SEASONAL ADJUSTMENT IN ECONOMIC TIME SERIES: THE EXPERIENCE OF THE BANCO DE ESPAÑA

(with the model-based method)

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Abstract.

For over 20 years the Banco de España has been using seasonally adjusted series for economic analysis and, more specifically, for monitoring the main monetary and financial magnitudes. This paper presents the Banco de España's experience in this field, describing the various methodological aspects that lead a central bank to use seasonally adjusted series in monetary monitoring and analysis. The paper further describes and substantiates the use of a procedure such as ARIMA model-based signal extraction for seasonally adjusting economic series. Lastly, a specific instance of seasonal adjustment using this methodology is offered: the analysis of the seasonality of the Spanish component of the euro area M3 aggregate. This case study illustrates in detail how the Banco de España has been regularly conducting its monetary and credit aggregate seasonal adjustment exercises up to 1999.

Key words: monetary aggregates, seasonal adjustment, model-based signal extraction, TRAMO/SEATS procedure.

Seasonal adjustment in economic time series: the experience of the Banco de España (with the model-based method)

1. INTRODUCTION

The experience of the Banco de España in seasonal adjustment has been very extensive over the past 20 years. During this time there have been progressive changes in strategies and methodology and, indeed, a certain loss of significance or a relativisation of analysis in terms of seasonal adjustment in recent years. In fact, since the early nineties, the Banco de España has progressively paid more attention to longer rates, with month-to-month developments becoming less important. In this sense, it should be noted that the importance and the means of using seasonally adjusted series is highly conditional upon the role we wish to give to economic series and, specifically, to monetary aggregates (and the HICP).

That said, this paper is based on a summary of some of the articles published by the Banco de España in its official publications, specifically in the Boletín Económico, relating to the successive annual exercises involving the seasonal adjustment of the monetary and credit aggregates. Throughout these articles, the Banco de España has explained first, the economic fundamentals that led it to monitor the monetary aggregates using seasonally adjusted series; and further, the justification and diffusion of the methodology and procedures which, to its understanding, were best suited to this task and which, from 1986 onwards, were carried out drawing on model-based signal extraction methodology. Initially the Burman (1980) procedure was used, followed by SEATS (Maravall, 1987) and, subsequently, TRAMO/SEATS (Gómez and Maravall, 1992).

The rest of this paper is structured as follows. Section two discusses the criteria that lead central banks -and in this case led the Banco de España- to seasonally adjust their monetary aggregates. Section 3 justifies from a methodological standpoint the advantages for monetary analysis in the short term of using a seasonal adjustment procedure such as ARIMA model-based signal extraction. Finally, section 4 illustrates, with an exercise involving the seasonal adjustment of the monetary series relating to the Spanish contribution to the M3 aggregate, the type of analysis and presentation structure that the Banco de España has habitually conducted using the analytical tools provided by TRAMO/SEATS.

2. WHY MAY THE SEASONAL ADJUSTMENT OF MONETARY AGGREGATES BE NECESSARY FOR A CENTRAL BANK?

In line with other central banks, the guiding principles previously adopted by the Banco de España, regarding the use of seasonally adjusted series in the monitoring of short-term monetary aggregates and their publication, may be summarised as follows:

1) Most monetary series show certain regular periodic fluctuations that emerge in a recurrent fashion each year with a similar intensity and frequency. As these fluctuations can be isolated by sufficiently reliable estimates, it is worthwhile eliminating them from the monetary magnitudes, constructing series adjusted for seasonal movements. Two basic arguments underlie the use of seasonally adjusted series by central banks. First, these periodic fluctuations contribute significantly to short-term movements in many monetary series. As a result, their presence dominates the movement of other components of a greater economic significance and precludes, therefore, proper evaluation of the behaviour of the monetary aggregates based on original series, especially over short periods of time. Further, central banks are usually interested in detecting certain regularities shown by the monetary series as a result of specific, systematic behaviour by the general public, in its demand for liquidity, and by financial intermediaries, in the process of multiple expansion of assets.

2) As in all signal extraction processes, seasonal adjustment is a relatively artificial transformation of the original series that may be of some importance for the decisions taken by the monetary authorities. This is what made the Banco de España particularly cautious when it came to incorporating new methodologies and to publishing alternative transformations of the monetary series to act as a reference for the monitoring of the reference variables, and all the more so if these were target variables.

   In this way, the Banco de España decided that, notwithstanding the fact that a rigorous statistical analysis of monetary developments may require the estimation of trends, cycles and irregular elements, the official presentation of the data should be limited to the seasonally adjusted series, since the revision errors were habitually smaller and revised annually.

Over the past ten years, however, the development of signal extraction techniques along with changes in the monetary implementation framework in parallel with the growth of money and financial markets, led the monetary authority to look for indicators in the monetary aggregates. Such indicators would enable it to assess liquidity developments not only from the standpoint of its short-term control, but also would desirably provide the most relevant information possible to explain the course of the end variables, principally prices. In this respect, progressively less emphasis was placed on monitoring the monetary aggregates on the basis of very short seasonally adjusted rates, and the use for internal monetary analysis purposes of some signal less contaminated by regular and irregular disturbances, such as the trend-cycle, was considered. It was thought that the signal could approximate more exactly to the course of the stable core of the money supply. That is to say, its course could be linked to the greater stability that the portion of liquidity that agents demand on the basis of their short-term expenditure planning should, in principle, show.

As a final reflection, one big advantage of model-based methods is that they provide a robust framework to deal with a large set of important statistical problems in an internally consistent manner.

3. USE OF THE ARIMA MODEL-BASED SIGNAL EXTRACTION METHOD IN THE BANCO DE ESPAÑA

The generalised use of the univariate model-based signal extraction method by the Banco de España is underpinned by the perception that this methodology offers advantages over other, more usual empirical methods. As is known, the justification for this methodology is extensively reflected in the traditional literature [see Box, Hilmer and Tiao (1978), Burman (1980), Hilmer and Tiao (1982), Bell and Hilmer (1984) and Maravall (1987)[1]]. Subsequently, numerous papers have analysed in greater depth the use of this methodology and its potential advantages compared with other alternatives. Specifically, taking Maravall's line (1987), the reasons behind the adoption of this methodology may be summarised as follows.

The procedures based on X11, for example, are empirically developed methods that include in an ad hoc fashion a series of characteristics common to a large number of economic series. The absence of a model severely limits an analyst's capacity. First, because it does not allow appropriate diagnosis of the results to be made and, therefore, it offers no means of improvement if this is inappropriate. Second, because the absence of a model for the non-observable components prevents statistical inference from being carried out. However, the model-based seasonal adjustment methodology allows for each series more specific treatment of the problem of extracting its seasonal component, and the rest of the non-observable components of an economic series.

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[1] Indeed, this last reference has been the basis for the official adoption by the Banco de España as from 1988 of the ARIMA model-based signal extraction methodology using the SEATS application.

A model-based seasonal adjustment method provides information on the properties of the estimators used, and the estimation errors. This makes it possible to estimate confidence intervals for the seasonally adjusted series that reflect the inaccuracy with which seasonality is estimated. The need for a mesure of the precision of the seasonal adjusted series estimator has been emphasised for a long time by “expert committees; see Bach et al, (1976), Moore et al, (1981)

Back in 1981, the committee of experts on seasonal adjustment techniques meeting in the United States Federal Reserve included among its recommendations the need to apply the model-based seasonal adjustment method to monetary series on an experimental basis in parallel with the official X11-ARIMA-based procedure. At that time a model-based method seemed to present two serious drawbacks: Computational expense and the need for expert help. Since then, the work conducted on signal extraction (much of it in the Banco de España) under this model-based approach has contributed notably to its statistical fundaments and to its better application for the seasonal adjustment of economic series. In particular, the procedure is very efficient computationally, and the need for time series experts is now minimal.

The model-based method provides for the development of a complete analytical framework in which questions relating to the diagnosis and inference of an economic series can be answered naturally. Such questions would be as follows:

- With what error is seasonality measured?
- What are the confidence intervals for the seasonal factors?
- How are these errors passed through to errors in growth rates?
- How is the effect of the errors smoothed by considering rates averaging several months?
- Would it be preferable to use the trend instead of the seasonally adjusted series in the short-term monitoring of the series?
- How often should seasonal adjustment be carried out?
- How long should the revision of the seasonally adjusted series last?
- If the central bank were to set a target range, what is the implicit tolerance band for the targets set for these rates?

- For a sequence of deviations from this target, how many months should elapse before it is accepted that growth is proving significantly different from the target?

The crucial point in this methodology is, on the basis of a univariate ARIMA model for the observed series, to derive ARIMA models for the various non-observable components, i.e. the seasonal component, the trend-cycle and the irregular component, and to be able to conduct an inference and diagnosis analysis not only of the series observed but also of its non-observable components.

Insofar as it is usual in short-term economic analysis to extrapolate from the original series using more or less complex ARIMA models, it is an additional advantage that the same model available for forecasting, whose behaviour and assessment should be monitored most closely, may also be the model that is used for extracting more specific and fully compatible information on the seasonal or trend pattern of the series.

The possibility of conducting inference and diagnostic analysis of the non-observable components arises due to the derivation of the estimation errors of these components. A highly descriptive explanation is given below of the means of obtaining and using the estimation errors on the components. The derivation of these errors, found in Maravall, 1987, is reproduced in annex 1.

Let $\mathbf{X}_t$ be an observed series, produced by a trend, a seasonal factor and a irregular factor. Taking logarithms, the multiplicative relationship becomes the following additive one:

$$Z_t = P_t + S_t + U_t \qquad \textbf{(1)}$$

Where $\mathbf{Z}_t = \mathbf{log}(\mathbf{X}_t)$ and the three terms on the right-hand side represent the trend, seasonal and irregular components respectively. These components are unknown. When they have been estimated the series Zt will be equal to the sum of the three estimators, i.e.:

$$\hat{Z}_t = \hat{P}_t + \hat{S}_t + \hat{U}_t \qquad \textbf{(2)}$$

The difference between an estimator and its corresponding component is the estimation error. For example, $S_t - \hat{S}_t$ is the estimation error of the seasonal component at time t, and will obviously be equal (although with the opposite sign) to the estimation error of the seasonally adjusted series. These errors are important, in a context of monitoring of the monetary aggregate using the seasonally adjusted series within the current year. In this respect, for example, if for a given month growth in the monetary aggregate of 9% is recorded (in annualised terms), how accurate is this measurement? If the reference (or the target) is growth of 5%, it is important to determine whether the difference indicates that the monetary aggregate is growing more or less than desired, or whether the difference can be perfectly explained by the measurement error arising from seasonal adjustment of the series.

At the same time, since the irregular component represents erratic and transitory changes, it could be useful to establish the monitoring of the monetary reference on the basis of a measure of the trend, for example, instead of on the basis of a seasonally adjusted series. It would therefore be useful to determine and verify the estimation errors of these two measurements.

Equation (1) implies that, for each new observation Z_t, it is necessary to estimate three non-observable components. This is, therefore, "a case of incidental parameters", in which the degrees of freedom do not increase with the number of observations. In consequence, even for an infinite series of data, the components would be estimated with an error with positive variance. This asymptotic error (which would exist even if the infinite history of the series were known) is called "error in the final estimator".

For a finite series, the estimation error of a component will be increased by the effect of the values of the variable outside the interval spanning the available data, which contain additional information for the estimation of the component. The estimator of a component for a time t is obtained as a linear combination (a filter) of values of the series at and around t. In all cases this filter is centred and symmetric, with weights which tend towards zero the further the observation from period t. The estimator of the component for time t thus depends symmetrically on past and future values of the series. In theory, the series may extend to infinity in both directions, but the tendency of the weights to approach zero means that it may be truncated after a finite number of years.

To estimate a component at times closer to the present, there will be two possible sources of error associated with the finite nature of the series. First, the filter may extend into the past beyond the initial observations available. Second, the filter will extend into the future and its application will require values of the series that are currently not known. What is most relevant here is the effect due to the absence of future observations. To estimate the component for a time close to the present (sufficiently close that the filter cannot be completed due to the absence of future observations), an optimal preliminary estimator is obtained by extending the available series with forecasts and applying the complete filter to the extended series (The Burman-Wilson algorithms provides an exact solution using just a small number of forecasts). As time passes and new observations arise the forecasts are updated and eventually replaced by observations. The preliminary estimator will be revised until, when the filter has been completed with observations, the "final estimator" is obtained. The difference between the final and the preliminary estimator provides the "revision error". The revision error and the final estimator are independent, so that the variance of the error in the preliminary estimation is the sum of the variance of both types of error. The problem in measuring the error in the estimation of a component is that they are never observed. However, the model-based method enables their structure to be derived and their distribution estimated (see Pierce, 1979 and Maravall, 1986).

