Meltzer, A. H. (1964) Some Further Investigations of Demand and Supply Functions for Money. *Journal of Finance*, 19, 240-283.

Corradi, V., M. Galeotti & R. Rovelli (1990) A Cointegration Analysis of the Relationship between Bank Reserves, Deposits and Loans. The Case of Italy, 1965-1987. *Journal of Banking and Finance,* 14. 199-214.

DeJong, D.N., Nankervis, J.C., Savin, N.E. & Witheman, Ch.H. (1992) The power problems of unit root tests in time series with autoregressive errors. *Journal of Econometrics*, 53, 323-343.

Dickey, D.A. & W.A. Fuller (1984) The Likelihood Ratio Statistics for Autorregressive Time Series with a Unit Root, *Econometrica*, 49, 1057-1072.

Dickey, D. A. & Pantula, S.G. (1987) Determining the order of Differencing in Autoregressive Time Series with a Unit Root, *Journal of Business and Economic Statistics*, 15, 455-461.

Dolado, J.J., Jenkinson, T. & Sosvilla-Rivero, S. (1990) Cointegration and Unit Roots, 4, 249-273.

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

Engle, R.F. & B.S. Yoo (1987) Forecasting and testing in co-integrated systems, *Journal of Econometrics*, 35, 143-159.

Escribano, A. (1990) Introducción al tema de cointegración y tendencias, *Cuadernos Económicos de I.C.E.*, 44, 7-42.

Fuller, W. A. (1976) *Introduction to Statistical Time Series*, Wiley, New York.

Gonzalo, J. (1989) Comparison of Five Alternative Methods of Estimating Long Run Equilibrium Relationships. *Discussion Paper* 89-55. University of California, San Diego.

Granger, C.W.J. (1988) Some recent developments in a concept of causality. *Journal of Econometrics*, 39. 199-211.

Hester, D.D. & Pierce, J.L. (1968) Cross-Section Analysis and Bank Dynamics. *Journal of Political Economy*, 76, part 2, 755-776.

Humphrey, D.B. (1981) Intermediation and Cost Determinants of Large Bank Liability Composition. *Journal of Banking and Finance*, 5, 167-185.

Johansen, S. (1988) Statistical Analysis of Cointegration Vectors. *Journal of Economic Dynamics and Control*, 12. 231-254.

Johansen, S. (1989) Estimation and Hypothesis Testing of Cointegrating Vectors in Gaussian Vector Autoregressive Models, *Preprint* 3/1989, Institute of Mathematical Statistics, University of Copenhagen.

Johansen, S. & Juselius, K. (1990) Maximum Likelihood Estimation and Inference on Cointegration with Applications to the Demand for Money. *Oxford Bulletin of Economics and Statistics*, 52, 169-210.

Koyck, L.M. (1954) *Distributed Lags and Investment Analyses*, North Holland Publishing Co.

Lewis, M. and K.T. Davis (1987) *Domestic and International Banking*. Phillip Allan.

Markowitz, H.M. (1959) *Portfolio Selection: Efficient Diversification of Investments*. New York, John Wiley and Sons.

Modigliani, F. & Papademos, L. (1990) The Supply of Money and the Control of Nominal Income in *Handbook of Monetary Economics*, vol. I, B.J. Friedman & F. H. Hahn (eds.). Elsevier Science Publishers B.V.

Orr, D. and W.G. Mellon (1961) Stochastic reserve losses and bank credit. *American Economic Review*, 51, 614-623.

Osterwald-Lenum, M. (1990) Recalculated and extended tables of the asymptotic distribution of some important maximum likelihood cointegration test statistics. Unpublished paper,University of Copenhagen/Economics Department UCSD.

Parkin, J.M., Gray, M.R. & Barrett, R.J. (1970) The Portfolio Behavior of Commercial Banks, in *The Econometric Study of the United Kingdom*, K. Hilton and D. F. Heathfield (eds.), pp. 229-251.

Pérez, F. & J. Quesada (1992) *Dinero y Sistema Bancario*. Espasa-Calpe.

Perron, P. (1988) Trends and Random Walks in Macroeconomic Time Series, *Journal of Economic Dynamics and Control* 12, 297-332.

Phillips, P.C.B. & Perron, P. (1988) Testing for a Unit Root in Time Series Regression, *Biometrika*, 75, 335-346.

Pierce, J.L. (1967) An Equilibrium Model of Commercial Bank Portfolio Management, in *Studies of Portfolio Behavior*, Donald D. Hester and James Tobin, 171-190. John Wiley & Sons Inc.

Repullo, R. (1990) La reforma del coeficiente de caja: una nota técnica. *Boletín Económico*, Abril, Banco de España.

