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An Economic Activity Index for Ireland: The Dynamic Single-Factor Method

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Abstract

This paper estimates a coincident indicator of economic activity for Ireland using a dynamic single-factor model. The composite index is used to identify the peaks and troughs in Irish economic activity, and is capable of being updated on a timelier basis than estimates of GDP or GNP. The contribution of this paper is to provide an easily understood coincident index reflecting current economic activity in the Irish economy. This could be useful in helping policy makers and private agents to identify the peaks and troughs in Irish economic activity.

JEL classification numbers: C13, C43.

Key words: coincident indicators, factor models.

1. Introduction

There is a considerable body of analysis concerning the causes of the recent growth of the Irish economy. This expansion of the Irish economy has raised economic activity levels substantially relative to that of our EU neighbours. Most people track changes in the economy through the changes in quarterly Gross Domestic Product (GDP) or Gross National Product (GNP). However, in some circumstances, it might be useful to have a timelier indicator of economic activity in the Irish economy. The aim of this paper is to estimate a monthly coincident index of economic activity for Ireland.

Policy makers and private agents monitor assessments of how the economy is performing, as they provide a useful picture of where we are and where we may be going. Providing timelier information on the state of the economy may have positive implications for these decision takers. If a range of economic indicators suggests that the economy is going to perform differently in the future than decision takers had previously anticipated, this may alter their strategy. However, it is not always clear which economic measure provides the best or most reliable answer about current economic conditions.

One of the potential problems in relying on economic forecasts tracking GDP or GNP is that they are published with a significant time lag, currently 90 days in Ireland¹. Both GDP and GNP tend to smooth out the data, potentially concealing some turning points in economic activity. An advantage of dynamic single-factor models is that they require a relatively small number of indicator variables to track economic activity. In this context a monthly economic activity index may be considered a useful tool, providing timely identification of expansionary or recessionary phases in economic activity².

This paper draws on coincident index estimation procedure proposed by Stock and Watson (1989) and utilises software developed by Clayton-Matthews (2001). The

¹ In most countries they are subject to several revision rounds before the final data is confirmed and in the Irish case, data used to compile GDP and GNP figures have occasionally been subject to major revision.

² In this context we describe the changes in the coincident index as consisting of broad based movements in economic activity.

Stock and Watson procedure is a dynamic single-factor index methodology. In essence it aggregates the movements of several key economic indicators providing a single summary statistic reflecting current economic activity in the economy.

This paper constructs the composite index of the Irish economic activity. The composite index is used to identify the peaks and troughs in Irish economic activity. The structure of this paper is as follows: in Section 2, we provide an overview of the relevant literature. Section 3 describes the data and Section 4 outlines the model. We report the results of our estimations in Section 5 and Section 6 offers some concluding comments.

2. Literature

In the 1980s James Stock and Mark Watson developed a new composite coincident index and a leading index of economic activity for the United States. The main contribution of their research was in the use of a statistical technique called the Kalman filter, which estimated the optimal weights on the component indicators. The traditional composite index methodology did not attempt to estimate optimal weights but simply applied equal weights once the volatility in each series was standardized. In contrast, Stock and Watson advanced the notion of statistically estimating the weights on the component series that best identifies a single underlying factor. This is an underlying factor, which is time dependent and best represents the co-movement in the components. Thus, the Stock and Watson index could be said to provide a superior and more precise picture of current economic activity.

Alan Clayton-Matthews and James Stock (1998) follow the Stock and Watson methodology and employ the Clayton-Matthews software for coincident index construction and apply it to the Massachusetts regional economy. They claim that the coincident economic indicator is a useful gauge for the near-term growth rate in the region, because it is based upon indicators closely tied to current production and income generation. In conclusion, they state that while leading indicators do add some information over and above that provided by a coincident economic indicator, they don't improve it by much.

Hobijn *et al* (2003) construct a coincident index of high-tech sector activity in the United States called the Tech-Pulse Index. They follow the Stock and Watson methodology and utilise the Clayton-Matthews software for their estimations. The Tech-Pulse Index offers a real-time assessment of the underlying movements in high-tech sector activity and potentially serves as a leading indicator of changes in aggregate activity.

One virtue of this method to track changes in economic activity is that a relatively small number of indicator variables are required to build the dynamic single-factor model. Schneider and Spitzer (2004) assess the performance of dynamic single-factor models as coincident indicators. They report that a model containing between five and eleven variables outperforms (i.e. tracking changes in economic activity) a model containing one hundred and forty three variables. This is somewhat reassuring given the limited availability of extended time series data for Ireland.

Fagan and Fell (1992) estimated a coincident index for Ireland using the principal component approach. Principal component analysis is a data reduction method allowing one to estimate which of the unit-length linear combinations of the indicator variables has the greatest co-variance. The estimated weight to apply on each indicator variable is given by the first principal component. These component weights for each indicator variable are used to create a weighted average growth rate of the original series to produce the coincident indicator.

Looking at their chronology of Irish recessions, it is broadly in line with those of the US and UK or both. Using GDP and GNP, they demonstrated that the coincident indicator moved broadly in line with annual aggregates of economic activity. As an additional check they compared the performance of GDP, GNP and the coincident indicator in explaining movements in total employment and investment respectively. Again the coincident indicator was shown to have more explanatory power for movements in either total employment or investment.