In order to illustrate how the statistical concepts presented above are applied in practice, an assessment is made in the following section of an exercise of seasonal adjustment of the monetary series corresponding to the Spanish contribution to the euro area monetary aggregate. The structure of this analysis and the presentation of results are similar to the way in which the Banco de España has annually been obtaining and publishing the results of the exercise of seasonal adjustment of monetary and credit aggregates.

4. SEASONAL ADJUSTMENT OF THE SPANISH COMPONENT OF THE MONETARY AGGREGATE M3

This section presents the results obtained in the seasonal adjustment exercise on the Spanish contribution to the aggregate M3. The aim of the analysis is twofold. First, by means of a practical application, it seeks to illustrate the use of ARIMA model-based signal extraction methodology, in the form in which the Banco de España has traditionally conducted its seasonal adjustment exercises. Further, taking the components of the Spanish contribution to the aggregate M3 as a basis, the three possible alternatives for seasonally adjusting the monetary aggregate are compared. These are, namely, direct seasonal adjustment of the aggregates (M1, M2 and M3), indirect seasonal adjustment through aggregation of the individual components and indirect seasonal adjustment through aggregation of the broadest sub-components (M1, M2-M1 and M3-M2).

The results given below have been obtained from the information available to August 1993[3]. The sample period analysed runs from January 1980 to June 1999. Although the analysis in this case is spread over 20 years, in a regular seasonal

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[3] Possibly, some subsequent revision of the underlying information may have been carried out, principally in association with adjustment series. In any event, in the Spanish case the revisions are scant, owing to their nature, and do not affect the seasonal pattern of the Spanish components of M3 that are identified and analysed in this paper.

adjustment exercise, in which there are no relevant revisions in the original underlying series and in which the process of revising the estimation of the non-observable components is finalised after around five years, a sample period of 10 years would suffice.

The analysis has been conducted on the 12 series of adjusted flows of the following components and aggregates:

- Currency in circulation **(CUR)**
- Overnight Deposits (**OD**)
- Deposits with agreed maturity up to 2 years (**TD**)
- Deposits redeemable at notice up to 3 months (**RD**)
- Repurchase agreements (**REPO**)
- Money market fund shares/units and money market paper (**MMF**)
- Debt securities issued with maturity up to 2 years (**DEBSEC**)
- **M1**=CUR+OD
- **M2**=M1+TD+RD
- **M3**=M2+REPO+MMF+DEBSEC
- **M2-M1**
- **M3-M2**

4.1. Characterisation of ARIMA models

An ARIMA model has been estimated for each of the monetary series using the TRAMO program in a pseudo-automatic identification process. For the treatment of "trading day" effects, a specific variable has been used for the stock series[4]. Likewise, a specific variable has been used to capture the effect of Spanish public holidays that fall at the end of the month. Probably, the overall consideration of the trading day effect, bearing in mind public holidays, could provide some additional improvement to the adjustment (see footnote 4 again). Nonetheless, in the calendar of national public holidays, the only ones with a certain effect on the end of the month are: 1st November (All Saints' Day), 1st January (New Year's Day), and in certain years the varying public holiday of Good Friday. The specific treatment provided in the TRAMO program has been used for this latter effect.

Table 1 presents the characterisation of the noise model and the different outliers identified in each of the components. In general terms, it is seen how, with the exception of the MMF and DEBSEC series, the models estimated show acceptable statistical properties. In the case of the two components mentioned, the breaks observed in the original series are indicative of the difficulty of modelling the behaviour of the series (see Chart A2.1 in Annex II).

4.1.2 Characterisation of the pattern

First, to obtain the best adjustment possible in the estimated single-equation models, allowing subsequently for the study of the profile of a series and optimal estimation of the unobservable components, it is necessary to isolate the possible breaks that might be identified and the profile of the series of aggregates and components. The most significant interventions identified and estimated in relation to the degree of incidence of some of the instruments considered in the light of their inclusion or not in some of the aggregates are also presented in Table 1.

These breaks in the profiles of the series are principally associated with financial phenomena, such as the emergence of new instruments or changes in prevailing regulations that may prompt switching from one instrument to another, or changes in the tax payment calendar that affect not only the trend pattern but also the seasonal behaviour of the series. By way of illustration, one of the latest effects to involve a break in the pattern of the Spanish monetary components in M3 was the tax reform that came into force in January 1999. However, the announcement of the entry into force of these fiscal measures, which essentially entailed a relative improvement in

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[4] This effect is constructed on the basis of a matrix of six dummy variables (one for each day of the week, Sunday excluded). The series have a 1 if the last day of the month falls on a trading day (Monday, Tuesday, Wednesday … Saturday) and 0 for the others. If the last day of the month is a Sunday, a -1 is introduced into each of the variables in this position. In that way the "trading day" effect is cancelled out over the whole of the sample period considered. One variant that has not been considered in this study is that of considering the effect of public holidays that fall at the end of the month on appropriate weightings. We should like to acknowledge Björn Fisher for having provided these series and a description of them.

the conditions for tax purposes of deposits as opposed to other financial assets such as mutual funds, translated into a significant positive step effect on overnight deposits. This probably included the realisation of capital gains on mutual funds with a view to avoiding the withholding that began to be applied to these funds as from February 1999. Likewise, deposits with a maturity of up to two years became, for much of 1999, recipients of money market mutual funds (FIAMMs and other fixed-income and equity funds), contrary to what occurred in 1997. This all leads to the identification and estimation of a step effect in November 1998 in the series of deposits (OD, TD) and in the aggregate M2. This effect has the opposite sign in the sub-component of M3-M2, and is neutralised in M3. However, the aggregate M1 does not reflect this effect. Likewise, the start of EMU has a transitory and marginal effect on the Spanish component that is essentially reflected in a low-value impulse effect in the narrower aggregates.

With regard to the structure of the noise models, 8 of the 12 series analysed have a stochastic seasonal structure reflected by means of a seasonal moving average term MA (12). A high value of the coefficient indicates that seasonality is less stochastic and less mobile. Specifically, the components OD and RD are characterised by their relatively non stochastic seasonal pattern. In the case of TD this pattern is virtually deterministic. On the contrary, it can be seen how the series of cash held by other residents sectors (CUR) shows a very mobile seasonal pattern throughout the sample period, which is combined with an autoregressive structure that reflects an intra-annual cycle of quarterly periodicity. The seasonal pattern of the rest of the components such as REPO, MMF and DEBSEC is much more blurred. Only the REPO series with the 12th-order seasonal autoregressive term shows apparently very mobile seasonality. It should be pointed out that one of the financial disturbances that has most affected the historical trend of the monetary component in Spain was the propagation of the 1985 Financial Assets Act, which granted favourable treatment in relative terms to short-term government securities at the expense of bank products[5].

This type of intense switching between components of the monetary aggregates, generally associated with regulatory changes, has entailed significant trend changes. These are reflected in the estimation of a high coefficient for the regular part of the stochastic structure, highlighting the presence of a relatively non-stochastic trend. This is the case of the components of MMF, REPO and DEBSEC, for

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[5] At that time the legislation appreciably affected not only trend changes but also the seasonal regularity of the national monetary aggregates, insofar as the component chiefly affected by public portfolio switching was bank deposits. Inasmuch as the distinguishing features of deposits and other types of instruments such as government securities became clearer, as did their role in the public's portfolios, the sizeable initial switching gradually diminished. This was reflected in the recovery by deposits of seasonal regularity and in the gradual appearance of a regular seasonal pattern for short-term public securities (which were included in the national aggregates in the past), and repos, associated with treasury management arrangements.

which periods of intense growth with subsequent and likewise intense declines are recorded.

Logically, insofar as these processes are internalised in the broadest aggregate, the regular structure shows a more stochastic trend, as is the case of M3. In the narrower aggregate, the only predominant pattern is a seasonal structure which, as can be seen, highlights the weight in the Spanish component of M3 of deposits. The latter, along with cash, are the core of the seasonality of the monetary components.

4.2. Characterisation of the seasonal pattern

The following step after the estimation of the ARIMA models for each of the series is the estimation of the seasonal component that will enable the corresponding seasonally adjusted series to be prepared.

As indicated in the foregoing section, the methodology was that of model-based signal extraction, using the SEATS application. The process of breaking down the series into non-observable components (trend-cycle, seasonal and irregular) involves an estimation of the theoretical model for each of them on the basis of the ARIMA model of the series observed. A comparative analysis of the results of the estimation of these components is made in this section. The focus is mainly on seasonality, having regard to least estimation error criteria for the components, and a revision of the seasonal factors as new information becomes available.

It may be concluded from comparing these results that the seasonal patterns of the three monetary aggregates considered do not show marked differences. Evidently, all of them are dominated by the seasonal pattern of deposits, which are, along with cash, the core of seasonality, accounting for more than 75% of the Spanish contribution to M3. This is why it may be ventured that this aggregate, both in terms of its trend or seasonal adjustment, offers better qualities for short-term monitoring, since it may be deduced from the estimation of its non-observable components that the trend is smoother and estimated with less error. The M3 aggregate, however, shows somewhat worse qualities compared with M2. This is specifically apparent in the estimation of a greater contribution of the irregular component to the unpredictability of the series approximated by residual variance. This is mainly determined by the greater erraticism of the components encompassing M3-M2, the trend of which is marked by greater volatility without such a marked trend or stochastical seasonal pattern.

This type of conclusion can be obtained from analysis of the data in Tables 2 and 3 in which the variance of the innovations and the variance of the estimation errors of the non-observable components are respectively presented for each of the series analysed. Other comments that may be made on the various instruments and aggregates in the light of these tables might be the following:

- Currency displays a high contribution by seasonal components to the residual variance of original series. Seasonally adjusted series significantly reduce the innovation of original series. It is important to note that the innovation of the irregular component is especially low.

- In the case of REPO, with the seasonal effect estimated by a AR(12) that can represent a highly stochastic seasonality, shows a high innovation of the seasonal component too.

- The estimation of the Time deposits innovations shows a low contribution by seasonal components to the residual variance. It shows the higher volatility in the trend-cycle component too. That implies a highly stochastic trend. This evidences the difficulty of short-term monitoring of this component.

- Overnight Deposits presents a very high contribution of innovation by the irregular component linked to the seasonal one. This linked, to innovation in the seasonal component, suggests that the monitoring of this component would be improved were trend component used, instead of seasonally adjusted series, although the innovation of the trend component implies a very stochastic trend too.

- Looking at aggregates, in M1 the innovation of the seasonal effect of overnight deposits predominates. The trend-cycle component shows a low innovation, probably due to the offsetting of the effects of OD and CUR. That makes this signal more useful than the seasonal adjustment. Moreover the irregular component, also display a higher innovation.

- The seasonal innovation of the rest of the deposits, and M1 is offset each other M2-M1 the innovation of the seasonal component fades out, although this is not the case for the innovation of the trend component that displays a high innovation. Moreover, the use of the seasonally adjusted series in M2, reduces the residual variance of the original series by, approximately 40%.

- The rest of the components, between M2 and M3, are dominated by the innovation of the trend-cycle and the very low innovation of the seasonal component. This innovation would correspond, mainly, to the seasonal innovation of REPO series.

With respect to the estimator error of the non-observable components, it can be seen that, in general, the revision error (referring to the concurrent estimator, which in turn is the estimator for month "t" when the latest data available are those of month "t") is around 50% of total error. This highlights that the series revision process substantially reduces revision error. Later, the degree to which the variance of the estimator is reduced is evaluated in the case of a concurrent adjustment in the various series.

It can further be seen in all the components that the trend-cycle estimator error, which is apparently a milder signal, is slightly higher than that of the adjusted series. The interpretation here could be that the use of a signal such as the trend-cycle signal does not generally mean an accurate estimation.

Considering the revision error of the contemporaneous estimator, Table 4 shows how a revision process for both the trend-cycle estimator and for the seasonally adjusted series is completed in virtually three years in the most liquid components (CUR and OD). This might advise the use of the concurrent estimation strategy for these components, as well as for the aggregate M1, as the percentage of reduction of the residual variance infers. By contrary, in the case of term deposits, it is important to see that this process of revision is much slower. This justifies the fact that, for M2 and M3, the advantage of using a concurrent adjustment procedure in terms of the improvement in the quality of the adjustment is not as clear as in the case of M1. This is set against the disadvantages to be found in this type of seasonal adjustment owing to the problems of interpretation and comparison of the new information.

One of the most interesting results is the analysis of the degree of change in seasonality. Table 5 presents a statistic for the total (stochastic plus deterministic) seasonal factors for the different components and aggregates, which is obtained by computing the deviation of seasonal factors from 100 (which implies no seasonality). Thus, under the hypothesis of regularity of the seasonal component that would be derived from the low innovation estimated for this component, it might be affirmed that the higher values for V_j would indicate more marked seasonality (the seasonal factor is greater the further the value is from 100). Conversely, much lower values for this statistic would infer the presence of less marked seasonality.