Santomero, A.M. (1984) Modeling the Banking Firm: A Survey, *Journal of Money, Credit and Banking*, 16, 576-602.

Sastre de Miguel, M.T. (1991) La determinación de los tipos de interés activos y pasivos de bancos y cajas de ahorro, *Estudio Económico* 45. Banco de España.

Sealey, C.W., Jr. & J. T. Lindley (1977) Inputs, outputs, and a theory of production and cost at depository financial institutions, *Journal of Finance*, 32, 1251-1266.

Simonson, D.G., Stowe, J.D. & Watson, C.J. (1983) A Canonical Correlation Analysis of Commercial Bank Asset/Liability Structures. *Journal of Financial and Quantitative Analysis*, 18, 125-140.

Sims, C., A. H. Stock and M.W. Watson (1988) Inference in linear time series models with some unit root, *Econometrica*, 58, 113-145.

Slovin, M. & M. E. Sushka (1983) A model of the commercial loan rate: Theory an Evidence. *Journal of Finance*, 38, 1583-1596.

Spindt, P.A. & V. Tarhan (1980) Liquidity Structure Adjustment Behavior of Large Money Center Banks. *Journal of Money, Credit and Banking*, 12, 198-208.

Stiglitz, J. E. & A. Weiss (1981) Credit Rationing in Markets with Imperfect Information. *American Economic Review*, 71, 393-410.

Tamarit, C.R. (1992) Análisis del Comportamiento de las Cajas de Ahorro a través de sus Relaciones de Balance: Teoría y Evidencia Empírica para el Caso Español. *Tesis Doctoral*, Universitat de València.

Table 1

TESTING PROCEDURE FOR PHILLIPS-PERRON UNIT ROOT TEST

(1)

GENERAL MODEL

$$Y_t = \tilde{\mu} + \tilde{\beta}\,(t\text{-}T/2) + \tilde{\alpha}\, Y_{t-1} + \tilde{\zeta}_t$$

H_0^3: Z (ϕ_3)

H_0^1: Z ($t_{\tilde{\alpha}}$)

STOP ← Rejected | Non-rejected ↓

H_0^2: Z ($t_{\tilde{\beta}}$)

Z($t_{\tilde{\alpha}}$) NORMAL ← Significant | Non-significant ↓

H_0^4: Z (ϕ_2)

(2)

MODEL WITH DRIFT

$$Y_t = \mu^* + \alpha^*\, Y_{t-1} + \zeta^*_t$$

H_0^5: Z (t_{α^*})

STOP ← Rejected | Non-rejected ↓

H_0^6: Z (t_{μ^*})

Z(t_{α^*}) NORMAL ← Significant | Non-significant ↓

H_0^7: Z (ϕ_1)

(3)

MODEL WITHOUT DRIFT OR TREND

$$Y_t = \hat{\alpha}\, Y_{t-1} + \hat{\zeta}_t$$

H_0^8: Z ($t_{\hat{\alpha}}$)

Table 2

PHILLIPS-PERRON TEST. PERIOD 8:01-90:12

	$\Delta^2 AR$	$\Delta^2 BR$	$\Delta^2 CR$	$\Delta^2 DR$	$\Delta^2 ER$
$Z(\phi_3)$	818.9a	643.80a	523.00a	666.90a	794.9a
$Z(t_{\tilde{\alpha}})$	-41.3a	-36.73a	-131.20a	-37.36a	-40.79a
$Z(t_{\tilde{\mu}})$	-0.37	0.04	-0.34	0.54	0.47
$Z(t_{\tilde{\beta}})$	0.90	-0.40	-1.06	0.61	0.40
$Z(\phi_2)$	546.0	429.20	348.70	444.60	530.0
	Δ AR	Δ BR	Δ CR	Δ DR	ER
$Z(\phi_3)$	110.1a	61.12a	55.19a	90.93a	96.34a
$Z(t_{\tilde{\alpha}})$	-15.14a	-11.27a	-10.73a	-13.74a	-14.14a
$Z(t_{\tilde{\mu}})$	1.12	5.97	4.19	5.49	5.99
$Z(t_{\tilde{\beta}})$	-2.01	2.87	0.82	1.26	1.50
$Z(\phi_2)$	73.43	40.75	36.81	60.66	1.39
	AR	BR	CR	DR	ER
$Z(\phi_3)$	3.33	6.40	4.96	5.06	5.41
$Z(t_{\tilde{\alpha}})$	-2.07	-1.44	-2.95	-3.00	-3.05
$Z(t_{\tilde{\mu}})$	2.18	1.94	3.25	3.18	3.25
$Z(t_{\tilde{\beta}})$	0.42	2.10	2.69	2.59	2.75
$Z(\phi_2)$	2.46	24.41a	11.89a	12.69a	15.24a
$Z(t_{\alpha^*})$	-2.58	3.11	1.01	11.37	1.29
$Z(t_{\mu^*})$	2.34	-0.53	1.21	0.40	0.49
$Z(\phi_1)$	9.59a	37.37	17.90	22.97	27.35
$Z(t_{\hat{\alpha}})$	0.36	8.50	5.78	6.86	7.46

