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# Research Technical Paper

## *Now-casting Irish GDP*

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**Abstract**

In this paper we present “now-casts” of Irish GDP using timely data from a panel data set of 41 different variables. The approach seeks to resolve two issues which commonly confront forecastors of GDP - how to parsimoniously avail of the many different series, which can potentially influence GDP and how to reconcile the within-quarterly release of many of these series with the quarterly estimates of GDP? The now-casts in this paper are generated by firstly, using dynamic factor analysis to extract a common factor from the panel data set and, secondly, through use of bridging equations to relate the monthly data to the quarterly GDP estimates. We conduct an out-of-sample forecasting simulation exercise, where the results of the now-casting exercise are compared with those of a standard benchmark model.

## Non Technical Summary

Providing accurate and timely estimates of the rate of GDP growth within the economy is an essential component of the CBFSAI's economic function. These forecasts are presented publicly four times a year in the Bank's Quarterly Bulletin and a further series of forecasts are submitted to the ECB as part of the Broad Macroeconomic Projection Exercise (BMPE).

In seeking to estimate the economy's performance at any point in time, a large number of variables are typically incorporated within the assessment of forecasters. This process is largely conducted on a judgemental basis, where forecasters adjust their estimates in an ad-hoc manner without necessarily using a quantitative framework. However, the present paper presents a modelling approach, which enables forecasters to use the information from a large panel of potentially relevant macroeconomic indicators in generating estimates of economic performance. In particular, information is derived from 41 different macroeconomic indicators to arrive at forecasts for GDP.

The approach also facillitates the most up-to-date information on these indicators to be used when estimates are being provided. As such, the adoption of this approach goes some way towards meeting the increasing emphasis of the ECB for model-based forecasts to be used by the national central banks (NCBs) in the preparation of their forecasts.

The paper also reviews the macroeconomic forecasts of the CBFSAI particularly, when compared with those of the ESRI over the timeframe 2000 - 2007. Finally, the paper notes that, when compared with other countries' GDP estimates, Irish estimates are notable for their volatility and for the degree of revision, which occurs between actual initial and latest GDP estimates.

# 1. Introduction

The coherent nature of policy making within the Eurosystem necessitates the provision of timely and accurate estimates of output growth by Member States. Evaluating the present state of the economy and generating "credible" short-term forecasts has often been a complex task of combining information from both qualitative and quantitative based sources usually available at different time delays. Qualitative, survey-type information concerning present conditions within the economy tends to be available on a timely and up to date basis, whereas data more typically used in model based forecasts is often only available at a significant time lag. Additionally, many timely and useful variables are released at monthly intervals, whereas the variable of interest - GDP is normally on a quarterly basis. These issues result in the relative popularity of more "judgemental" based forecasts, where analysts weigh up the available set of information and generate a forecast accordingly.

A separate, but related issue concerning macroeconomic forecasts is the sheer quantity of series, which may potentially be of use in predicting GDP movements. Both large scale and reduced-form econometric models can provide strong theoretical underpinnings for a relationship between aggregate income and certain variables, however, in forecasting terms many of these models are outperformed by standard time-series approaches. Optimal forecasts in the case of individual countries will seek to avail of the most relevant information, which may, very often, be particular to that country. For example, in the case of Ireland, the residential construction sector has, over the past 10 years, assumed a considerable importance in the overall performance of the economy. Consequently, information pertaining to the Irish construction sector may be a significant predictor of aggregate output movements. Of interest, therefore, is a modelling approach, which enables one to avail of the potential forecasting power of a large set of variables.

This paper generates early estimates or "now-casts" and "back-casts" of quarterly Irish GDP. In terms of the timeliness of Irish GDP releases, for the first two months in any given quarter, the most recent available release of GDP is for the second last quarter. By the end of the third month in each quarter, releases of GDP are available for the previous quarter. In this paper we generate estimates for the current quarter, (now-cast), and for the previous quarter, (back-cast). In the case of the latter, this is only done when no release is available i.e. for the first two months of the quarter.

This involves the use of "bridging equations" whereby small models are used to "bridge" the information in key monthly data with quarterly GDP, where the quarterly GDP is released after the monthly data. A variety of approaches can then be employed vis-à-vis the bridge equation. In work by Diron (2006) and Rünstler and Sédillot (2003) a number of selected bridge equations with multiple regressors was used to generate now-casts, while in Kitchen and Monaco (2003) forecasts of GDP based on a large number of bridge equations were pooled. In the latter case, each equation had only one predictor.

However, another development has drawn upon the factor analysis based literature in seeking to distill significant information from relatively large amounts of variables. In this sense, the approach in this paper follows that of Giannone, Reichlin and Small (2005) who produce now-casts of output and inflation for the US using a dynamic factor model proposed by Doz, Giannone and Reichlin (2005). The merits of factor models as forecasting tools were lauded in a series of papers by Stock and Watson (2002a), and Stock and Watson (2002b) and Forni, Hallin, Lippi and Reichlin (2005). The use of factor models in a now-casting context is mainly attributable to the work of Giannone, Reichlin and Small (2005). A now-cast estimate of GDP is obtained in two steps. In the first step, monthly indicators are used to estimate factors. These factors are then used as regressors in an associated bridge equation. In an Irish case, we compile a monthly panel dataset of 40 variables.