Hence, a horizontal reading enables the degree of seasonality of the different aggregates and components to be compared. A vertical reading of the table shows the trend of seasonality over time, insofar as the value V_j varies from one year to the next. Moreover, the adjustment of a simple regression against time of the related V_j estimated for each aggregate gives a measure of the relevance of the trend of this seasonality, as well as the direction of this trend.

One of the most relevant points in this characterisation is the change of seasonality of currency since 1980. The spread of use of ATM (Automated teller machines) and plastic money, has made the seasonality less marked and the loss of a seasonal pattern has been very significant in the last twenty years. By contrary, OD maintains the seasonal pattern associated with the payment of salaries, interest rate payments, and taxation, i.e. this series maintains a very close link to the annual pattern of the public´s income/spending. The same is the case with RD. Other components more associated with the saving concept, depending more on changes in interest rates and other aspects with lesser marked seasonality, generally, less marked and are relatively stable over time.

Apparently, the seasonality of REPO series is very marked. This is odd, because these financial assets have traditionally substituted TD and the seasonality of TD is more related to the role of this component in the financial innovation process, until the finalisation of the fiscal harmonisation process. 1984 saw the first public debt repos, and these were very attractive in relation to TD or other deposits. In 1985 there was a law of fiscal reform of financial assets, and in 1987 the Treasury bill issues began. Comparing the trend and degree of seasonality of the various aggregates, the most marked seasonality is seen to be that of M1. This pattern has also changed considerably, becoming progressively blurred over the years, while in the case of the other two aggregates, seasonality that is not so marked and changes less has prevailed. In this respect, it is important to analyse the degree of internalisation of seasonality between components. M2 and M3 reflect the neutralisation in the seasonality between deposits and repos and MMFs. Consequently, M2 and M3 remain very stable over time in the seasonal pattern, which is associated with the integration of components with a relatively different seasonal pattern offsetting one another.

4.2.1 Suitable filters for evaluating growth rates

Another notable features of the methodology used is the ability to obtain confidence intervals for the growth rates estimated drawing on the seasonally adjusted series, as well as for the seasonal factors. This inference analysis reflects to some extent the results relative to estimation errors, the revision of non-observable components, changes in seasonality, etc, discussed previously.

The confidence intervals estimated for the final factors presented in Table 6 indicate the width that this interval represents in respect of the level of the series. These intervals highlight, in the case of the three aggregates considered, that M3 has the least width in its confidence interval, from 1% in terms of the contemporaneous estimator to 95% confidence of the estimation, declining to 0.8% of the level of the series in terms of the final estimator. For its part, M2 has a very similar width to that of

M3. Without being particularly big, these intervals give some idea of the degree of caution with which the seasonally adjusted data of the monetary aggregates must be handled. Nonetheless, the width difference between the contemporaneous and final estimators also highlights that the information revision process is not particularly relevant in determining the goodness of fit in the estimation of seasonal factors in the case of an annual projection strategy (and in the absence of additional revisions of the original series). However, in the case of M1 the difference in the estimated interval widths for the factors relative to the contemporaneous or the final estimators broadens to almost 0.7% of the level of the series. It is seen how this estimated interval for factors duplicates in relation to that of the aggregates M2 or M3.

In respect of some of the components, it might be pointed out that the seasonal factors of term deposits up to a maturity of two years are those which show least width, of around 1%. The estimated width in the case of REPOS gives some idea of the scant quality of the estimation of seasonal factors and the caution required in interpreting the seasonally adjusted components. Yet insofar as monitoring and the growth references (or targets) are set in terms of rates, it is worth analysing the effect of measurement errors on these growth rates.

In this respect, Table 7 offers the different types of rates traditionally used in the Banco de España in monitoring the monetary aggregates or other financial magnitudes. In order to make annual growth references comparable, the shortest-dated rates, which measure month-on-month or quarter-on-quarter changes, are annualised. It is known that such annualisation implicitly entails a prediction in the sense that the latest estimated change holds constant for the rest of the year[6] [7].

The problem posed by a rate as short as that of a month-on-month growth rate (whether annualised or not) is the fact that, frequently, the month-to-month interpretation is especially difficult as it is confined to such a short space of time. Occasionally, this may be determined by a "discrete" disturbance that may affect a specific month, or by the very provisionality of the latest data with which this type of rate is calculated. This is why the Banco de España has also used other short rates in which an interval of several months is averaged. That gives a less erratic pattern as regards the trend of the aggregate. Chart 1 shows the monetary aggregates using several growth rates for the series, which have undergone seasonal adjustment by the direct method. It can be seen how rates such as T^1_3 (T^1_3 and T^3_1 are virtually

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[6] In the use of annualised rates, it is also assumed that, in respect of annual rates, variance is not homogeneous.

[7] Another aspect that should be taken into account in the comparison between annual rates and month-on-month rates (whether annualised or not) is the centring of the former in order to set them in phase with what we call "basic growth" in Table 7. No considerations are made in this section of the advisability or not of centring rates.

equivalent) or T^3_3 are alternative rates which, if they are centred, show an identical profile to the foregoing month-on-month rate, only smoother.

Turning to the analysis and interpretation of the confidence intervals estimated for these rates, it should be pointed out that the size of the errors is the barrier to the measurement of the monthly growth of the seasonally adjusted series and the trend. Logically, the greater variability of the shortest rates becomes particularly patent in the greater width estimated for the confidence interval. This underscores what was previously said regarding the caution required for interpreting the results in terms of a rate as short as, for example, T^1_1. In this respect, Table 8 presents the confidence interval for month-on-month non-annualised growth.

The interval band for trend-cycle is for all components less than s.a. series, although the estimator error for trend is generally higher. The interval around T^1_1 of the trend is lower, due to the presence of greater autocorrelation in its errors series. In general, there are few differences between the intervals of trend and s.a. There is only a more relevant difference in the case of the "core" of liquidity. Indeed, it is possible to see how in the components and aggregates with more marked seasonality and higher innovation in seasonal component, there is a greater difference between trend and s.a (CUR,OD and M1). For these components and M1, a signal such as trend would be more recommendable in short-term monitoring.

On the contrary, for the TD series, the interval for trend is slightly higher. It is in consonance with that shown before of an estimation of a smooth and less marked seasonality.

In the case of M3, the interval using the concurrent estimator is 0.25 (3 percentage points in annualised terms). In terms of final estimators after revision it is reduced to 2.3%. This interval for the Spanish M3 seems a little bit smaller than estimated for our old ALP and ALPF.

The potential use of this confidence interval would be as follows:

If, for example, +/- 3 % was the interval estimated for euro-area M3 aggregate and the growth in August 99 was 0.0, the true value could be between –3% or +3%. In this case it is significantly below 4.5%. On the contrary, in September 99 it was 0.6 (7.2 points annualised), when the lower significance band is 4.2%; this implies that 4.5% is in the lower limit So, if there were a persistent month-on-month growth of around 6%, it could be compatible with the reference, depending on the month-on month confidence band

Obviously, in terms of a smoother rate of growth such as a 3-month moving average - T^3_1 -, the confidence interval is lower and, consequently, it is possible to monitor the reference more accurately (Table 9).

In conclusion, if the annual growth reference were in terms of a T^3_{12}, the short term month-on-month, monitoring could be more appropriate using the T^3_1 or using an smoother rates of growth like T^3_3. Concretely, for the Spanish contribution to M3, the confidence band of the final estimator error, using the T^3_1 s.a. series, falls by around 1.2 points, practically reducing the uncertainty by 50% , in comparison with the T^1_1.

4.3. Evaluation of direct versus indirect adjustment

One of the methodological aspects which most usually concerns users of seasonal adjustment techniques and analysts of this information is the choice of the aggregation strategy to be followed to obtain seasonal adjustment, mainly in the case of the main variables, such as the monetary and credit magnitudes, or of other economic indicators such as the consumer price index.

Evaluation of the better quality that a -direct or indirect- seasonal adjustment of an aggregate can offer will depend on the features of each particular case. Specific rules cannot be set since the best strategy depends on many factors: e.g. the intensity of potential switching processes involving components, the seasonal pattern that such components may follow, and, in this respect, the greater or lesser impact on this seasonal pattern of the switching processes. Naturally, there are other more subjective factors such as the use that is to be made of the seasonally adjusted information, the importance attached to the principle of additivity, etc.

One of the initial aspects to be analysed when the selection of the seasonal adjustment strategy is tackled is the degree of correlation between the components of an aggregate. A simple graphic inspection of the original series of these components can already give an idea of this potential correlation. In the case of Spain, as in that of other countries, an intense switching process is observed; this involves negative correlation between term deposits and repos, firstly, and mutual funds, subsequently. (See once again chart A2.1 and A2.2 in the annex II).

Another means of evaluating the quality of direct versus indirect seasonal adjustment is to compare the differences between the seasonal pattern obtained from the factors estimated by the direct method with that obtained by the indirect procedure. Specifically, the better quality of the adjustment can be assessed by having regard to the criterion of minimum variance of the stochastic factor. However, an analysis has been conducted here in respect of the lesser variability of the final factors.

Chart 2 depicts the seasonal profile estimated for the aggregates M1 to M3 under both approaches. In the case of M2, it is first seen how this seasonal profile has held very stable in recent years (average of 93-98) in relation to that estimated for the year 98. The stability is highlighted both in the direct and indirect approach. Both profiles are virtually identical, which underscores the fact that there are no superimposed seasonal effects between components and aggregates, a relatively marked profile being sustained in each of the components. This similarity in seasonal profiles is evidently determined by the seasonality of deposits, in response to a more marked seasonal pattern and to the very weight of deposits in the composition of the narrower aggregates.

The seasonal profile of M3 does not show any great differences either between the indirect and direct approach on average between the years 93-98. In terms of variability, the indirect approach is only marginally somewhat more volatile. This greater variability is more patent in a comparison of the profiles estimated for the year 1998. In this respect, despite the fact that the component of M3-M2 is that which presents a more variable seasonal pattern, its incidence in the seasonality of the aggregate obtained by the indirect method is not relevant. On one hand, in the total of the aggregate this sub-component does not reach 23%, of which amount bank securities and MMFs (10% of M3, approximately) show no clear evidence of the presence of seasonality. Indeed, an additional exercise consisting of the consideration of these two components has no incidence either on the estimation of the implicit factors obtained by the indirect adjustment or on the estimation of the related short rates of the seasonally adjusted series. In this context, the indirect approach by sub-component (M1, M2-M1 and M3-M2) in the Spanish case gives virtually identical results to the indirect adjustment process at the maximum level of dissagregation, as is are observed in Chart 3.

A complementary exercise to compare the degree of discrepancy between both methods is to analyse what we have called the liaison term, which is shown in Chart 4. This is the difference between the aggregate seasonal adjustment and the seasonal adjustment obtained by aggregation of the seasonally adjusted components. Two points may be made here. First, the scale of the discrepancy in absolute terms or as a log (percentage of discrepancy in relation to the level of the series). And second, potential residual seasonality, i.e. the seasonality not reflected by the indirect method, and which would implicitly be internalised in the direct adjustment. Evidence of a liaison term with a defined seasonal profile and one of some scale would show that the seasonality of the aggregate would be better reflected having regard to a direct seasonal adjustment criterion.

In our specific case, the scale of the liaison term can be seen to relatively small, oscillating between 0.8% and -0.9% of the level of the series. Moreover, although a slight seasonal pattern is perceptible in the behaviour of the liaison term around the period 93 to 95, this becomes blurred at the end of the sample while the scale of the term increases.

Thus, having regard both to the analysis of the variability of the seasonal profiles estimated for both strategies and to the evidence that may be derived from the liaison term, on the information analysed there is no robust statistical evidence supporting either seasonal adjustment strategy in the case of the Spanish component. Indeed, in terms of the variability of short growth rates, the estimated profiles are very similar, although in the final years of the sample (1997 to 1999) the volatility of the rates estimated for the direct adjustment is slightly less (see Chart 5).

5. CONCLUSIONS

1. In the regular seasonal adjustment exercises for its main economic indicators, the Banco de España has traditionally used the ARIMA model-based signal extraction method and, specifically, the TRAMO/SEATS procedure.

2. The reason for using this methodology and procedure lies mainly in the fact that this method offers information on the properties of the estimators used and of the estimation errors. Specifically, the methodology makes it possible to perform inference analysis and a diagnosis of the non-observable components. In this respect, the TRAMO/SEATS application provides a robust statistical information infrastructure to conduct an exercise involving the decomposition of the time series into its non-observable components.