Another body of research has tended to focus on the duration of the economic cycle and secondly whether the volatility of changes in economic activity has diminished over time. Diebold and Rudebusch (1992) focus on the duration of the economic cycle

in the US. They report that post WWII there has been a shift towards longer expansions and shorter contractions in the economic cycle. Christodoulakis *et al* (1995) find that both the volatility and persistence of GDP, investment, prices and private consumption is similar across the EU 12. Wynne and Koo (2000) study economic cycles from 1950 to 1995 in the EU 15 with 12 US states. Overall, they find considerably more statistically significant positive correlations across the 12 US states for employment, output and price gaps compared to either the original EU 6 or the EU 15 member countries.

3. Data

Based on the Clayton-Matthews criteria, selected indicator series must have co-movement with economic activity. A variable must be of high frequency and timeliness of availability. The selected variable is required to have sufficient length of historical record, exhibit reliability and be robust to revisions. A selected variable must have a turning point that can be aligned with movements of the other variables within the index.

Hobijn *et al* (2003) states that variables should reflect movements or changes in supply, demand and employment conditions. Looking at supply side indicators, he utilises industrial production and information technology shipments. Labour market conditions are captured by total employment. Both IT investment and computer consumption in high-tech sectors are used to proxy demand conditions.

On a practical level, where possible only real variables, measuring activity in quantities, are used and nominal economic variables measuring activity in Euros are omitted³. The indicator series selected for this estimation are; new car sales (volumes), export (volumes), import (volumes), real M1 (growth rate), retail sales (volumes) and the live register of unemployment (growth rate)⁴. This model is

³ Using the Dickey-Fuller test: testing for stationarity against the alternative of a unit root we rejected the null hypothesis that the individual series are stationary. The series are I(1) and were logged (unless they were in percentage growth rate format) and first differenced to achieve stationarity.

⁴ There have been changes to compilation methods for some of the indicator series. Where necessary linear imputing and interpolation of the data based on growth rates has been undertaken to provide a unified indicator series.

estimated for the period April 1970 to July 2003 using monthly observations of all the indicator variables. The variables used in this estimation and how the data was treated prior to estimation is shown in table 1. Table 2 gives the annualised growth rates and summary statistics for the indicator variables used in the model.

4. Theory and Model

In this section, the dynamic single-index methodology developed by Stock and Watson (1989) is described and the Clayton-Matthews (2001) procedure is outlined.

4.1 The Dynamic Single-Factor Model

The structure of this dynamic single-factor model is:

$$(1) \Delta x_t = \beta + \gamma(L)\Delta c_t + \mu_t$$

$$(2) D(L)\mu_t = P(L)\varepsilon_t$$

$$(3) \phi(L)\Delta c_t = \delta + q(L)\eta_t$$

The three equations above form the dynamic factor single-index model that was first proposed by Sargent and Sims (1977). The observed data consisting of the pre-selected composite indicator variables are stacked in the vector of series (x) ⁵. A single underlying series (Δc) represents the state of the economy⁶.

The vector μ_t comprises G mutually uncorrelated, mean zero and stationary autoregressive moving average (ARMA) processes. The $G \times 1$ vector ε_t and the scalar η_t comprise $G+1$ mutually uncorrelated white noise processes and thus the disturbances (ε_t, η_t) are serially uncorrelated with the diagonal covariance matrix Σ (parameter 7). $D(L)$ (parameter 5a) and $P(L)$ (parameter 8a) which are the lag

⁵ Where a time series variable is subscripted with a “ t ” and Δx_t is a $G \times 1$ vector of observable stationary series. Measured in log form and appropriately differenced it is assumed to be stationary.

⁶ Which is a scalar latent series that is common to the G observable series and has the interpretation as the underlying growth rate of the economy.

polynomial matrices are assumed to be diagonal⁷. Therefore, in the difference equations in (2), the autoregressive disturbances, the $(\mu's)$, are contemporaneously and serially uncorrelated with each other.

The model parameters are expressed as follows:

$$(4a) \gamma(L) \equiv [\gamma_1(L), \gamma_2(L), \dots, \gamma_G(L)]',$$

$$(4b) \text{ Where } \gamma_g(L) \equiv \gamma_{g0} + \gamma_{g1}L + \gamma_{g2}L^2 + \dots$$

$$(5a) \mathbf{D}(L) \equiv \text{diag}[d_1(L), d_2(L), \dots, d_G(L)]',$$

$$(5b) \text{ Where } d_g(L) \equiv 1 - d_{g1}L - d_{g2}L^2 - \dots$$

$$(6) \phi(L) \equiv 1 - \phi_1L - \phi_2L^2 - \dots$$

$$(7) \Sigma \equiv \text{cov}([\varepsilon_t', \eta_t']') = \text{diag}[\sigma_1^2, \sigma_2^2, \dots, \sigma_G^2, \sigma_\eta^2]$$

$$(8a) \mathbf{P}(L) \equiv \text{diag}[p_1(L), p_2(L), \dots, p_G(L)]',$$

$$(8b) \text{ Where } p_g(L) \equiv 1 + p_{g1}L + p_{g2}L^2 + \dots$$

$$(9) q(L) \equiv 1 + q_1L + q_2L^2 + \dots$$

This model can be interpreted as a time series version of a factor analysis model, in which the output of the system consists of the common component, that is a time series of the estimated growth in the state of the economy⁸, $\{\Delta c_{s|T}, s = 1, \dots, T\}$. In the factor analysis model the Δc is known as the “common factor” and the $\Delta x's$ are called “indicators”. While in state-space terminology, $\Delta c's$ are known as “state” series and $\Delta x's$ are called “measurement” series. The $\Delta x's$ form the coincident index for the Irish economic activity index.