We generate the now-casts using a pseudo-real time approach. By this, we mean that when a now-cast is derived from the data in every quarter, the data availability situation which existed at that quarter is exactly replicated. In essence, we are seeking to replicate the timeliness, which would have pertained for an analyst at the time the GDP estimate is formulated. However, adopting this approach does give rise to what has been referred to as the “jagged edge” issue. Some data series do not have observations for the most recent month or two so the panel from which the factor is derived is unbalanced in nature. In addressing this problem, we follow the same two-step approach as Giannone, Reichlin and Small (2005). Therefore, the now-casting methodology enables both current and recent GDP to be estimated conditional on a large number of variables. Most of these variables are already used in gauging the current state of the economy, however, the now-casting approach presents a coherent framework for the inclusion of this information. As such, the modelling approach represents a significant addition to the policy-analysis tool kit of the Irish Central Bank. This is particularly the case for a small open economy, where movements in GDP and other major macroeconomic variables can be quite volatile.

To place the now-casting exercise in context, we discuss some of the challenges, which arise in forecasting Irish GDP. The chronology of Irish GDP releases is also discussed in terms of its relevance for two of the more influential forecasts of GDP within the Irish economy. These forecasts are compared with both initial and revised GDP estimates. In the rest of the paper details of the now-casting approach are presented followed by the results of an out-of-sample forecast simulation. A final section offers some concluding comments.

## 2. The Challenges of Forecasting Irish GDP

The Quarterly National Accounts (QNA) releases of the Irish Central Statistics Office (CSO) provide the most comprehensive available information on recent developments in the Irish economy. The QNA provide estimates of GDP and its main output and expenditure components and the current release delay is (no later than) 90 days meaning that GDP growth for a reference quarter is available at the very end of the following quarter. In view of this significant release delay, conjunctural assessments of the Irish economy would benefit from an early indicator of quarterly GDP of sufficient accuracy and timeliness. However, such an exercise is faced with a number of significant challenges. The Quarterly National Accounts data, as repeatedly emphasised by the CSO, are subject to a large margin of error and there are two issues in particular that merit attention in the context of a forecasting exercise:

- Irish quarterly GDP is quite volatile by international standards. This may be be observed from Figure 1, where the upper panel plots the year-on-year GDP growth rates for each quarter from 2000 to the present. McCarthy (2004) notes that Irish quarterly GDP has shown significantly more volatility than corresponding data for any other OECD country. McCarthy pointed to the structure of the manufacturing sector in Ireland as the source of much of the volatility, with sectors such as the manufacture of basic chemicals particularly prominent in this respect. This could be partly attributable to large value changes occurring in the chemicals sector output. Production in the chemical sector often switches from patented products to lower priced generic products and it can be difficult to get a proper handle on the changes in relevant deflators. While the volatility of Irish GDP appears to have moderated somewhat in recent years, it still remains quite high by international standards.

- The revisions to Irish quarterly GDP are quite significant by international standards and these revisions have been examined by Bermingham (2006) and by Quill (2008). The lower panel of Figure 1 plots the inital and the latest estimate of GDP released by the CSO. The main revisions take place when the detailed annual national income and expenditure accounts are published during the middle of the year after the reference year and the initial quarterly estimates are aligned with more comprehensive annual data at this point. Quill (2008) points out that significant revisions can arise when the consistency checks are performed on the fully audited accounts of large multinational firms. Although the latest available estimates for quarterly and annual GDP give the most reliable indications for the state of the economy at any point in time in the past, it could argued that the initial GDP outturns have a greater influence, as by the time later revisions and potentially quite significant revisions come out, the forecasters and economic policy-makers may have in a sense moved on.

Despite the volatility and preliminary nature of quarterly GDP, forecasters place significant weight on the latest data on quarterly GDP when formulating or updating their forecasts for the whole year GDP growth, as it is the best available indicator of the overall state of the economy. In analysing forecasts of Irish GDP, we concentrate on the forecasts of two of the main domestic economic forecasting institutions - the Central Bank and Financial Services Authority of Ireland (CBFSAI) and the Economic and Social Research Institute (ESRI).[1]

Typically, in recent years, when forecasts are published by the CBFSAI or ESRI, only the GDP outturns up to two quarters earlier are available. At the CBFSAI, for example, the forecast for GDP growth for the whole year is normally finalised towards the end of a quarter, say $q_{t-1}$, at which time the GDP outturn for the previous quarter, $q_{t-2}$, has become available; the forecast is then published at the beginning of $q_t$. At the ESRI, the forecast is typically finalised and published during the final month of a quarter, $q_t$, when the latest GDP outturn is for $q_{t-2}$. The ESRI only has the GDP outturns available up to $t - 2$, as is the case for the CBFSAI, but the ESRI can also draw from other (often monthly) data released during a large part of $q_t$. Therefore, it is important to keep in mind in any comparison of forecasting performances that the information set available to the two teams of forecasters is not the same and that as a result, the two sets of forecasts are not strictly comparable.