3. The monetary and credit aggregates were subject to regular seasonal adjustment at the Banco de España. This seasonal adjustment exercise was conducted annually and its results (projection and revision of factors) and other methodological factors were published in the Banco de España Boletín Económico.

4. The change in the monetary policy implementation strategy over the course of the nineties entailed a sizeable loss in the significance of the very short-term monitoring of the monetary aggregates, and the consequent relativisation of the role of the seasonally adjusted series of the monetary aggregates. In any event, the official seasonal adjustment of the monetary aggregates has been performed uninterruptedly through to 1999, insofar as the seasonally adjusted series continued to provide for short-term monitoring not so much on a month-to-month

basis but over a broader time frame (for instance, the average for one quarter in relation to the previous quarter).

5. In the analysis of the seasonality of the Spanish contribution of M3 to the euro-area aggregate, M3 is seen to follow a relatively stable seasonal pattern, dominated by the seasonality of bank deposits. The contribution to the M2 aggregate shows somewhat better statistical properties than the broader aggregate, by virtue of the characterisation of its short-term behaviour. The components between M2 and M3, comprising repos, MMFs and bank securities maturing at up to two years, do not show a marked seasonal pattern.

6. The results of the seasonal adjustment exercise for the Spanish component of M3 do not allow statistically robust conclusions to be drawn on whether a direct or indirect seasonal adjustment strategy would be best for Spain. Indeed, there are no observable differences between the seasonal profile estimated on the basis of the maximum level of disaggregation and that estimated indirectly on the basis of the major sub-components (M1, M2-M1 and M3-M2).

References

Bach,G.L. ,Cagan, P.D. , Friedman,M., Hildreth,C.G., Modigliani,F, and Okun,A. (1976) Improving the Monetary Aggregates: Report of the advisory Committee on Monetary Statistics, Washington D.C.: Board of Governors of the federal Reserve System

Bank of England (1992) “Report on the Seasonal Adjustment Working Party”, Ocassional paper nº 2, October 1992

Bell W.R. and, Hillmer S.C (1984): "Issues involved with the Seasonal Adjustment of Economic Time Series” ,*Journal of Bussines and Economic Statistics, vol 2 nº 4*

Box G.E.P., Hillmer S.C. and Tiao G.C. (1978): "Analysis and modelling of Seasonal Time Series" *, in Seasonal Analysis of Economic Time Series, ed A.Zellner*

Burman J.P. (1980): "Seasonal adjustment by signal extraction" *Journal of the Royal Statistical Society, A 143,221-337*

Hillmer S.C. and G.C. Tiao (1982): "An ARIMA-Model Based Approach to Seasonal Adjustment” *Journal of the American Statistical Assocation,77 63-70 .*

Gómez, V. and Maravall, A. (1996), “Programs TRAMO and SEATS”, in Banco de España, working paper 9628

Gómez, V. and Maravall, A. (1998), “Guide for using the programs TRAMO and SEATS”, in Banco de España, working paper nº 9805

Gómez, V. and Maravall, A. (1998), “Automatic modeling methods for univariate series”, in Banco de España, working paper nº 9808. Forthcoming, in *A Course in Time Series (eds. D.Peña, G.C. Tiao, and R.S. Tsay). N.Y. I.Wiley and sons*

Gomez, V. and Maravall, A. (1998), “Seasonal adjustment and signal extraction in economic time series” working paper nº 9809. Forthcoming, in *A Course in Time Series (eds. D.Peña, G.C. Tiao, and R.S. Tsay). N.Y. I.Wiley and sons*

Maravall, A. (1984): “On issues involved with the seasonal adjustment of time series”, Banco de España ,working paper nº 8408. Also in *Journal of Business and Economic Statistics , 2, 1984*

Maravall, A. (1987): “The Use of ARIMA Models in Unobserved Components Estimation: an application to spanish monetary control”, Banco de España , working paper nº 8701. Also in *Dynamic Econometric Modelling, Prceedings of the third International Symposium in Economic Theory and Econometrics, Austin (Cambridge):Cambridge University Press,1998*

Maravall, A. (1997): “Two discussions on new seasonal adjustment methods”, Banco de España , working paper 9704. Also in *Journal of Business and Economic Statistics , 2, 1998*

Moore, G.H., Box,G.E.P., Kaitz,H.B., Stephenson,J.A. and Zellner,A. (1981), Seasonal Adjustment of the Monetary Aggregates: Report of the Committee of Experts on Seasonal Adjustment Techniques, Washington D.C.: Board of Governors of the Federal Reserve System

TABLES AND CHARTS

Table 1

ARIMA models of components of Spanish contribution to M3 (end of month data) (*)

	CUR Log	OD Log	TD Log	RD Log	REPO Log	MMF Log	DEBSEC Level	M2-M1 Log	M3-M2 Log	M1 Log	M2 Log	M3 Log
Sample period	80/1 99/6	80/1 99/6	80/1 99/6	80/1 99/6	84/1 99/6	87/1 99/6	87/1 99/6	80/1 99/6	80/1 99/6	80/1 99/6	80/1 99/6	80/1 99/6
Dif	$\Delta\Delta_{12}$	$\Delta\Delta_{12}$	$\Delta\Delta_{12}$	$\Delta\Delta_{12}$	Δ^2	Δ^2	Δ	$\Delta\Delta_{12}$	Δ	$\Delta\Delta_{12}$	$\Delta\Delta_{12}$	$\Delta\Delta_{12}$
T(1)	-	-	-	-	-0.78 (-17)	-0.63 (-5)	0.53 (6.2)	-0.43 (-4.9)	-	-	-	-0.13 (-1.8)
T(2)	-	-	-	-	-	-	0.35 (4.1)	-0.60 (-8.9)	-	-	-	-
T(12)	-0.27 (-3.4)	-0.49 (-8.4)	-0.84 (-13)	-0.50 (-7.9)	-	-	-	-0.60 (-8.9)	-	-0.49 (-7.5)	-0.54 (-9)	-0.6 (-8.9)
F(1)	0.06 (0.9)	-	-0.78 (-17.8)	0.05 (0.79)	-	-0.39 (-3)	-	-0.87 (-19)	-0.18 (-3.3)	0.24 (-3.5)	-	-
F(2)	-0.23 (-3.5)	-	-	-0.31 (-4.6)	-	0.35 (4.2)	-	-	-0.1 (-1.8)	-	-	-
F(3)	-0.29 (-4.7)	-	-	-	-	-	-	-	-0.60 (-10.9)	-	-	-
F(12)	-	-	-	-	-0.49 (-7)	-	-	-	_	-	-	-
σx100	0.76	1.4	0.55	0.64	3.1	2.28	125.6	0.43	2.5	1.2	0.52	0.64
μ	-0.0002 (0.3)	0.0001 (-0.11)	0.0009 (0.3)	0.0002 (0.5)	0.002 (0.79)	-0.002 (-1)	-2.5 (-0.22)	0.0003 (-1.2)	0.0001 (0.07)	0 (0.03)	0 (0.2)	0.0002 (0.4)
L-B Q(24)	29.9	34.1	12	25	31.2	24.4	15.12	7.4	29.5	34.5	34	30
SE L-B Q(24)	30.6	30.6	31	38	39.7	28.8	19.3	14.55	79.2	14.2	18	16.55
Normality Test χ^2	3.1	0.85	4.5	2.1	1.9	11.7	2.1	0.85	3.5	2.9	2.3	0.87

(*)Between brackets: t-student

AUTOMATIC OUTLIERS IDENTIFICATION WITH TRAMO												
	CUR	OD	TD	RD	REPO	MMF	DEBSEC	M2-M1	M3-M2	M1	M2	M3
Dec-80									TC			
Dec-81									TC			
Oct-82	LS											
Dec-82									LS			
Mar-83	TC								LS			
May-83									TC			
Oct-83									AO			
Jan-84									LS			
Jun-84	LS											
Aug-84									AO			
Sep-84					LS							
Oct-84									LS			
Mar-85					AO				AO			
May-85		AO	TC					TC			TC	
Aug-85									TC			
Oct-85									LS			
Dec-85											LS	
Apr-86								TC			LS	
May-86			TC					TC				
Jul-86					LS				LS			
Aug-86					LS				LS			
Apr-87						AO						
May-87		TC										
Jun-87					TC				LS			
Nov-87						AO						
Mar-88												
Jul-88		LS								LS	LS	
Mar-89			TC								AO	
Jul-89		AO	TC					TC			AO	TC
Mar-90								AO				
Abr-90				LS								
Dec-91	TC								AO			
Jan-92			TC				LS	LS				
Mar-92							LS					
Jun-92							AO					
Oct-92		LS								LS		
Feb-93						AO						
Apr-93							AO					
Dec-93							LS					
Jun-94							TC					
Jul-94		AO										
Jun-96							TC					
Sep-96							LS					
Nov-96							AO					
Dec-96									LS			
Feb-97		LS										
May-97							LS					
Jun-97		TC								AO	AO	
Sep-97									AO			
Feb-98		AO								AO	AO	
Mar-98	AO					LS						LS
May-98		AO									AO	
Jun-98							AO		TC			
Nov-98		LS							LS		LS	
Nov-98			LS									
Dec-98							AO					
Jan-99		TC			AO					AO	AO	
Feb-99			AO						TC			TC
Mar-99						LS	LS		TC			
Apr-99							LS					
Jun-99							AO					
Total number	5	12	7	1	6	5	15	6	16	5	11	3

Table 2

VARIANCE OF THE INNOVATIONS IN THE MODELS OF COMPONENTS (Percentage over s^2a) (*)						
	Total Series	Trend-cycle	Seasonal	Irregular	Seasonally Adjusted Series	σ^2_a
CUR	1	0.06	0.19	0.05	0.38	0.54 x10^{-4}
OD	1	0.14	0.09	0.14	0.57	0.18 x10^{-3}
TD	1	0.32	0.02	0.06	0.84	0.28 x10^{-4}
RD	1	0.11	0.14	0.08	0.44	0.40 x10^{-4}
REPO	1	0.07	0.27	0.09	0.39	0.80 x10^{-3}
MMF	1	0.33	-	0.05	1	0.45 x10^{-3}
DEBSEC	1	0.47	-	0.10	1	13.290 (level)
M1	1	0.09	0.07	0.16	0.58	0.13 x10^{-3}
M2	1	0.15	0.07	0.15	0.61	0.25 x10^{-4}
M3	1	0.13	0.05	0.21	0.68	0.30 x10^{-4}
M2-M1	1	0.19	0.05	0.09	0.65	0.18 x10^{-4}
M3-M2	1	0.11	0.06	0.09	0.53	0.58 x10^{-3}

(*) The last column is the residual variance of the estimated model given for each component

Table 3

VARIANCE OF ESTIMATION ERRORS
(Units s^2a) (*)

	Revision error		Final estimator error		Total error of concurrent estimator		σ^2_a
	Trend-Cycle	Seasonally Adjusted	Trend-Cycle	Seasonally Adjusted	Trend-Cycle	Seasonal Adjusted	
CUR	0.33	0.29	0.18	0.20	0.51	0.48	0.54×10^{-4}
OD	0.24	0.20	0.19	0.18	0.42	0.37	0.18×10^{-3}
TD	0.24	0.21	0.23	0.20	0.47	0.41	0.28×10^{-4}
RD	0.30	0.26	0.21	0.21	0.51	0.47	0.4×10^{-4}
REPO	0.44	0.36	0.28	0.31	0.72	0.67	0.79×10^{-3}
MMF	0.14	-	0.25	-	0.39	-	0.45×10^{-3}
DEBSEC	0.07	-	0.02	-	0.09	-	13.290 (level)
M1	0.19	0.15	0.14	0.13	0.33	0.28	0.13×10^{-3}
M2	0.22	0.18	0.19	0.16	0.41	0.34	0.25×10^{-4}
M3	0.18	0.13	0.16	0.12	0.35	0.26	0.3×10^{-4}
M2-M1	0.33	0.27	0.25	0.23	0.58	0.50	0.18×10^{-4}
M3-M2	0.09	0.05	0.05	0.05	0.14	0.1	0.58×10^{-3}

(*) The last column is the residual variances of the estimated model given for each component.