Following the Stock and Watson procedure, we assume the differenced state to be an ARMA process. Autoregressive disturbances, μ_t , are taken to be the idiosyncratic element of each observed coincident series in the ARMA process. It is assumed that

⁷ L is the lag operator such that $L^k x_t = x_{t-k}$.

⁸ These models assume that there is only one underlying common factor.

the logged and first differenced coincident series, forming (x) has to be normalized⁹. By setting the variance of η to one, we have fixed the scale of the coefficients of $\gamma(L)$. We fix the timing of the coincident index by using one of the equations in (1) and setting all but one of the elements of $\gamma(L)$ to zero in that equation.

With the system of equations (1) to (3) transformed into the state-space form and using a Kalman filter, the parameters of the system is estimated and produces the estimated smoothed “state”¹⁰. Output (the estimated smoothed “state”) from the Kalman filter, by construction, is a normalized and drift-less composite index containing unit-variance shock.

4.2 The Clayton-Matthews Estimation Method

The Clayton-Matthews (2001) software employs maximum likelihood and Kalman filter techniques to filter each constituent of the coincident indicator to eliminate idiosyncratic noise. Filtering produces an index that best estimates the common co-movements of all the component variables. This index of the common trend is our estimate of the coincident index of Irish economic activity.

Let (Δc_t) be the unobserved growth rate of coincident index of the Irish economic activity and (Δx_{it}) is the growth rate of indicator (i) at time (t) . Where: $(i) = 1, \dots, n$ are the individual indicator series.

We make the following assumptions:

$$(10) \Delta x_{it} = \beta_i + \sum_{j=1}^p \phi_{ij} \Delta x_{it-j} + \gamma_i \Delta c_t + \varepsilon_{it}.$$

The growth rate of an individual indicator is comprised of an indicator specific random effect ε_{it} , the weighted sum of its own p historical values and Δc_t the growth rate of the common factor to be estimated. In this application $p=4$ was chosen, but

⁹ Subtracting from them their mean difference and dividing by the standard deviation of its differences achieves this, which in terms of estimation identifies $\beta = 0$ and $\delta = 0$.

¹⁰ This is a (Quasi) maximum likelihood estimation of the parameters in the system (1) to (3).

the results obtained are robust for nearly all the specifications for p that were estimated.

The assumptions about the behaviour of the common factor are:

$$(11) \Delta c_t = \delta_t + \sum_{j=1}^T \theta_j \Delta c_{t-j} + v_t.$$

where v_t is a random shock and has a unit variance.

This is a state-space model in which the unobserved state variable, c_t , determines the observed indicators, x_{it} . It is assumed that the random disturbances, ε_{it} and v_t are independently normally distributed. In this model c_t (the estimated trend growth rate) is a weighted average of the average growth rates of x_{it} (the indicator variables). These weights, referred to as cumulative dynamic multipliers, represent a complex function of the estimated parameters of the model. The multipliers are normalised by the Clayton-Matthews software to calculate the share that the average growth rate of each indicator contributes to the trend growth rate c_t . In other words, the coincident index produced by the Clayton-Matthews software is a de-normalized translation of the filtered “state”, in that it gives the “state” series (Δc) a trend that is a weighted average of the trends of the “measurement” series (Δx).

5. Results

Looking at Figures 1 and 2, which show the static principal component and factor analysis results respectively, it appears that they provide somewhat similar results, particularly when one looks at their respective turning points in the time domain. The magnitudes of the recessions and growth phases mainly coincide except for the 1985 and 1992 recessions. The principal component method reports a deeper recession for the 1985 episode and the factor analysis method for the 1992 episode. While we cannot make direct comparisons between coincident indices, it is interesting to note that the principal component and factor analysis indices have similar means and standard deviations.

Figure 3 shows the Stock and Watson activity index for Ireland from 1970 to 2003, with the shaded areas of the graph denoting periods of recession. The recession periods are identified using the classical cycle concept, meaning that economic activity must decline over two quarters¹¹. This selection criteria allows for identification of a number of turning points in the economic activity index that otherwise may have been missed¹². Most of the recessions identified in Figure 3 in terms of time period are comparable with recessions that occurred in the US or UK or both. It is clear from the economic activity index that after the minor recession in 1990/91, the 1990s was Ireland's decade of "catch-up" with her European partners. The index shows two mild recession phases that coincide with the "dot com" collapse in 2000.