The CBFSAI produces ten sets of comprehensive forecasts during the year - the four sets of forecasts for the Bank's Quarterly Bulletins and the three rounds of the Spring and Autumn biannual broad macroeconomic projection exercises (BMPE) that run in conjunction with the rest of the Eurosystem. Each of these forecast exercises draws together individual forecasts from experts covering sectors across the economy. The projections are based partly on the available historical data and on technical assumptions for exchange rates, interest rates, world demand for Irish exports, competitiveness developments and oil and other commodity futures prices. These forecasts for volumes and deflators from each of the sectors of activity are reconciled and the Bank's macroeconometric forecasting model for the Irish economy may also be used to provide complementary projections and for carrying out some consistency checks.

In Figure 2, we again plot the initial and latest CSO estimate for GDP growth. Also included are the CBFSAI and ESRI whole year GDP forecasts over the course of each corresponding year (neither institution currently publishes quarterly GDP estimates). The figure is also helpful in assessing the degree to which forecasters are influenced by the latest available quarterly GDP outturn. Generally, forecasters would tend to put more weight on quarterly GDP outturns as the year progresses. In the case of the CBFSAI forecasts, there is a maximum of two outturns for the

[1]The ESRI is an independent economic and social research think tank.

first and second quarter in a year that can be availed of (as Q3 comes out at end of Q4, with the next Bulletin forecast published the following year and therefore does not count in our assessment of annual nowcast estimates). Taking the year 2005 as an example, it is not apparent that the forecasters in their whole year forecast published in the third quarter are putting a large weight on the available first quarter GDP outturn. The usually weak first quarter GDP outturn appears to lead to only a slight downward revision by the CBFSAI and even a slight upward revision from the ESRI (from a lower baseline).

Forecasters are of course also taking into account the most recent monthly data outturns and may also have been anticipating a pick-up in the second half of 2005, which did in fact materialise. It also reflects to an extent the knowledge that quarterly GDP outturns can be quite volatile. In addition, there was a small revision for 2004 but there is a big upward revision for 2003 and this may have had some influence also in setting a forecast that corresponds with the anticipated final outturn for GDP for the year. Although Quill finds that there was no trend of positive revisions based on data over the period 1998 to 2007, revisions have tended to be upward and can be quite large since 2002. Finally, it is worth noting that expectations for the outturns for the remaining quarters for a particular year may be influenced by leading indicators and may also take into account some base effects.

The forecast errors of the CBFSAI and ESRI are of a similar magnitude - see the respective mean squared forecast errors over the period 2000 to 2007 in Table 1 below. The ESRI forecasts for 2000 turned out to be quite conservative and its forecast error for that one year may have an undue influence on the full sample results. According to the forecast errors since 2001, there is not much to separate the two forecast teams in terms of their performances in forecasting the initial full year CSO outturn. The ESRI appears to perform slightly better at forecasting the final estimates for GDP. However, as mentioned earlier, while the latest available GDP release is the most definitive record of the value added for a particular year, forecasting performances are often in practise judged against the initial or intermediate outturns. Forecasters may have sensed that the initial data are inconsistent with their own judgement or intuition as to the state of the economy at that time. However, clearly, it is not possible to validate this retrospectively using an empirical test. Also, tests over the full sample of quarterly GDP data suggest that there is no predictable element to the subsequent revisions to the GDP outturns. It should be recalled that the CBFSAI forecast is typically published during the first month of a quarter while the ESRI forecast is often published during the final month of a quarter. Thus, due simply to the timing of the respective publications, the ESRI forecasts may have the advantage of up to two months extra data releases.

## 2.1. Dataset

The GDP now-casting model incorporates information from the lags of quarterly GDP and a large set of more timely and in the main higher frequency indicators that try to capture conjunctural developments in the Irish and international economies. There are 41 indicator series in the conditioning set. The full list of indicators along with their respective sources, release delays and transformations are presented in Table 2. These series are part of a larger set of series used by the CBFSAI in projection exercises but the series in the conditioning set must also satisfy other criteria including having a sufficiently timely release delay. The series are generally of monthly frequency and are significantly more timely than the GDP releases, with the longest release delay for the monthly series at about 50 days. Each of the series must also be sufficiently long for modeling purposes. The dataset begins in January 1985 and is unbalanced at the end of the sample reflecting the different release delays of the indicators. The structure of the dataset should be largely the same, at least for the set of monthly series, at each monthly update of the quarterly GDP nowcast. The model attempts to nowcast year-on-year GDP growth for a given quarter and the indicator series undergo transformations before entering the model. Typically, the series are converted to year-on-year growth rates helping to avoid the excessive volatility of quarter-on-quarter growth rates.