Table 4

PERCENTAGE REDUCTION IN THE STANDARD ERROR OF THE REVISION (COMPOSITION WITH THE CONCURRENT ESTIMATOR) (*) (Units of s^2_a)

	CUR 0.54 x10^{-4}		OD 0.18 x10^{-3}		TD 0.28 x10^{-4}		RD 0.40 x10^{-4}		REPO 0.79 x10^{-3}		M1 0.13 x10^{-3}		M2 0.25 x10^{-4}		M3 0.30 x10^{-4}		M2-M1 0.2 x10^{-4}		M3-M2 0.58 x10^{-3}	
	Trend Cycle	S.a	Trend cycle	S.a	Trend Cycle	S.a	Trend Cycle	S.a	Trend cycle	S.a	Trend cycle	S.a	Trend cycle	S.a	Trend Cycle	S.a	Trend Cycle	S.a	Trend cycle	S.a
Concurrent Error	0.50	0.48	0.43	0.37	0.47	0.41	0.51	0.47	0.72	0.67	0.33	0.28	0.41	0.34	0.35	0.26	0.58	0.50	0.14	0.1
1 years	75.4	67.2	64.0	49.9	23.4	15.5	58.1	50.4	95.3	90.2	68.4	48.4	60.4	44.6	60.4	36.2	48.4	37.4	100	100
2 years	93.4	91.2	82.4	75.4	35.2	28.5	78.7	74.8	99.7	99.7	84.3	74.3	78.4	69.9	75.0	59.8	69.0	62.4	100	100
3 years	98.2	97.7	91.4	87.9	45.3	39.6	89.2	87.2	100	100	92.2	87.3	88.2	83.6	84.3	74.7	81.4	77.4	100	100
4 years	99.5	99.4	95.8	94.1	53.7	48.9	94.5	93.5	100	100	96.1	93.7	93.6	91.1	90.1	84.0	88.8	86.4	100	100
5 years	99.9	99.8	97.9	97.1	60.9	56.8	97.2	96.7	100	100	98.1	96.9	96.5	95.1	93.8	89.9	93.3	91.9	100	100
	Average percentage reduction in RMSE from concurrent adjustment (**)																			
	18.6		20.4		4.1		16.2		13.9		22.0		18.5		16.4		8.3		39.3	

(*) Revision error in the concurrent estimator and after one to five years the annual revision in percentage over the data revision period comprising five years

(**) Indicates the equivalent improvement in the variance of the total estimation error if seasonal adjustment is carried out each time a new figure is received.

Table 5

Changes in seasonality (on final seasonal factor)(*)

	CUR	OD	TD	RD	REPO	MMF	M1	M2	M3	M2-M1	M3-M2
1980	3.302	2.621	0.487	1.663	-	-	2.401	0.935	0.866	0.470	0.343
1981	3.259	2.482	0.494	1.649	-	-	2.402	0.951	0.888	0.480	0.402
1982	3.178	2.336	0.448	1.639	-	-	2.246	0.887	0.812	0.468	1.056
1983	3.037	2.267	0.426	1.663	-	-	2.150	0.871	0.783	0.453	1.944
1984	2.799	2.536	0.435	1.577	4.897	-	2.361	0.880	0.734	0.400	1.773
1985	2.607	2.509	0.389	1.442	4.068	-	2.266	0.877	0.717	0.345	1.750
1986	2.493	2.391	0.375	1.480	3.482	-	2.171	0.869	0.652	0.364	1.471
1987	2.621	2.546	0.379	1.451	2.284	0.227	2.284	0.937	0.732	0.402	0.494
1988	2.720	2.389	0.347	1.600	1.422	0.301	2.187	0.957	0.699	0.467	0.758
1989	2.631	2.486	0.354	1.710	1.277	0.231	2.381	1.044	0.730	0.464	0.931
1990	2.144	2.419	0.362	1.651	0.937	0.269	2.230	1.065	0.718	0.474	0.515
1991	1.648	2.251	0.314	1.579	1.532	0.221	1.970	0.998	0.712	0.420	0.726
1992	1.605	2.245	0.318	1.510	1.197	0.252	1.872	0.950	0.712	0.368	0.648
1993	1.589	2.204	0.290	1.630	1.801	0.221	1.725	0.853	0.684	0.377	0.531
1994	1.555	2.113	0.269	1.589	2.048	0.283	1.738	0.870	0.729	0.394	0.878
1995	1.464	2.195	0.270	1.537	2.423	0.266	1.783	0.814	0.766	0.413	0.604
1996	1.229	2.260	0.248	1.401	2.402	0.193	1.690	0.822	0.779	0.483	0.883
1997	1.198	2.254	0.257	1.305	1.631	0.223	1.640	0.825	0.741	0.588	0.870
1998	1.290	2.431	0.290	1.284	2.450	0.252	1.838	0.850	0.810	0.684	0.983
ß (**)	-0.13 (-16.3)	-0.02 (-3.9)	-0.01 (-15.3)	-0.01 (-3)	-0.12 (-1.96)	-0.02 (-0.7)	-0.04 (-7.5)	-0.04 (-1.4)	-0.04 (-1.4)	0.005 (1.5)	1.1 (4.9)

(*) Change in Seasonality is observed from the change over time of the statistics V_j, defined as

$$V_j = \left[\frac{\sum_{t=1}^{12} (F_t - 100)^2}{12} \right]^{1/2}$$

where F_t are the related seasonal factors in month t.

(**) The coefficient ß, measures the degree of change of seasonality. It is the coefficient resulting from the adjustment of the V_j against time. In brackets is the t statistic.

Table 6

CONFIDENCE INTERVAL AROUND SEASONAL FACTORS OF 100

	95%		70%	
	Concurrent estimation	Final estimation	Concurrent estimation	Final estimation
CUR	99.00 – 101.00	99.40 – 100.60	99.50 – 100.50	99.70 - 100.30
OD	98.40 – 101.60	98.90 – 101.10	99.15 – 100.90	99.42 – 100.60
TD	99.33 – 100.70	99.53 – 100.50	99.65 – 100.40	99.75 – 100.20
RD	99.15 – 100.90	99.43 – 100.60	99.55 – 100.50	99.70 – 100.30
REPO	95.60 – 104.60	97.00 – 103.10	97.65 – 102.40	98.40 – 101.60
MMF	-	-	-	-
DEBSEC	-	-	-	-
M1	98.81 – 101.20	99.18 – 100.80	99.37 – 100.60	99.56 – 100.40
M2	99.44 – 100.60	99.60 – 100.40	99.70 – 100.30	99.79 – 100.20
M3	99.46 – 100.50	99.63 – 100.40	99.72 – 100.30	99.80 – 100.20
M2-M1	99.41 – 100.60	99.61 – 100.4	99.69 – 100.30	99.79 – 100.20
M3-M2	98.55 – 101.50	98.95 – 101.10	99.23 – 100.80	99.44 – 100.60

Table 7

Several kinds of rates of growth	
Basic growth:	$m1=\left(\frac{x_t}{x_{t-1}}-1\right)*100$
Month-on-month change annualised:	$T_1^1=\left(\left[\frac{x_t}{x_{t-1}}\right]^{12}-1\right)*100$
3-month moving average annualised (centred)	$T_1^3=\left(\left[\frac{x_{t-1}+x_t+x_{t+1}}{x_{t-2}+x_{t-1}+x_t}\right]^{12}-1\right)*100$
Month-on -3-months earlier annualised (centred)	$T_3^1=\left(\left[\frac{x_t}{x_{t-3}}\right]^{\frac{12}{3}}-1\right)*100$
3-month average on the 3 previous months´ average (centred)	$T_3^3=\left(\left[\frac{x_t+x_{t+1}+x_{t+2}}{x_{t-3}+x_{t-2}+x_{t-1}}\right]^{\frac{12}{3}}-1\right)*100$
Annual change (centred)	$T_{12}^1=\left(\left[\frac{x_{t+6}}{x_{t-6}}\right]-1\right)*100$

Table 8

CONFIDENCE INTERVAL FOR THE NON-ANNUALISED PERCENTAGE GROWTH OF T^1_1 (month-on-month growth) (Linear approximation)				
	TREND-CYCLE	SEASONALLY ADJUSTED	TREND-CYCLE	SEASONALLY ADJUSTED
	Concurrent estimator		Final estimator	
CUR	0.25	0.35	0.17	0.28
OD	0.56	0.66	0.45	0.50
TD	0.24	0.21	0.18	0.15
RD	0.26	0.30	0.19	0.24
REPO	1.10	1.30	0.8	1.10
MMF	1.40	-	1.30	-
DEBSEC	44.4	-	37.1	-
M1	0.40	0.58	0.34	0.44
M2	0.21	0.24	0.17	0.18
M3	0.22	0.25	0.18	0.19
M2-M1	0.20	0.19	0.14	0.14
M3-M2	0.86	0.99	0.53	0.81

Table 9

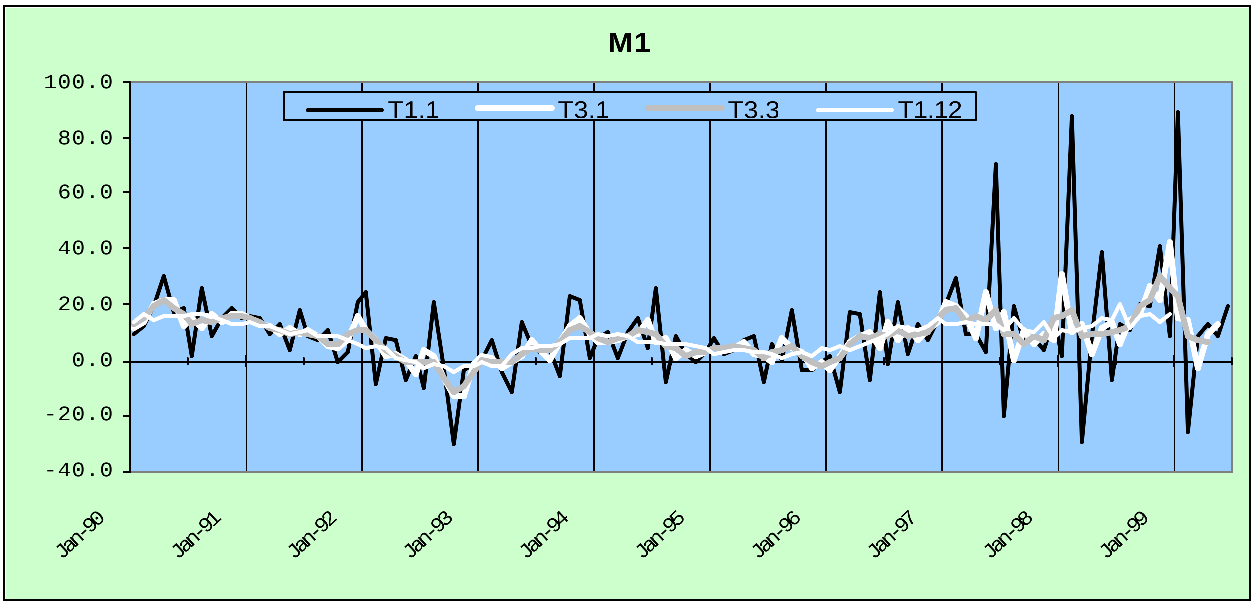
CONFIDENCE INTERVAL FOR THE NON-ANNUALICED PERCENTAGE GROWTH OF T^3_1 (3-month average centered)

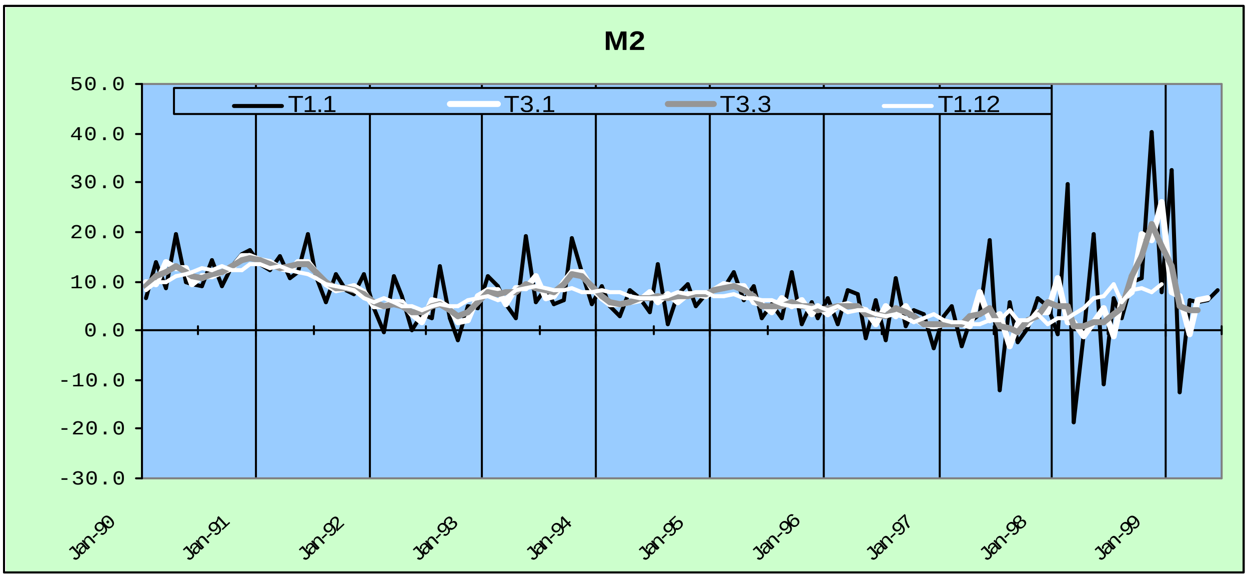
(linear approximation)