NOTES: (I) "a" and "b" denote significance at the 1% and 5% levels, respectively. (II) The critical values for $Z(t_{\mu}*)$, $Z(t_{\tilde{\mu}})$, $Z(t_{\tilde{\beta}})$ and $Z(\phi_i)$ (i = 1, 2, 3) are taken from Dickey-Fuller (1981, Tables I to VI, respectively). The critical values for $Z(t_{\hat{\alpha}})$, $Z(t_{\alpha}*)$ and $Z(t_{\tilde{\alpha}})$ are taken from Fuller (1976, Table 8.5.2)

Table 3

BOERO-BURRIDGE TEST CRITICAL VALUES

Percentiles for the distribution of the number of sign changes under the null of a random walk. The entries give the probability of a greater or equal number of sign changes

Sample size	sign changes							
	14	15	16	17	18	19	20	21
50	.0346	.0214	.0117	.0067	.0037	.0020		
100	.2240	.1770	.1380	.1060	.0805	.0594	.0430	.0311
150				.2380	.1990	.1640	.1350	.1090
250							.2350	.2010

DGP for Y_t is: $\beta + \alpha Y_{t-1} + u_t$, with $\beta = 0$, $\alpha = 1$ and u_t is N(0,1). The sign change is computed on the OLS residuals of the regression $Y_t - Y_0 = \beta t + \Sigma u_t$, that is, the residuals from the regression of $Y_t - Y_0$ on t. Since the test is invariant to β, setting $\beta = 0$ implies no loss of generality.

Table 4

TESTS FOR COINTEGRATION
FOLLOWING JOHANSEN PROCEDURE
PERIOD 1981:01-1990:12

Normalized vectors						
Eigenvalues	0.326	0.21464	0.32826	0.34489	0.32562	0.34716
Variables						
A	-1	-1	—	—	-1	-1
B	-0.059	—	-1	-1	—	-0.1
D	—	0.03	1.63	—	—	0.11
E	—	—	—	1.35	0.03	—
CONST	7302.6	3673	-32045.9	-23099.5	3020.0	4128.8
Lag in VAR	1	4	3	3	3	2
Test λ max.						
Case 1	47.01*	28.02*	46.55*	49.48*	46.09*	37.27*
Case 2	7.31	8.30	2.98	3.14	7.90	10.94
Test Trace						
Case 1	54.33*	36.33*	49.53*	52.63*	53.99*	51.63*
Case 2	7.31	8.70	2.98	3.14	7.90	14.36

	hypothesis			hypothesis	
Test λ max.	null	alternative	Test trace	null	alternative
Case 1	r=0	r=1	Case 1	r=0	r≥1
Case 2	r≤1	r=2	Case 2	r≤1	r=2

* means the null hypothesis can be rejected.

Critical values are taken from Osterwald-Lenum (1990).

Table 5

Short Term Causality (Sims et al.,1990)	
Direction of the Causality	Liquid Assets ⇒ Earn. Assets
Test F	$F(11,82) = 1.892$
Level of Significance	0.052
Direction of the Causality	Deposits ⇒ Liquid Assets
Test F	$F(11,82) = 1.701$
Level of Significance	0.087
Direction of the Causality	Deposits ⇒ Earn. Assets
Test F	$F(11,82) = 3.645$
Level of Significance	0.0003
Direction of the Causality	Liabilities ⇒ Earn. Assets
Test F	$F(11,82) = 3.149$
Level of Significance	0.001
Direction of the Causality	Liabilities ⇒ Liquid Assets
Test F	$F(11,82) = 1.866$
Level of Significance	0.056
Long Term Causality (Sims et al.,1990)	
Direction of the Causality	Earn.Assets ⇒ Liquid Assets
Test F	$F(1,82) = 3.763$
Level of Significance	0.055
Direction of the Causality	Deposits ⇒ Earn. Assets
Test F	$F(1,82) = 17.669$
Level of Significance	0.00006
Direction of the Causality	Earn.Assets ⇒ Deposits
Test F	$F(1,82)= 4.634$
Level of Significance	0.034
Direction of the Causality	Liabilities ⇒ Earn. Assets
Test F	$F(1,82) = 16.944$
Level of Significance	0.00009

Note: "⇒" denotes Granger's causality.