The dataset contains direct measures of economic activity and price dynamics along with indirect measures such as business and consumer sentiment surveys and financial indicators. Almost each sector of the economy is represented but efforts are made to adequately cover in particular those sectors with both higher weighting and more volatile outturns. Industrial output, which accounts for about a quarter of GDP at factor cost, is an important source of volatility, as illustrated in Table 3 below. The volatility is particularly pronounced in certain manufacturing sub-sectors, such as the manufacture of basic chemicals, and this can present significant challenges in a forecasting context. The overall monthly industrial output index is included as an indicator, but more detailed sub-sectoral data were not included as according to out tests they did not bring useful additional explanatory power. It is worth noting that the explanatory power of industrial production indices may be limited by the fact that the monthly industrial production series are not adjusted for royalties and licence services imports whereas GDP is adjusted as these inputs are not regarded as value added. In this respect, it is worth noting that the increasing use of service inputs over time may not be taken into account adequately (data on services inputs are only available quarterly with the Balance of International Payments, which is released at the same time as the QNA).

The contribution of the construction sector to GDP growth has undergone significant changes during this decade and indicators such as housing completions and housing registrations are included to capture activity in the sector. Activity in the market services sector is accounted for primarily by the monthly retail sales and car sales indices. Financial data, such as money and credit data, are also included. Exchange rate data are daily but they enter the model as monthly averages. International factors are represented by business and consumer surveys for the euro area, an indicator of extra euro area demand for Irish exports and a competitiveness indicator. Finally, there are two labour market indicators i.e. the monthly unemployment rate and the numbers on the live register.

## 3. The Model

In this section we outline the dynamic factor model (Giannone, Reichlin and Small (2005)) used to generate the monthly estimates of GDP. The estimation strategy with this approach is twofold, in the first, a set of factors are extracted from a panel of monthly indicators, in the second step, the GDP series is projected onto the factors via a bridge equation.

The Giannone, Reichlin and Small (2005) model can be summarized as follows. A vector of $n$ stationary (standardized) variables $x_t = (x_{1,t}, x_{2,t}, ..., x_{n,t})'$ $t = 1, 2, ..., T$ is assumed to have the following dynamic factor model characterisation:

$$x_t = \chi_t + \xi_t = \Lambda f_t + \xi_t \tag{1}$$

$$f_t = \sum_{i=1}^{p} A_i f_{t-i} + \zeta_t \tag{2}$$

$$\zeta_t = B\eta_t \tag{3}$$

where $x_t$ in eq.(1) is the sum of two orthogonal components, the common component $\chi_t$ and the idiosyncratic component $\xi_t$. The common component is the product of an $n \times r$ matrix of loadings $\Lambda$ and a $r \times 1$ vector of latent factors $f_t'$. The idiosyncratic component is a multivariate white noise with diagonal covariance matrix $\Sigma_\xi$. Factor dynamics are described in eq.(2), which is a VAR(p). $A_1, A_2, ..., A_p$ are matrices of parameters and $\zeta_t \sim N(0, BB')$, where B is a $(r \times q)$ matrix[2] with $q \leq r$; $\eta_t \sim N(0, I_q)$

In the Appendix, we outline how consistent estimates of the parameters of the model can be obtained. Using these estimates, the factors can be estimated in the following manner:

[2] We assume $B'B = \Sigma$

$$\hat{F}_t = proj[F_t|x_1, ..., x_T; \hat{\Lambda}, \hat{A}, \hat{B}, \hat{\Sigma}_\xi]$$

that is, by applying the Kalman filter to the state-space representation obtained by replacing estimated parameters in the factor representation:

$$x_t = \hat{\Lambda} f_t + \xi_t \tag{4}$$

$$f_t = \sum_{i=1}^{p} \hat{A}_i f_{t-i} + \zeta_t \tag{5}$$

The Kalman filter can be also used to evaluate the degree of precision of the factor estimates

$$V_k = E[(F_t - \hat{F}_t)(F_t - \hat{F}_t)|x_1, ..., x_T; \hat{\Lambda}, \hat{A}, \hat{B}, \hat{\Sigma}_\xi].$$

while, the estimates of the signal and their degree of precision are given, respectively, by

$$\chi_t = Proj[\chi_t|x_1, ..., x_T; \hat{\Lambda}, \hat{A}, \hat{B}, \hat{\Sigma}_\xi] = \hat{\Lambda}\hat{F}_t$$

$$E(\chi_t - \hat{\chi}_t)^2 = \hat{\Lambda}' V_0 \hat{\Lambda}$$

This framework is adapted to estimate the factors on the basis of an incomplete dataset, i.e. a dataset which contains some missing values corresponding to data which has not yet been released. In this case, the parameters of the model, $\hat{\Lambda}$, $\hat{A}$, $\hat{B}$ and $\hat{\Sigma}_\xi$ are estimated using data up to the last date when the balanced panel is available. Hence, rows with missing observations are simply skipped when applying the Kalman recursion. This is equivalent to setting the variance of the idiosyncratic component related to the missing observations equal to zero.