	TREND-CYCLE	SEASONALLY ADJUSTED	TREND-CYCLE	SEASONALLY ADJUSTED
	Concurrent estimator		Final estimator	
CUR	0.66	0.71	0.37	0.39
OD	1.26	1.37	0.82	0.80
TD	0.69	0.70	0.36	0.33
RD	0.65	0.67	0.39	0.39
REPO	2.80	2.98	1.62	1.79
MMF	2.71	-	1.59	-
DEBSEC	117.4	-	43.8	-
M1	0.9	1.09	0.59	0.6
M2	0.47	0.51	0.30	0.29
M3	0.48	0.95	0.31	0.28
M2-M1	0.52	0.54	0.28	0.27
M3-M2	2.17	2.33	0.82	0.68

Chart 1

Monetary aggregates of Spanish contribution
Several rates of growth of S.a. series (centred)
(seasonally adjusted by direct method)





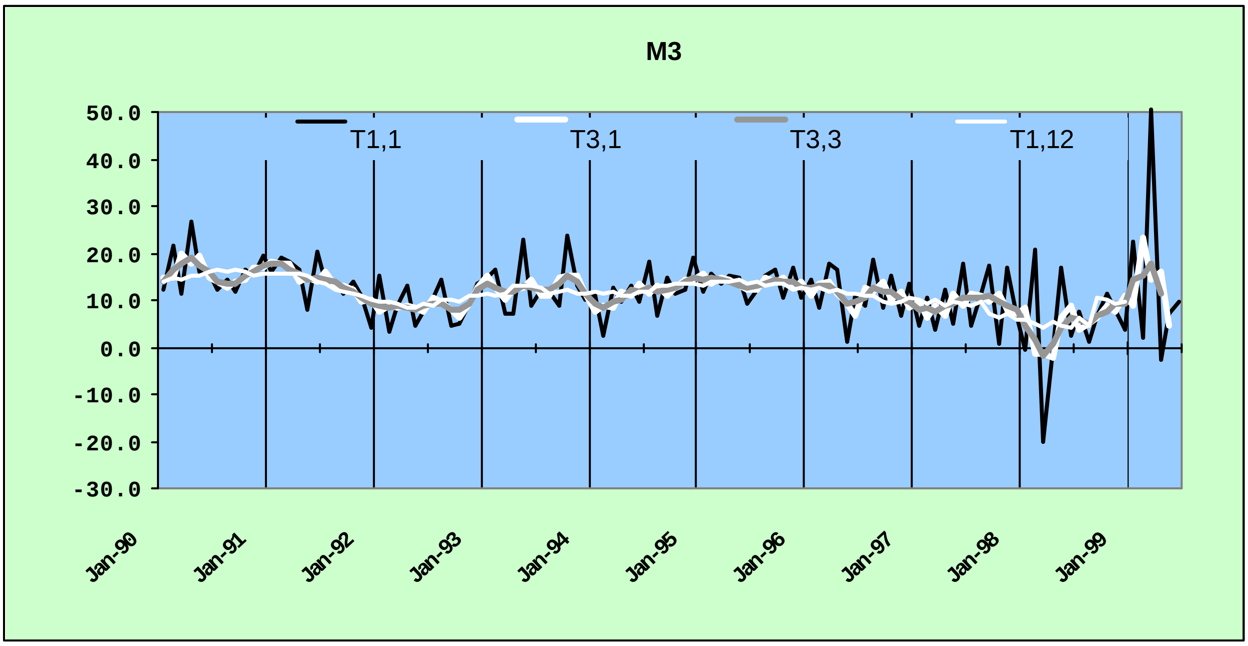


Chart 2

Pattern of seasonal factors of Spanish contribution to monetary aggregates (Direct vs indirect method by single components aggregation)

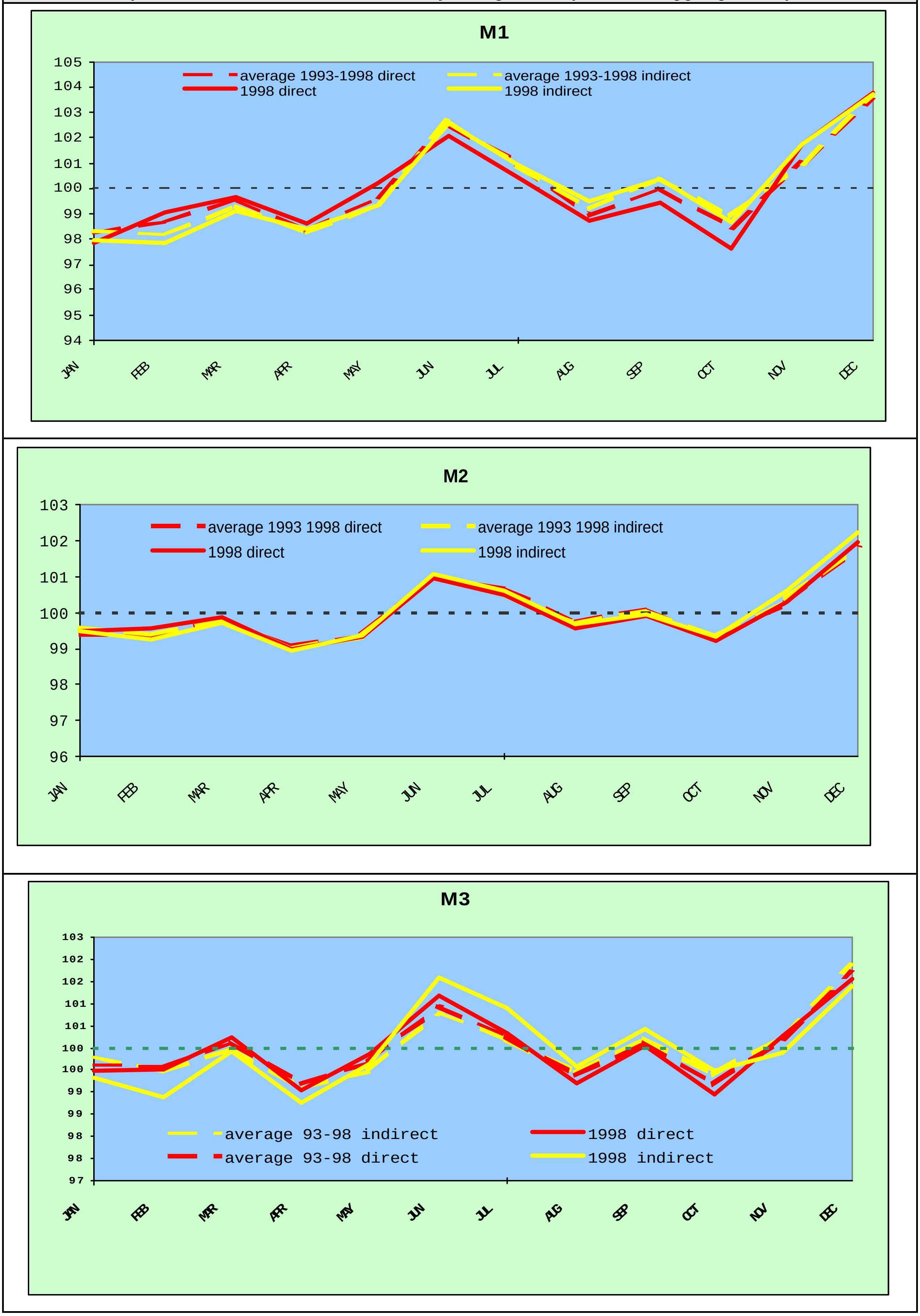


Chart 3

Pattern of seasonal factors of Spanish contribution to M3
(Direct vs indirect method by single and broader components aggregation)

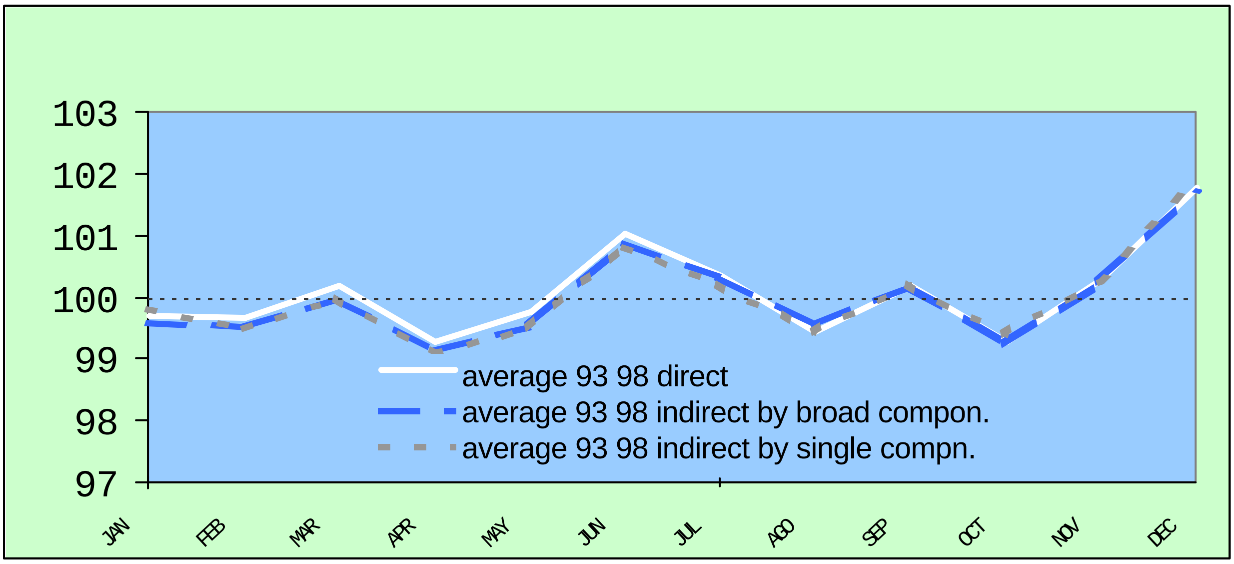


Chart 4

Liason term of Spanish contribution to M3
(in logs)