A chronology of the Irish economic activity index is listed in Table 3. It can be seen that the longest and deepest phase of recession in the Irish economy was between May 1973 and March 1975, lasting 22 months with a decline from the peak of the economic activity index to the trough of the recession of 13.34 per cent. The other period of significant downturn in the economic activity index is June 1981 to March 1983, with the recession phase lasting 21 months and a decline in the index of 11.03 per cent. Starting with the 1984 recession we see that the magnitude of change from peak to trough has declined significantly. The first five recessions in Table 3 have an average change from peak to trough of 8.5 per cent, while the later recessions have an average change from peak to trough of 3.2 per cent¹³. This result confirms what other studies report, that in the last three decades output volatility has declined in the OECD countries.

These changes in magnitude may in part be due to the increasing flexibility of the Irish economy and those of our main trading partners. In large economies, such as the

¹¹ Using this rule of two consecutive quarters of period-to-period negative growth does not imply there must be six consecutive months of economic decline. Rather, the recession phase of the economic activity index must contain more months of decline than increase. Secondly, the economic activity index must be lower at the end of a recession phase than at the start.

¹² The NBER does not define a recession in terms of two consecutive quarters of decline in real GDP. Rather, a recession is a significant decline in economic activity spread across the economy, lasting more than a few months, normally visible in real income, employment, industrial production, and wholesale/retail sales.

¹³ These changes from peak to trough in the activity index are not directly comparable with changes in either GDP or GNP.

US the national economic activity index influences regional economic activity indices. The influence of our traditional trading partner the UK is evident through trade and the number of UK owned firms operating within Ireland. While this influence has been declining since the 1960s in terms of export volumes and in manufacturing, investment is growing in the retail and financial service sectors. The importance to the Irish economy of US owned multinational enterprises has been well documented (see Murphy and Ruane, 2004). Several reasons may account for this decline in economic activity index volatility over time. These include the increase in flexibility within the economy, which for example may be linked to increases in human capital and labour mobility.

A more diverse economy in terms of trading partners has emerged over time, especially with the growth of the hi-tech and service sectors in Ireland. This can be seen in the change in destination countries of Irish exports, with our traditional trading partner the UK now accounting for less than 18 per cent of total Irish exports. Strong links exist between the Irish and US economies, especially through the presence of US multinational enterprises based in Ireland to serve the European market.

Table 4 lists the Irish business cycle turning points identified by Fagan and Fell. The Fagan and Fell average period of recession is 15 months, while using the Stock and Watson the average period of recession is 13.5 months (the is for the period 1971 to 1992). The longest period of recession identified by Fagan and Fell was from September 1981 to May 1983, a period of 21 months and the coincident index declined by 17.2 per cent. They note that other business cycle chronologies missed the recession that lasted from June 1985 until June 1986.

Figures 4 and 5 show the growth rate of the coincident index compared to GNP and GDP respectively. As it is derived from monthly data, the coincident economic activity index is more volatile than either GDP or GNP estimates. In addition the activity index turns negative more frequently, confirming that estimates based on GDP and GNP tend to smooth out the data. Looking at Figures 6 and 7 we see the scaled turning points in the time domain of the coincident index compared with GNP

and GDP respectively. The activity index performs well as a coincident signal in the time domain, however a notable exception is the 1988-89 episode¹⁴.

6. Concluding Comments

This paper utilised the coincident index estimation procedure proposed by Stock and Watson (1989) and the software developed by Clayton-Matthews (2001). In this paper we estimated a dynamic factor model that aggregates the underlying movements of several key economic indicators providing a single summary statistic reflecting current economic activity.

The coincident indicator of economic activity derived from the dynamic factor method has been shown to provide a consistent indicator of economic activity in Ireland. The volatility of the activity index had diminished since the 1970s and this is in line with the findings of other studies of OECD countries. It is clear from the activity index that the 1990s was a period of exceptional growth; this was the decade where the Irish economy caught up with our EU neighbours.

The contribution of this paper is to provide an easily understood coincident index reflecting current economic activity in the Irish economy. The indicator is also capable of being updated on a timelier basis than estimates of GDP or GNP. It would be interesting exercise to check the performance of this activity index on a real time basis. This could be useful in helping policy makers and private agents to identify the turning points of peaks and troughs in Irish economic activity.

¹⁴ As noted by Hobijn *et al* (2003) one must interpret these growth and recession rates carefully. These rates are weighted averages of the underlying growth trends of the individual component series and as such cannot be compared with the growth or recession rate of an individual series. Only comparisons of the relative growth or recession rates within the index at different points in time are interpretable.

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Table 1:

Indicator Variables Considered for the Coincident Indicator				
Indicator	Data type	Seasonality: Tramo/Seats	Logged & 1st differenced	Data period
New Car Sales	Volume (real)	Y	Y/Y	01.1970 to 06.2003
Exports	Volume (real)	Y	Y/Y	01.1970 to 01.2003
Imports	Volume (real)	Y	Y/Y	01.1970 to 01.2003
M1	Growth (real)	Y	N/Y	03.1971 to 06.2003
Retail sales	Volume (real)	Y	Y/Y	01.1970 to 07.2003
Live Register	Growth rate	Y	N/Y	01.1970 to 06.2003

Source: CSO

Table 2:

Summary Statistics for Estimation of the Irish Economic Activity Index			
	Annualised growth rate		The Model
	Mean (percent)	Standard Deviation (percent)	Share (percent)
Exports	0.07623	0.06771	33.05
Imports	0.05119	0.06065	30.90
M1	0.0972	0.0506	5.86
New Car Sales	0.02385	0.17097	9.01
Retail sales	0.02913	0.01571	12.47
Live Register	0.02183	0.01807	8.71

Source: Authors own calculations.