We define the yearly GDP as the average of the latent observations in the quarter $GDP_t^Y = \frac{1}{3}(GDP_t + GDP_{t-1} + GDP_{t-2})$. Yearly factors are obtained as $f_t^Y = (f_t + f_{t-1} + f_{t-2})$. Estimates of the year-on-year GDP are computed with the following bridge equations:

$$\widehat{GDP_t}^Y = \hat{\beta}' \hat{f}_t^Y \tag{6}$$

where $\hat{\beta}$ is a $r \times 1$ vector of estimated parameters. Backcasts, now-casts and forecasts of the GDP series can be computed every month as soon as new information becomes available. The estimate of yearly GDP (computed in the last month $t$ of the quarter) is given by

$$\widehat{GDP}_t^Y = \frac{1}{3}(\hat{y}_t + \hat{y}_{t-1} + \hat{y}_{t-2}) \tag{7}$$

The forecast error is defined as the difference between the estimated and (ex post) realized value $\varepsilon_t^Y = \hat{y}_t^Y - y_t^Y$. We assume that $\varepsilon_t^Y \sim N(0, \sigma_\varepsilon^2)$ and that $\xi_t$, $\zeta_t$ and $\varepsilon_t$ are mutually independent at all leads and lags.

## 3.1. Model Evaluation

To evaluate the forecast performance of the modelling approach, we perform a pseudo real-time out of sample simulation. In using the pseudo real-time approach, we are seeking to replicate the actual data availability situation, which pertained at the time the now-cast/forecast is generated. Therefore, the parameters of the model are generated recursively based on the data availability at a particular quarter.

The out of sample simulation procedure is as follows; the exercise begins by estimating the model on a sub-sample called the estimation window 1980:Q1 to 1996:Q4. The estimated parameters are then used to back-cast and now-cast GDP. The estimation window is updated sequentially with one observation and the parameters are re-estimated based on the new sample available. The estimates of GDP are again generated using the new sample. This procedure is then iterated until the end of the sample.

We evaluate the performance of the model by generating two sets of statistics. The first is the Mean Squared Back-Cast Error (MSBE), which is defined as

$$MSBE = \frac{1}{(t_1 - t_0 + 1)} \sum_{t=t_0}^{t_1} (GDP_k - \widehat{GDP}_{k|m^{k+1}})^2, \quad \text{where } m = 1, 2$$

and the second is the Mean Squared Now-Cast Error

$$MSNE = \frac{1}{(t_1 - t_0 + 1)} \sum_{t=t_0}^{t_1} (GDP_q - \widehat{GDP}_{k|3^k})^2,$$

where $k$ refers to the quarter and $k^q$ refers to the month $m$ in quarter $k$. $GDP_k$ is the ex-post realised value, while $\widehat{GDP}_{k|m^{k+1}}$ and $\widehat{GDP}_{k+1|3^{k+1}}$ are, respectively, the back-cast and now-cast estimates of $GDP_k$.

We also compare the accuracy of the models estimates with that of a benchmark model.[3] In

[3]The standard benchmark model in this literature is the constant growth model. However, owing to the particularly volatile nature of Irish quarter-on-quarter GDP changes, we elect to use, as the standard GDP transformation, year-on-

our case we take, as the benchmark model, the average of the last four most recently available year-on-year GDP changes.[4]

### 3.2. Results

We now compare the forecast performance of the model in terms of both now-casts and back-casts vis-à-vis that of the benchmark model. Table 4 presents the mean squared errors (MSE) for the different applications. These are presented for the case where the now-cast or the back-cast is generated for each of the three different months in each quarter.

It can be seen from the Table that in both the case of the back-casts and the now-casts, the mean squared back-cast error (MSBE) and the mean squared forecast error (MSNE) of the benchmark model is considerably greater than the model proposed here. In terms of the month in the quarter the now/back-cast is generated, it is evident, as one would expect, that as one moves from the first month to the second and onto the third month, the quantity of information available increases, thereby resulting in a decline in the MSBE and the MSNE.

In Figures 3 and 4, we plot the back-cast and the now-cast respectively along with the observed series and the results from the benchmark model. From Figure 3, it may be observed that the back-cast generated for the second month tracks the observed series quite well, particularly when compared with the estimate of the benchmark. In the case of the now-cast estimates in Figure 4, the estimate generated for the third also can be seen to improve on that estimated in the first and second months of the quarter.

It is tempting to compare the estimates from the now-casting approach with the forecasts of the CBFSAI and ESRI presented in Figure 2. While the results from the now-casting are more accurate than either of the two institutions, such a comparison is somewhat unfair due to the timeliness of the dataset used to condition the individual now-casts. A fairer comparison would entail compiling a real-time database and generating the now-cast accordingly.

A further point of note is that in the case of both the CBFSAI and the ESRI, the forecast is an annual now-cast for each year in question, whereas, in the model application, the estimate is the year-on-year growth rate for the individual quarter in a particular year.