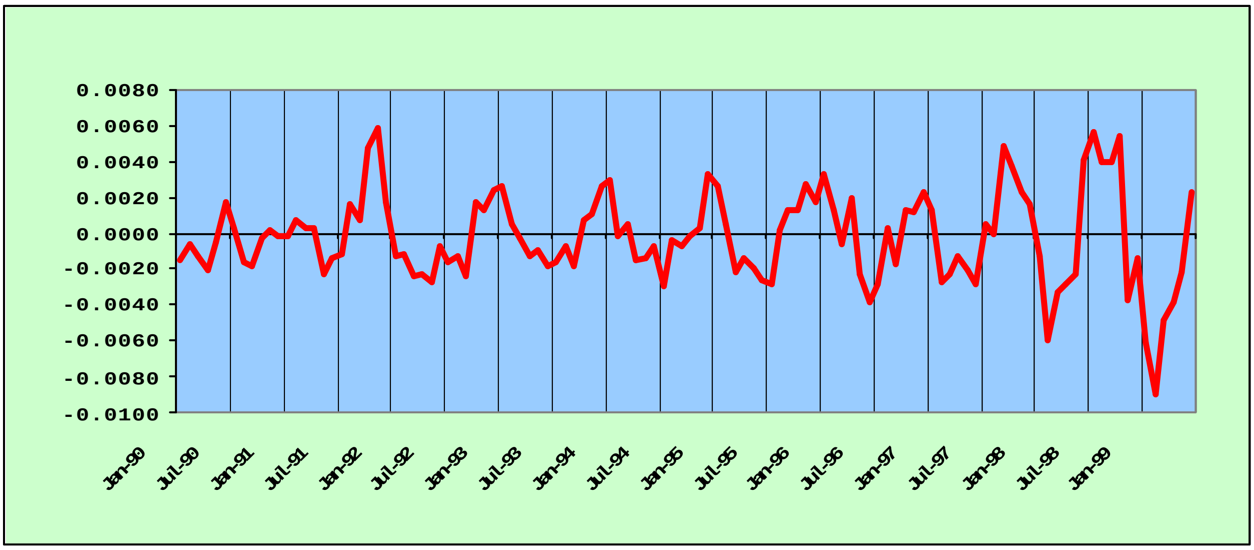
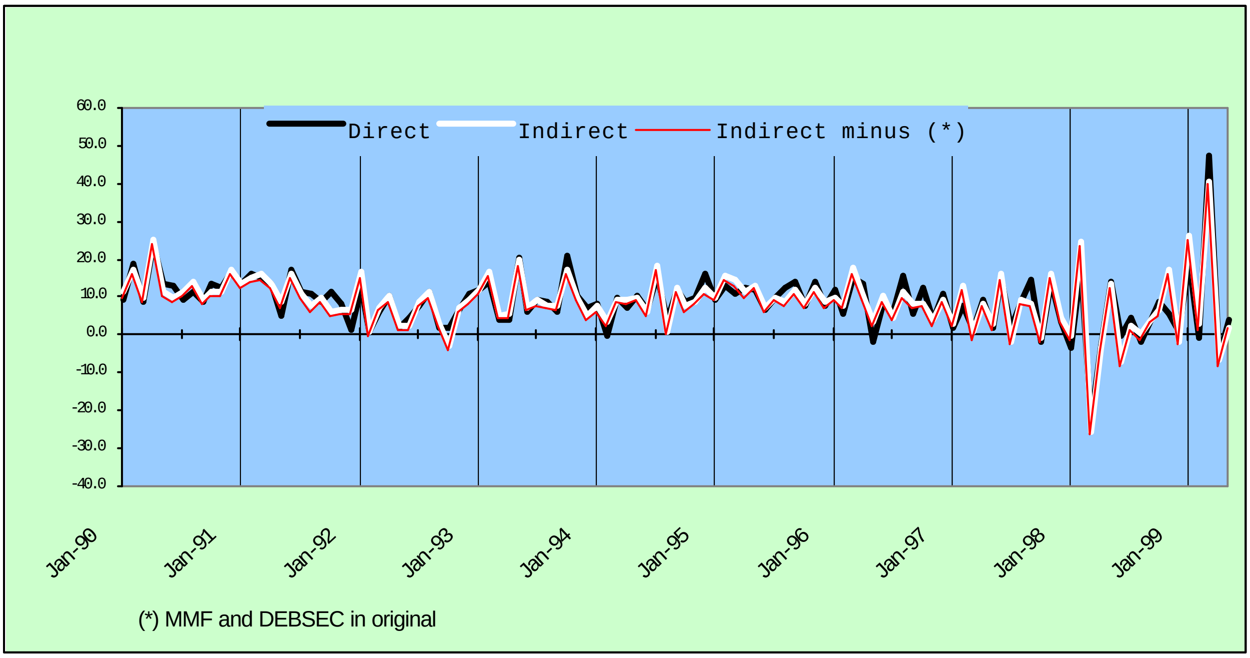


Chart 5

Spanish contribution to M3
Month-on-month rates of growth
Estimated by direct and indirect methods



(*) MMF and DEBSEC in original

ANNEX 1: Estimation errors in the non-observable components

ANNEX 2: Complementary charts

ANNEX 1: Estimation errors in the non-observable components

Let z_t be the stationary transformation of the observed series X_t. Let us assume that z_t can be decomposed into several independent components z_{it} which are, for example, the trend (z_{pt}), seasonal (z_{st}), cyclical (z_{ct}) and irregular (z_{ut}) components, such that

$$z_t = \sum_i z_{it} + u_t \quad \textit{where } \mathrm{u}_t \approx \mathrm{niid}(0, \sigma_u^2) \tag{1}$$

Let us assume that the components follow a linear process of the type

$$z_{it} = \psi_i(B)\, a_{it} \quad \textit{where} \quad a_{it}\,\_\,\mathrm{n}iid(0, \sigma_{ai}^2) \tag{2}$$

The series observed also follows a linear model

$$z_t = \psi\,(B)\, a_t \quad \textit{where} \quad a_t\,\_\,\mathrm{n}iid(0, \sigma_a^2) \tag{3}$$

it being possible to express the polynomial Ψ(B) as the ratio of the two finite-order polynomials:

$$\psi(B) = \frac{\theta(B)}{\varphi(B)} \tag{4}$$

From the foregoing expressions it is obtained that:

$$z_t = \sum_i \frac{\theta_i(B)}{\varphi_i(B)} a_{it} + u_t \tag{5}$$

That is to say, both the components and the series observed follow ARIMA models. One approximation that allows the models of the non-observable components to be obtained is to use the specification of the ARIMA model for z_t, which would be like the "reduced form" of the former.

In this connection the estimator of the component z_{it} with minimum mean square error is used, which is given by

$$\hat{Z}_{i_t} = K_i \frac{\psi_i(B)\psi_i(F)}{\psi(B)\psi(F)} z_t = \nu_i(B,F) z_t$$

(**6**)

$$\text{where } k_i = \frac{\sigma_i^2}{\sigma_a^2}$$

In the case of the ARIMA models, the filter $u_i(B,F)$ can be expressed as

$$\nu_i(B,F) = k_i \frac{\theta_i(B)\theta_i(F)\phi_i^*(B)\phi_i^*(F)}{\theta(B)\theta(F)} \tag{7}$$

The filter $\nu_j(B,F)$ is symmetrical and centred, of infinite order. However, the invertibility of z_t ensures the convergence of the filter, whereby the latter may be truncated and applied to a series with a finite number of observations.

Based on (6), we can thus define the <u>final estimator</u> of z_{it} as

$$\hat{z}_{i_t} = \nu_0 z_t + \sum_{j=1}^{m} \nu_j(z_{t-j} + z_{t+j}) \tag{8}$$

m being the lag on the basis of which the filter is truncated.

To obtain z_{it}, z_{t-m}..... z_{t+m} observations are required. To calculate the estimator in a period t, so that t<m or t>m, observations preceding z_1 or following z_T will be necessary. Nonetheless, an estimator of z_{it} can be obtained in the period t=1...T by replacing the unavailable observations by the forecasts made at t with horizon j: $\hat{z}_t(J)$ 9.

The estimator obtained in this way is called the <u>concurrent estimator</u> and is defined by:

$$\hat{z}_{it}^0 = \nu_0 z_t + \sum_{j=1}^{m} \nu_j(z_{t-j} + \hat{z}_t(j)) \tag{9}$$

These two estimators give rise to two types of estimation errors:

Error in the final estimator error, owing to the truncation of the filter $V_{\infty}(L)$

$e_f = z_{it} - \hat{z}_{it}$

Revision error, which gives an idea of the degree of revision recorded by the concurrent estimator in relation to the final estimator, by using forecasts for the tails: $e_r = \hat{z}_{it} - \hat{z}^0_{it}$

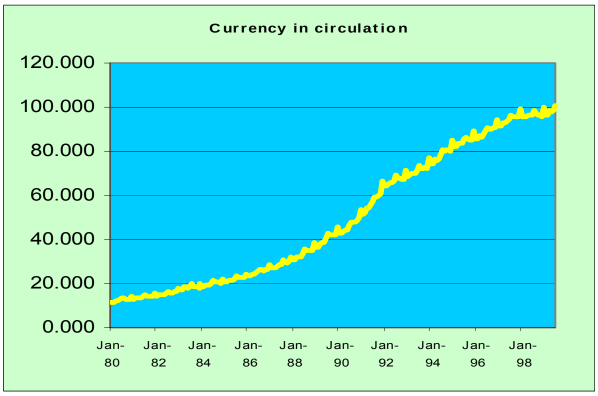
Error in the total estimator[(*)], which is the sum of both errors. This is the error committed by using the concurrent estimator $e_t = e_f + e_r = z_{it} - \hat{z}^0_{it}$

[(*)] In new SEATS, given that the unobserved component, and hence its “final estimator error”, is never known, it is of little applied relevance. New SEATS uses “Total Estimation error” for testing signal of seasonally. “Revision error” to asses imprecision of the previous estimation in short-term monitoring of series.

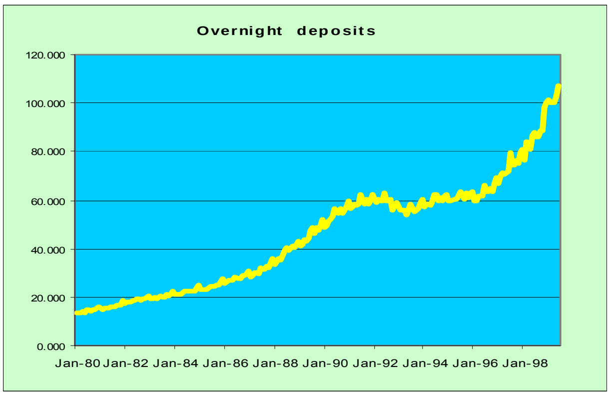
ANNEX 2: Complementary charts

Chart A2.1

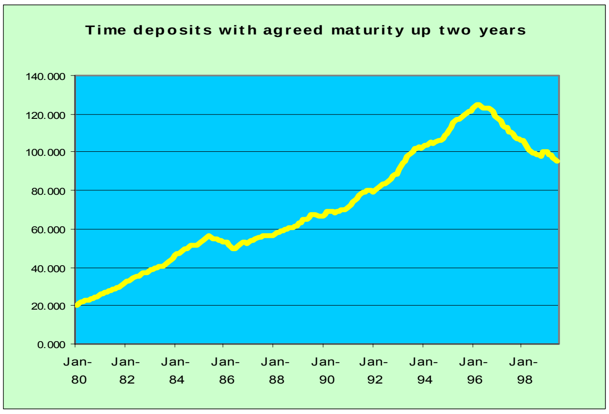
Spanish contribution to the monetary aggregates of euro area. Original adjusted Index of components



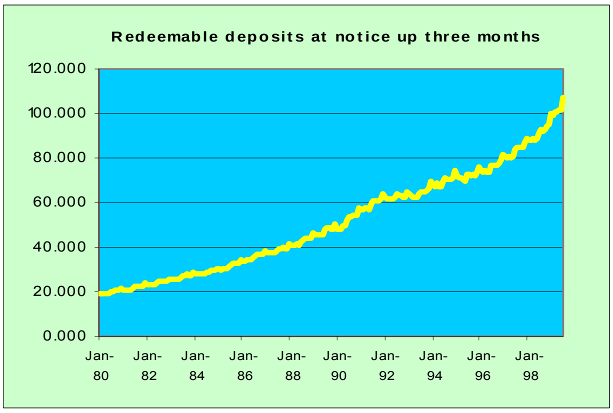
Currency in circulation



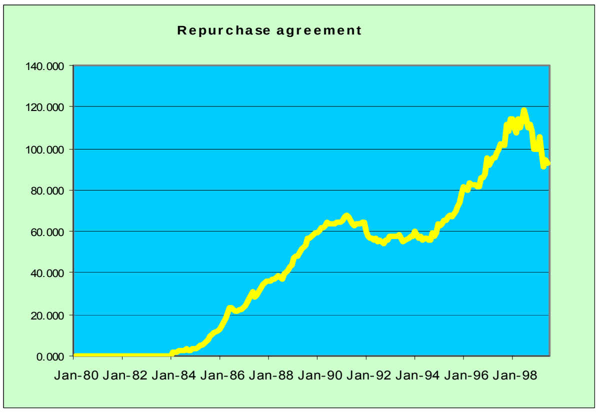
Overnight deposits



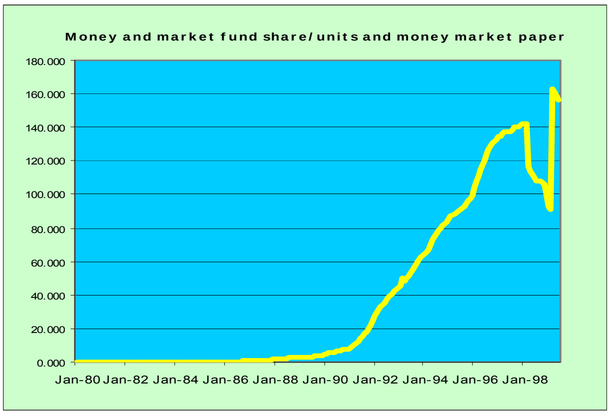
Time deposits with agreed maturity up two years



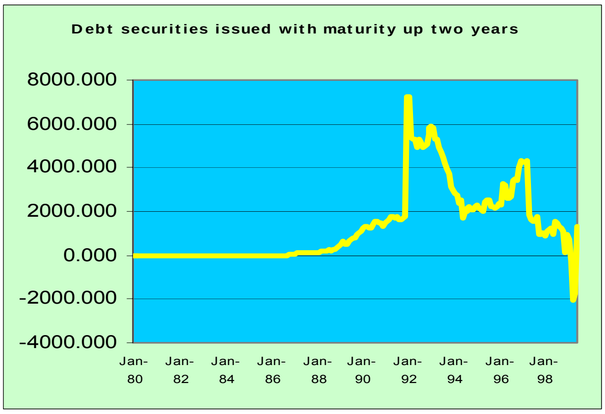
Redeemable deposits at notice up three months