Note: Share percent of the model rounded to two decimal places.

Table 3:**Chronology of the Irish Economic Activity Index 1971 – 2003**

Peak	Trough	Length in months	Months of decline	Change from peak to trough
01:1971	09:1971	9	7	- 7.86%
05:1973	03:1975	22	15	- 13.34%
05:1978	11:1978	7	5	- 2.59%
08:1979	02:1981	19	12	- 7.72%
06:1981	03:1983	21	14	- 11.03%
04:1984	10:1984	7	5	- 2.95%
03:1990	11:1991	20	13	- 4.95%
05:1992	12:1992	8	6	- 2.81%
01:2001	07:2001	7	5	- 1.7%
04:2002	10:2002	7	6	- 1.9%

Source: Authors own calculations.

Note: Index normalisation date used is June 1985 to allow for comparison with Fagan and Fell (1992).

Table 4:**Fagan and Fell Chronology of the Irish Business Cycle 1961 - 1992**

Peak	Trough	Length in months	Months of decline	% change from peak to trough
06:1965	04:1966	11	7	- 9.75
01:1970	06:1970	6	5	- 1.54
04:1971	10:1971	7	6	- 3.21
09:1973	04:1975	20	15	- 15.62
07:1979	06:1980	13	11	- 8.95
09:1981	05:1983	21	13	- 17.20
06:1985	06:1986	13	10	- 5.92
10:1990	01:1992	16	13	- 5.67

Source: Fagan and Fell (1992).

Note: Normalisation date used by Fagan and Fell (1992) was June 1985.