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year changes. Therefore, for such a transformation, the average growth rates is a more appropriate model rather than the constant growth rate. Nonetheless, we also compare our results with those of the standard benchmark model - the results do not change. They are available, upon request, from the authors.

[4]The results in the model simulation are generated with a specification with one dynamic factor, one static factor and the VAR for the factors of order 4. This specification results in the lowest mean square forecast error for the sample in question.

## 4. Conclusions

The employment of the now-casting framework represents a significant addition in the forecasting skill set of the CBFSAI. In providing timely estimates of GDP, the approach has a number of attractive features; a large panel dataset of potential determinants of GDP may be parsimoniously employed through the factor methodology. Within individual quarters of the year, the approach enables the data flow on monthly information during the quarter to be exploited. A pseudo-real time data approach is followed in that the data availability situation, which exists at each quarter is replicated for the model estimates.

To place the now-casting work in context, a chronology is provided of the release of GDP estimates by the Irish Central Statistics Office and how these are incorporated within the forecasts of the CBFSAI and the ESRI - the two main forecasting institutions of GDP within the Irish economy. In general the observed series for Irish GDP is characterised by two features when compared with that of other countries, firstly, Irish GDP is particularly volatile mainly due to the compositional relevance of the manufacturing sector and secondly, there tends to be significant revisions between the initial and final estimate of GDP. The performance of both the CBFSAI and ESRIs forecasts are evaluated over the period 2000 to 2007.

In evaluating the now-casting model, we perform an out of sample simulation where the estimates of the model are compared with that of a benchmark approach. We find that the mean squared forecast errors for both the now-casts and the back-casts are considerably smaller than those of the benchmark model. Unsurprisingly, the later in the quarter the now-cast or the back-cast is generated, the more accurate the estimate is relative to the observed series.

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## Appendix A: Parameters Estimation

In this Appendix, we outline how consistent estimates of the parameters of the dynamic factor model are obtianed.

Suppose that $z_{it} = y_{it} - \hat{\mu}_i$ and that $x_{it} = \frac{1}{\hat{\sigma}_i}(y_{it} - \hat{\mu}_i)$, where $\hat{\mu} = \frac{1}{T}\sum_{t=1}^{T} y_t$ and $\hat{\sigma}_i = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(y_t - \hat{\mu}_i)^2}$.

Consider the following estimator of the common factors:

$$(\tilde{F}_t, \hat{\Lambda}) = \arg\min_{F_t,\Lambda} \sum_{t=1}^{T}\sum_{i=1}^{n}(z_{it-\Lambda_i Ft})^2$$

Let's define the correlation matrix of the observables $(y_t)$ as:

$$S = \frac{1}{T}\sum_{t=1}^{T} x_t x_t'$$

Let's define $D$ the $r \times r$ diagonal matrix with diagonal elements given by the $r$ largest eigenvalues of $S$ and $V$ the $n \times r$ matrix of the corresponding eigenvectors subject to the normalization $V'V = I_r$. Factors are estimated as:

$$\tilde{F}_t = \Lambda x_t$$

and the factor loadings $\hat{\Lambda}$ are estimated by regressing the variables on the estimated factors:

$$\hat{\Lambda} = \sum_{t=1}^{T} x_t \tilde{F}_t' (\sum_{t=1}^{T} \tilde{F}_t \tilde{F}_t{}')^{-1}$$

and the cavariance matrix of the idiosyncratic component as estimated as:

$$\hat{\Sigma}_\xi = diags(S - VDV)$$

The other parameters $\hat{A}$ and $\Sigma$ are estimated by running a VAR on the estimated factors:

$$\hat{A} = \sum_{t=2}^{T} \tilde{F}_t \tilde{F}_{t-1}' (\sum_{t=2}^{T} \tilde{F}_{t-1} \tilde{F}_{t-1}')^{-1}$$

$$\hat{\Sigma} = \frac{1}{T-1}\sum_{t=2}^{T} \tilde{F}_t \tilde{F}_t' - \hat{A}(\frac{1}{T-1}\sum_{t=2}^{T} \tilde{F}_{t-1}\tilde{F}_{t-1}')\hat{A}'$$

Finally, let's define $P$ as the $q \times q$ diagonal matrix with the entries given by the largest $q$ eigenvalues of $\hat{\Sigma}$ and by $M$ the $r \times q$ matrix of the corresponding eigenvectors, then:

$$\hat{B} = MP^{\frac{1}{2}}$$

Table 1: Mean Squared Forecast Errors (MSFE) for the CBFSAI (CB) and the ESRI

| | CB versus CSO Inital | ESRI versus CSO Initial | CB versus CSO Intermediate | ESRI versus CSO Intermediate | CB versus CSO Latest | ESRI versus CSO Latest |
|---|---|---|---|---|---|---|
| 2000 - 2007 | 1.5 | 2.3 | 2.6 | 2.9 | 2.5 | 2.0 |
| 2001 - 2007 | 1.2 | 1.2 | 2.6 | 2.1 | 2.8 | 2.1 |

**Note:** Initial estimate= first release for the final quarter; Intermediate=first release of comprehensive National Income and Expenditure accounts (normally released at the middle of the subsequent year); and Latest= latest available national accounts.