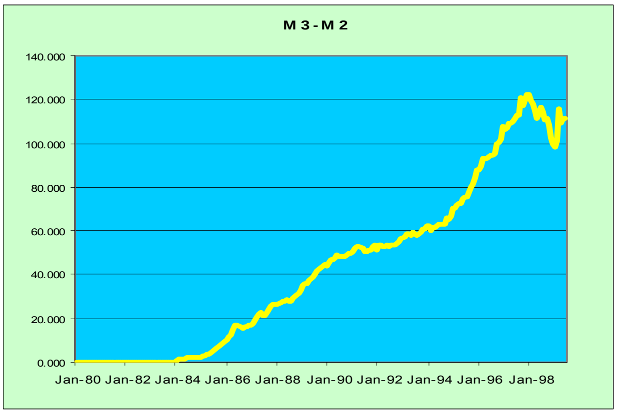
Repurchase agreement



Money and market fund share/units and money market paper



Debt securities issued with maturity up two years



M3-M2

Chart A2.2

Components of Spanish contribution to M3
Several rates of growth on S.a series (centred)

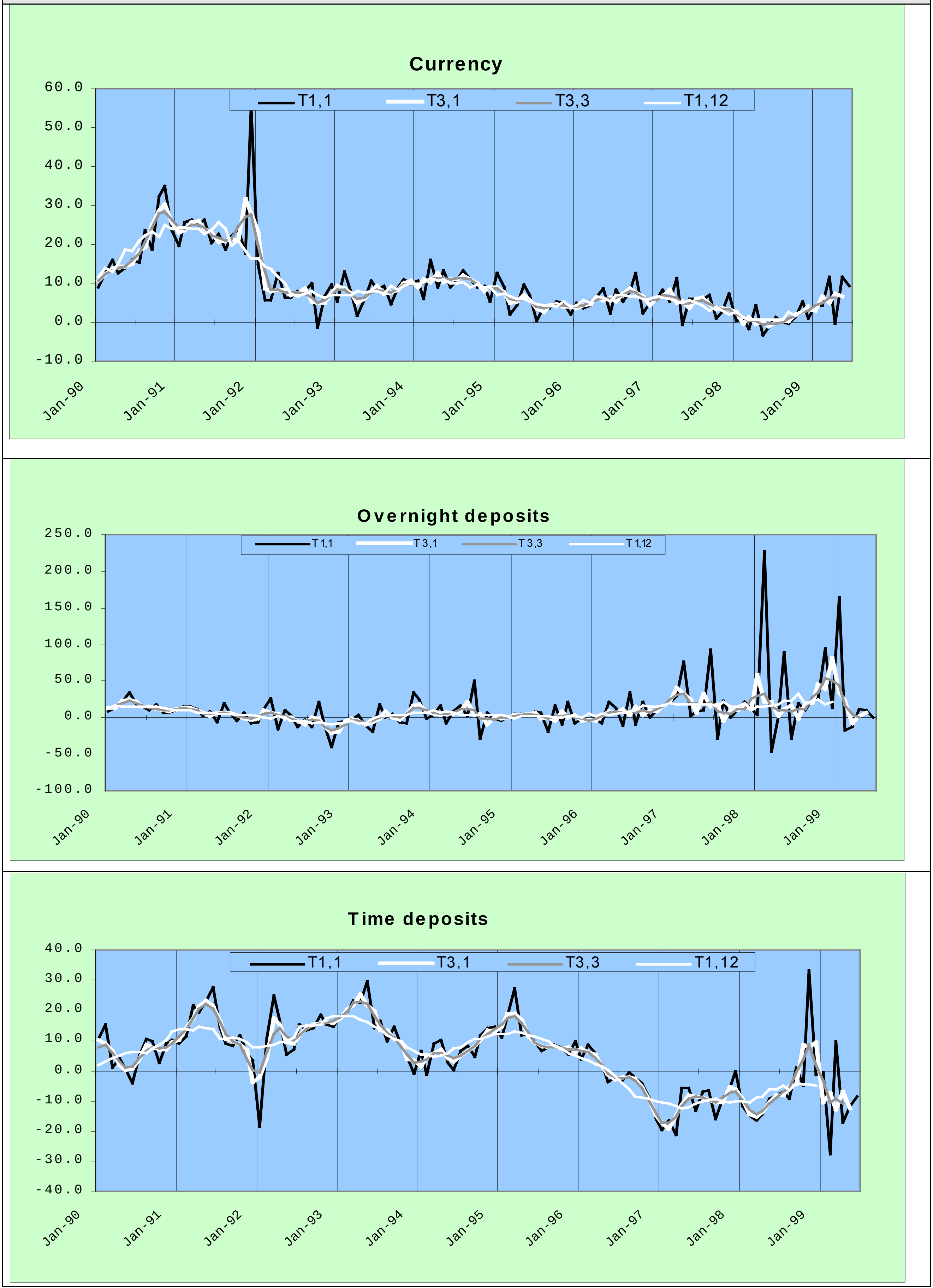
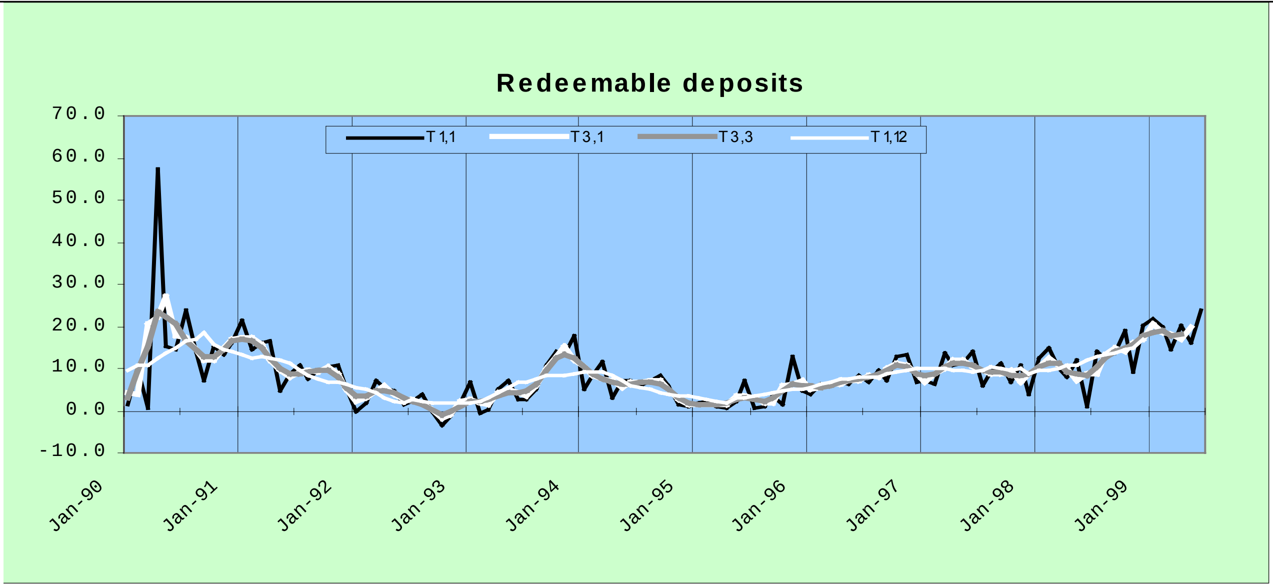
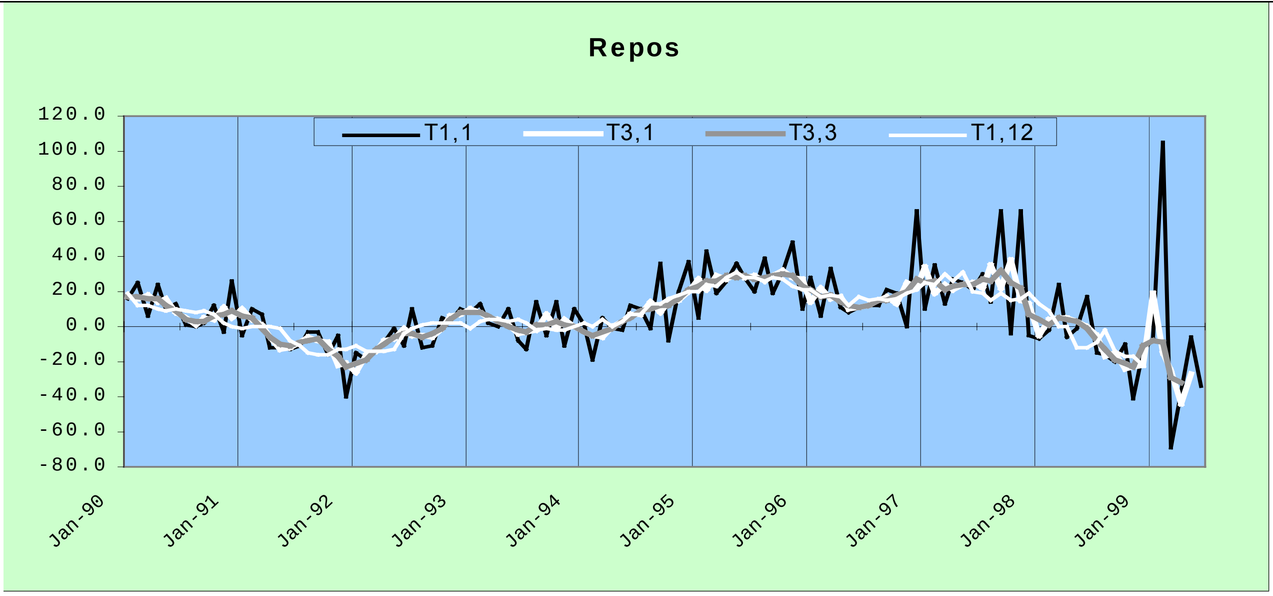
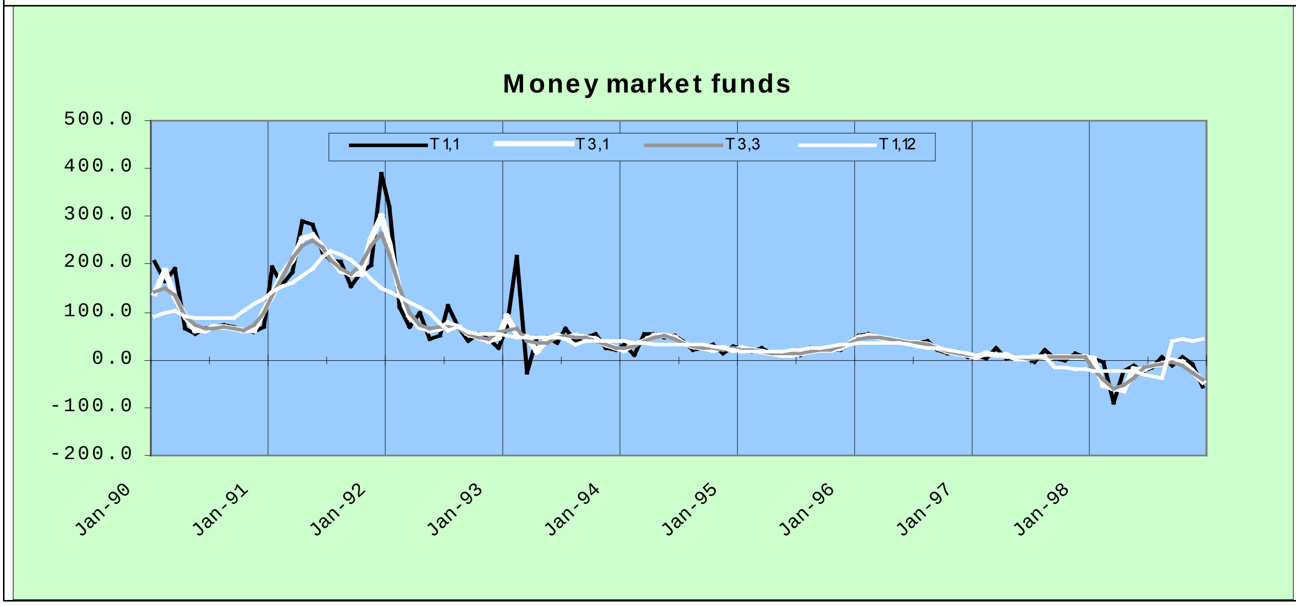


Chart A2.2 (cont.)

Components of Spanish contribution to M3
Several rates of growth on S.a series (centred)







Components of Spanish contribution to M3
Several rates of growth on S.a series (centred)