Figure 1
Principal Component: Activity Index

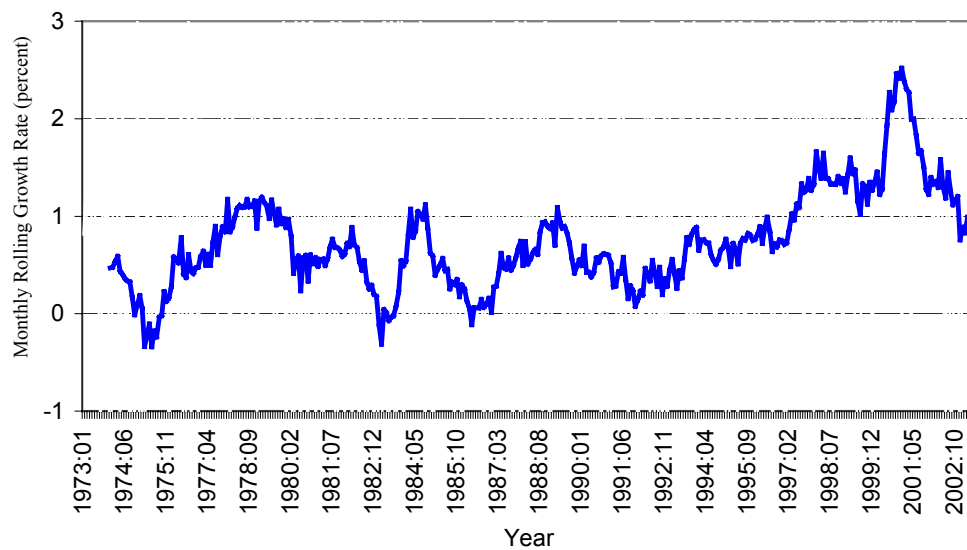


Figure 2
Factor Analysis: Activity Index

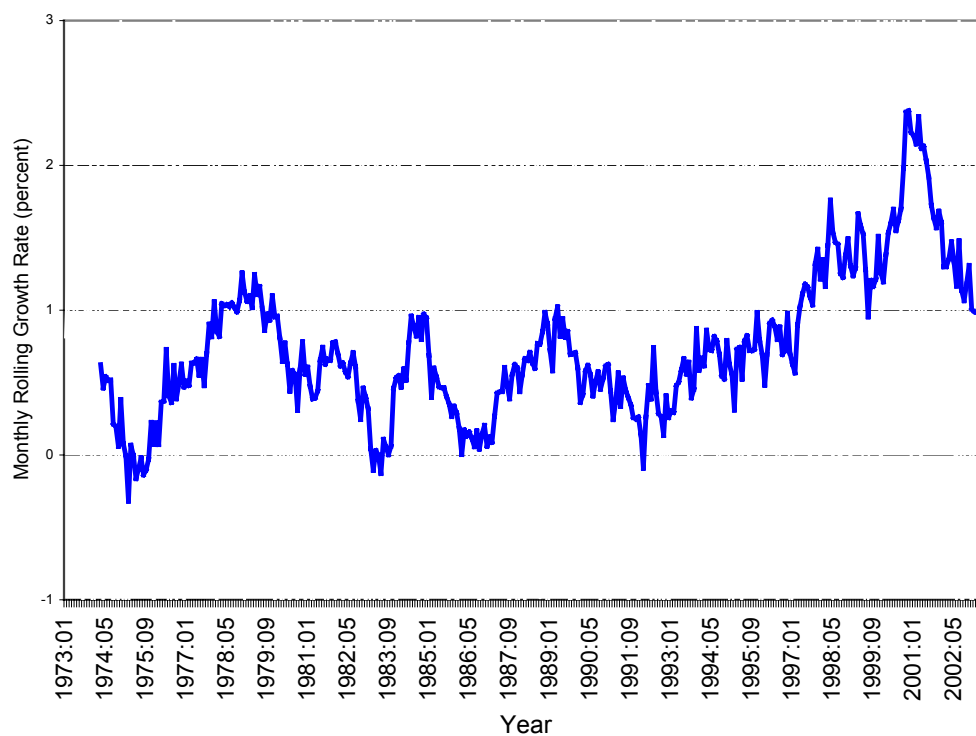


Figure 3:
Coincident Economic Activity Index for Ireland

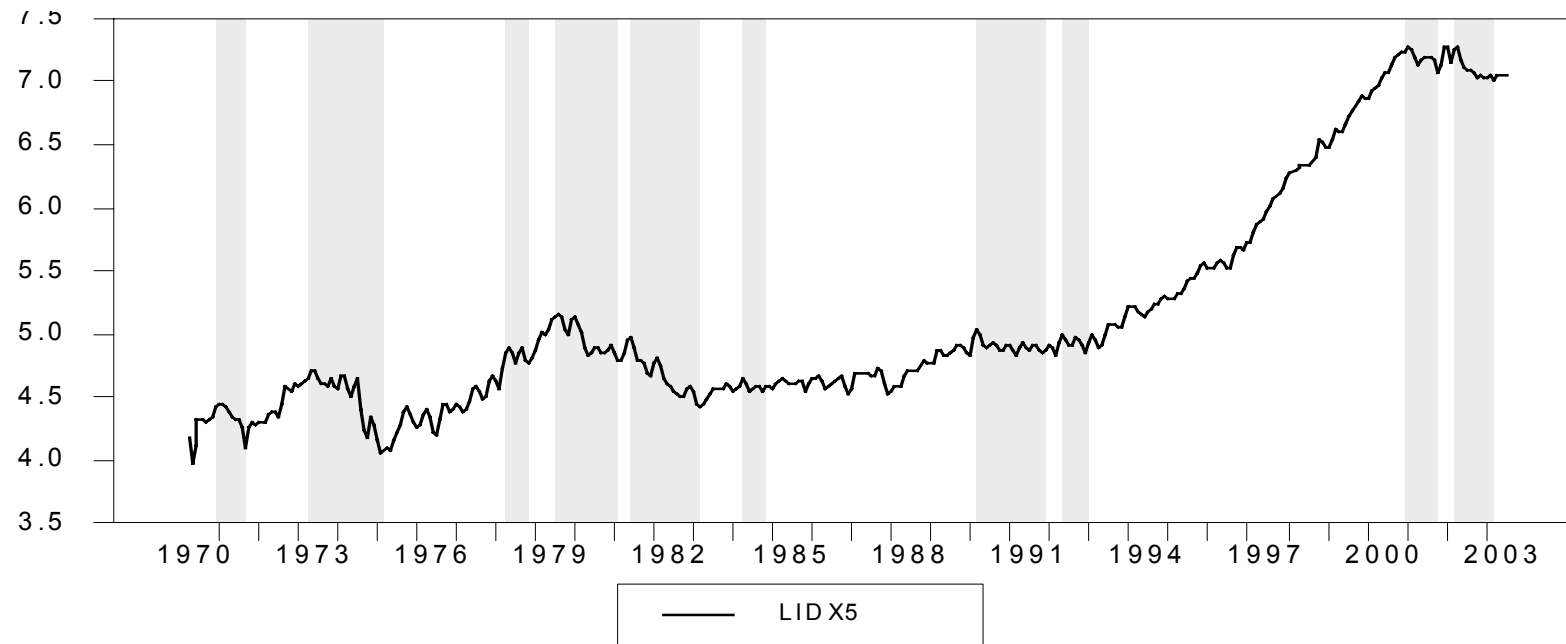


Figure 4:

Growth Rate: Real GNP and the Irish Activity Index

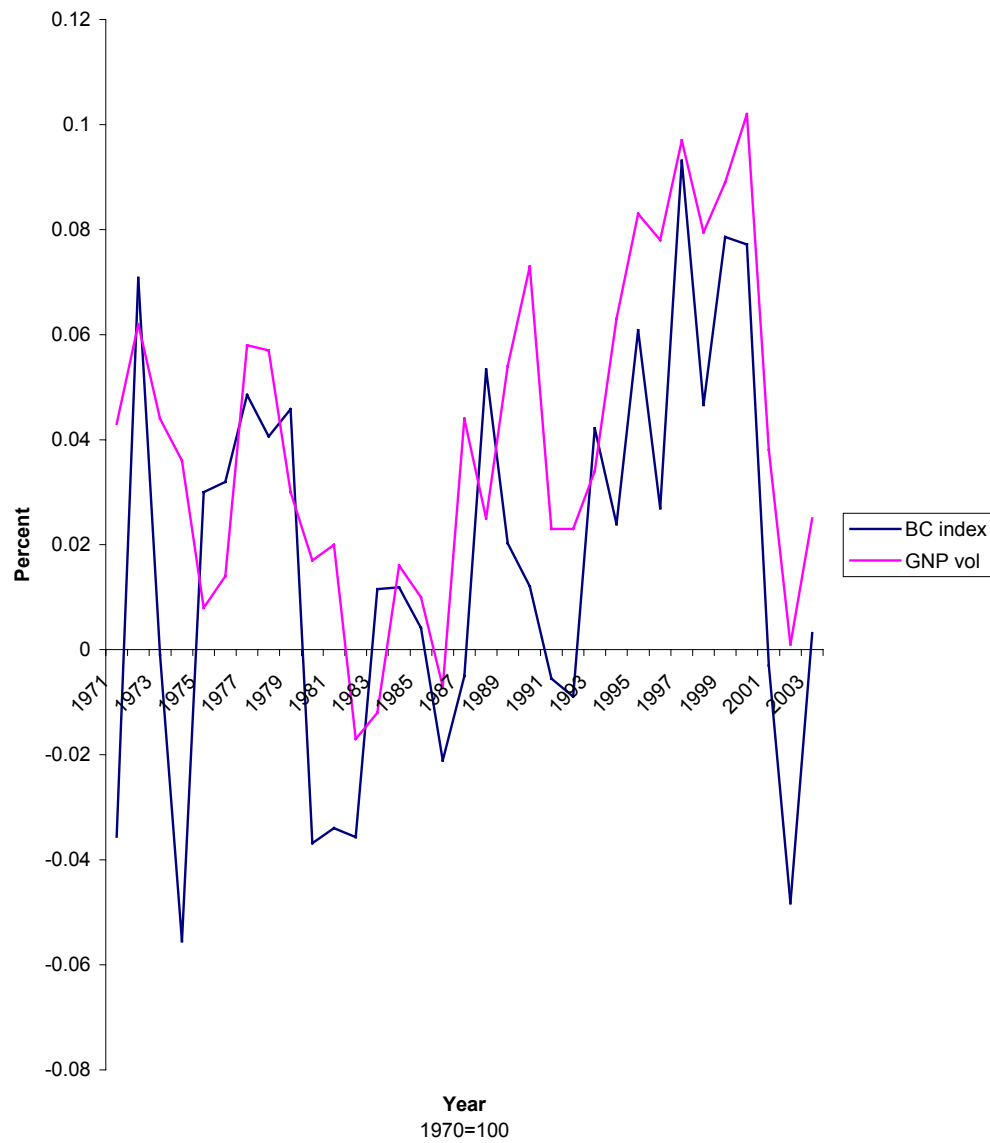


Figure 5:

Growth Rate: Real GDP and the Irish Activity Index

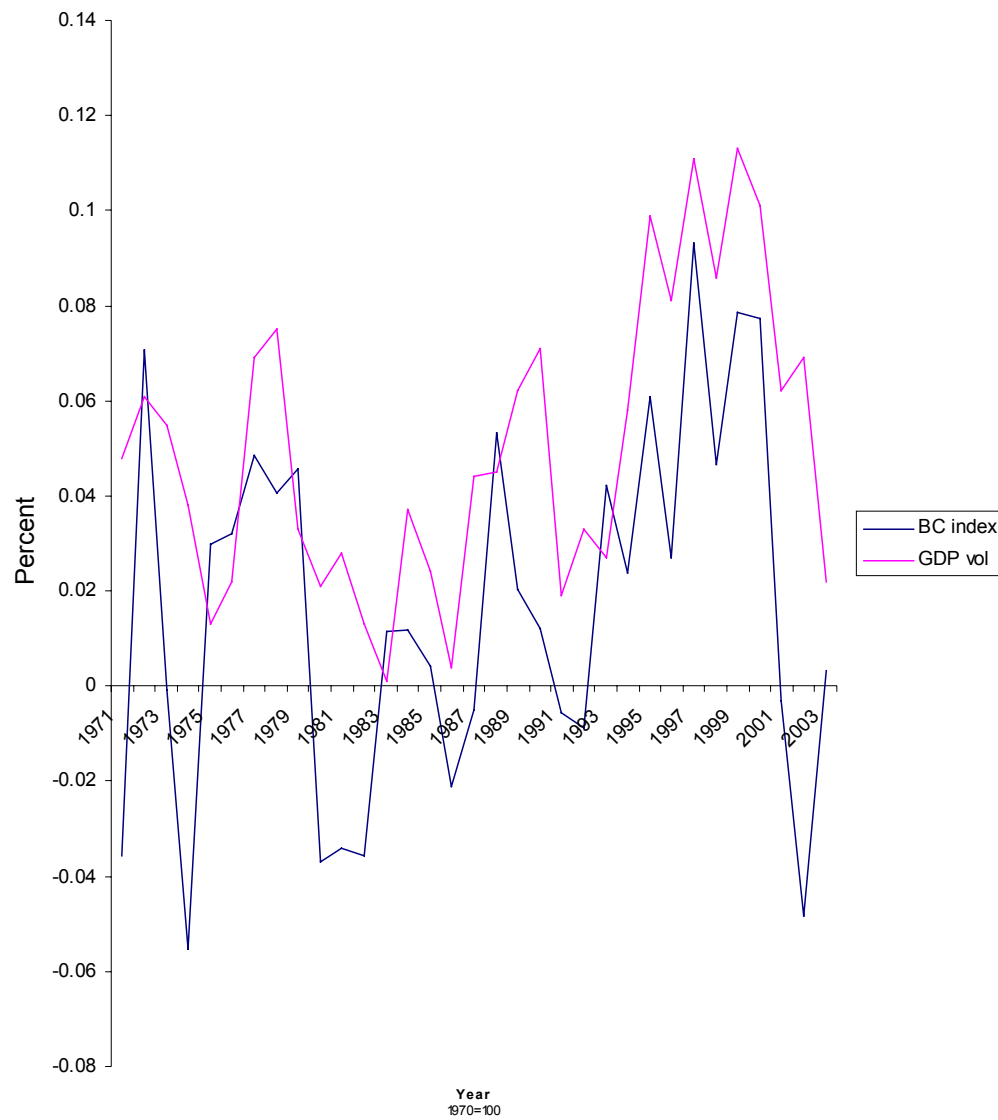


Figure 6:

Scaled Turning Points: Real GNP and the Irish Activity Index

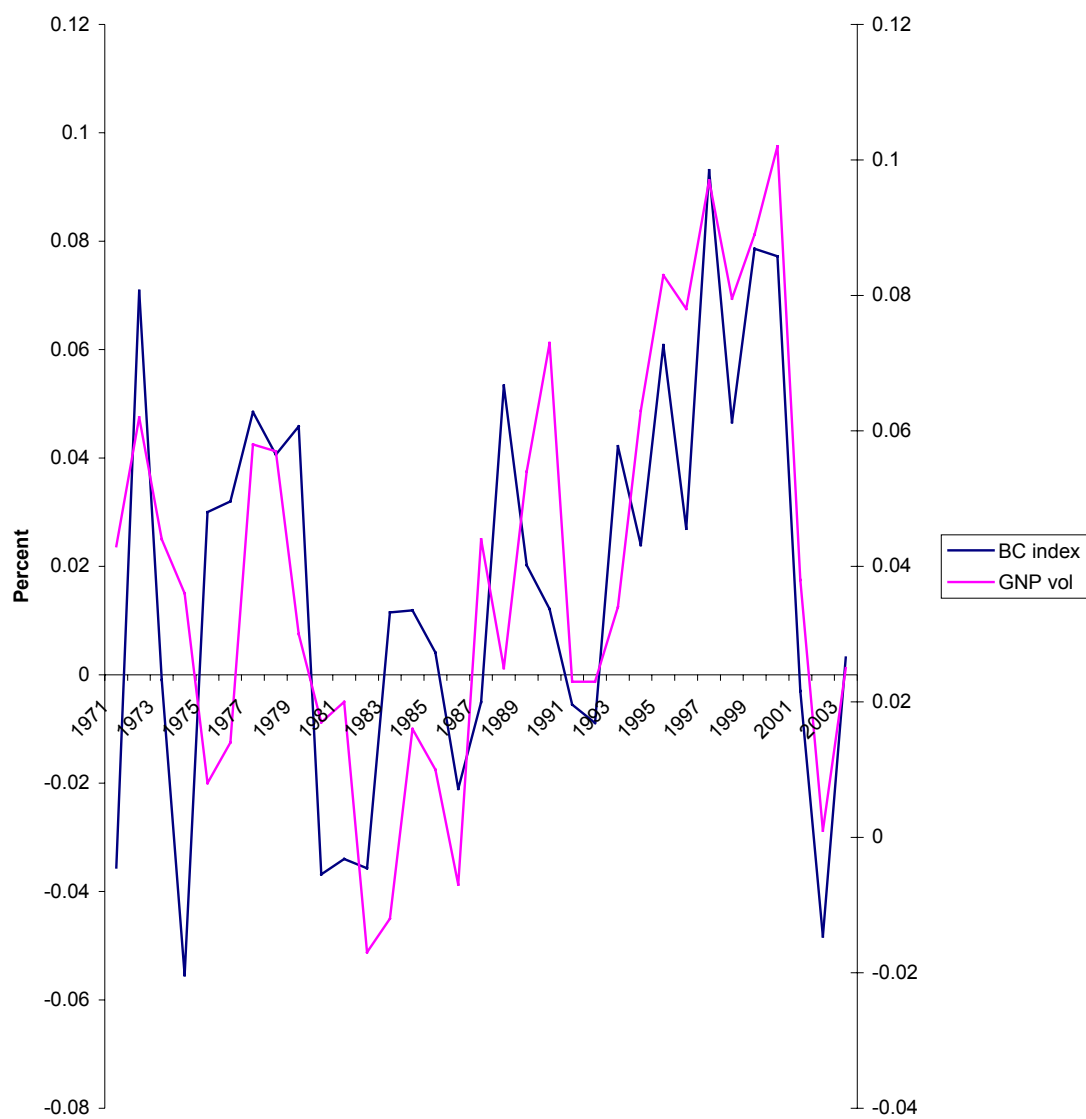


Figure 7:

Scaled Turning Points: Real GDP and the Irish Activity Index