Table 2: List of Variables used in the Factor Analysis

| Name | Frequency | Timeliness (approx. days) | Source |
|---|---|---|---|
| Live Register | M | 10 | http://www.cso.ie/prlabfor.htm |
| Retail Sales | M | 50 | http://www.cso.ie/prservices.htm |
| Car Sales | M | 10 | http://www.cso.ie/prtransport.htm |
| Unemployment Rate | M | 10 | http://www.cso.ie/prlabfor.htm |
| Industrial Production | M | 40 | http://www.cso.ie/prind.htm |
| Real M1 | M | 30 | http://www.cso.ie/FinancialIndicators.asp |
| Real M2 | M | 30 | http://www.cso.ie/FinancialIndicators.asp |
| Real M3 | M | 30 | http://www.cso.ie/FinancialIndicators.asp |
| Real Private Sector Credit | M | 30 | www.centralbank.ie |
| CPI sub-indices | M | 30 | http://www.cso.ie/prprices.htm |
| House Completions | M | 20 | http://www.esri.ie/ |
| House Registrations | M | 20 | http://www.esri.ie/ |
| Consumer sentiment index | M | 3 | http://www.esri.ie/ |
| Index of consumer expectations | M | 3 | http://www.esri.ie/ |
| Exchange rates | M | 0 | www.centralbank.ie |
| Euro area consumer surveys | M | 30 | http://ec.europa.eu/ |
| Extra euro area demand for Irish exports (WDREX) | Q | BMPE | ECB |
| CXDIN | Q | BMPE | ECB |
| Gross Domestic Product | | | http://www.cso.ie/prnatacc.htm |

Table 3: Mean Absolute Deviations of Year-on-Year Growth Rates by Sector

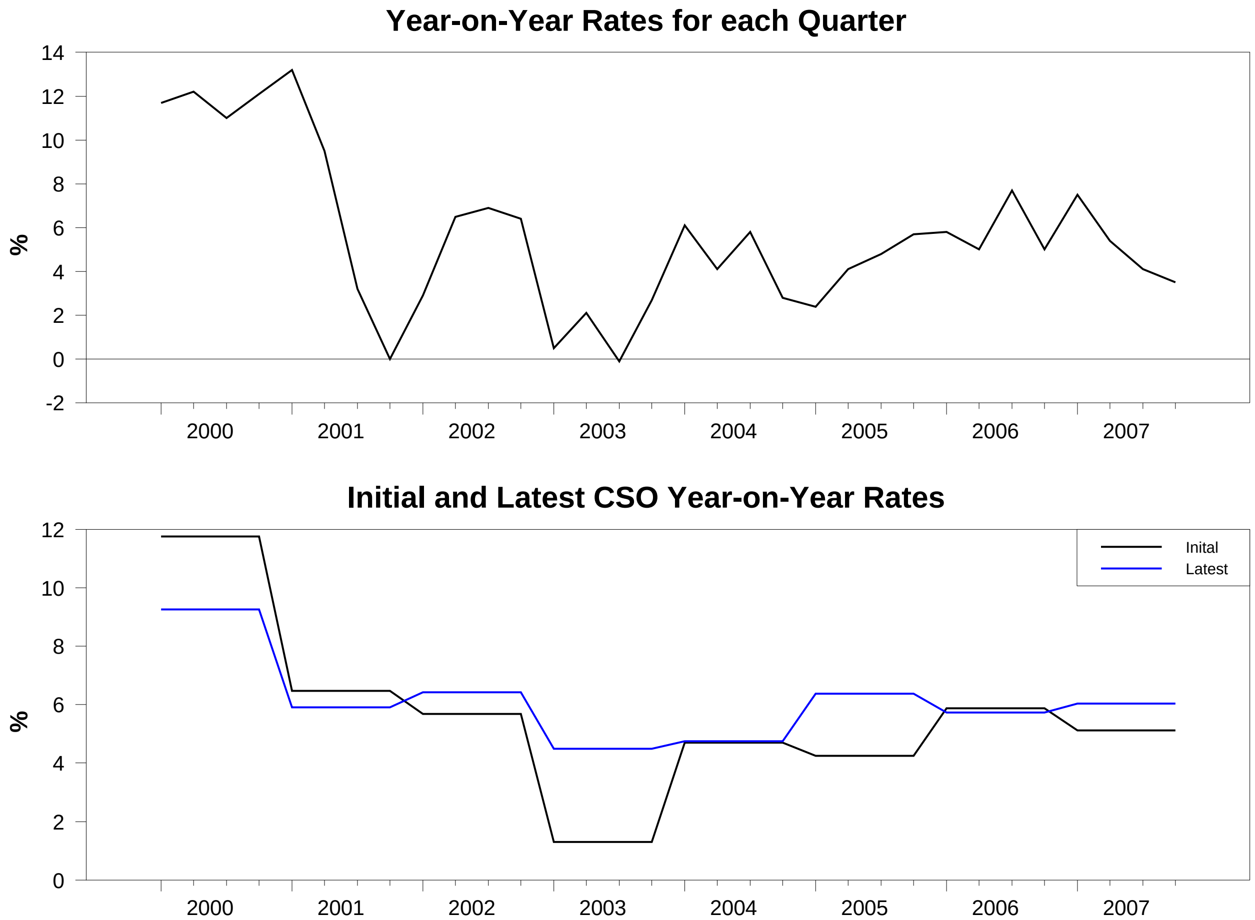
| | Mean Absolute Deviation | Share of GDP at Factor Cost |
|---|---|---|
| Agriculture | 28.0 | 2.3 |
| Industry (excl. Construction) | 31.4 | 25.1 |
| Building and Construction | 16.7 | 8.5 |
| Distribution, Transport and Communication | 8.0 | 15.6 |
| Public Administration and Defence | 2.4 | 3.4 |
| Other Services | 8.1 | 46.2 |

**Note:** Shares are approximate, due to non-additivity of the chained-linked data, and do not add to 100.

Table 4: Mean Squared Errors (MSE) for Back-Casts and Now-Casts

| Model | MSBE | MSNE |
|---|---|---|
| 1st Month | 5.317 | 6.145 |
| 2nd Month | 5.034 | 5.570 |
| 3rd Month | | 5.475 |
| Benchmark | 8.189 | 8.361 |

# Figure 1: Irish GDP Growth Rates 2000 - 2007



# Figure 2

*CBFSAI (CB) and ESRI (ESRI) Forecasts and CSO Initial and Final Annual Outturns*

Figure 3: *Comparison of Back-Casting Performance*

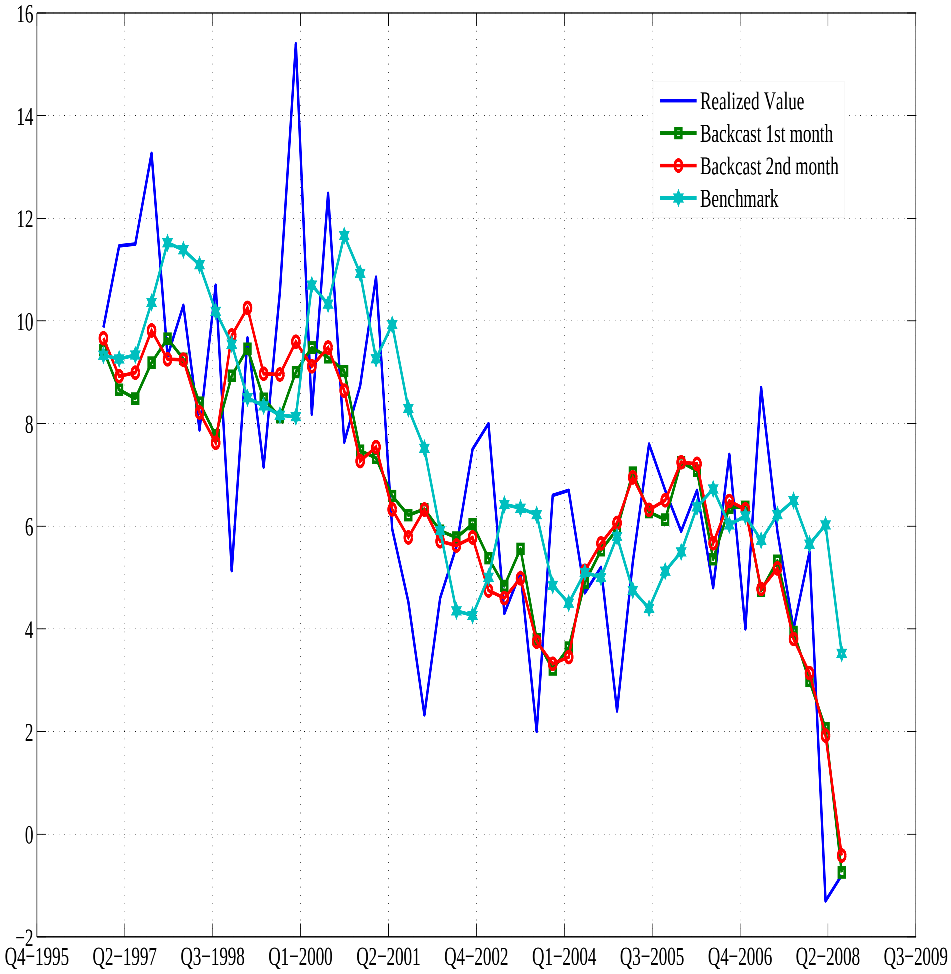


Figure 4: *Comparison of Now-Casting Performance*