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Predicting Growth and Recessions Using Leading Indicators: Evidence from Greece

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Πρόβλεψη της Ανάπτυξης και των Υφέσεων με τη Χρήση Δεικτών Προήγησης: Ενδείξεις για την Ελλάδα

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Predicting Growth and Recessions Using Leading Indicators:

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Abstract

In this paper we use selected individual leading indicators, including business expectation indices, to construct a composite leading indicator of Greek economic activity by applying a dynamic factor model. We investigate the growth and recession forecasting ability of the derived leading indicator within a bivariate VAR specification and a probit model framework, respectively. We use data covering the January 2000-March 2010 period. The evidence supports the use of business expectation indicators for the construction of the composite leading indicator. The latter appears to possess satisfactory leading properties with regard to forecasting growth, as indicated by in-sample and out-of-sample analysis and forecasting recessions as indicated by the fitted recession probabilities.

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1. Introduction

The recent domestic developments in the Greek economy, which are partly related to the latest global recession but mainly result from misdirected policy implementation, have once again brought in the foreground the importance of timely monitoring and accurately predicting the course of economic activity. This is, however, not an easy task, especially when the deficiencies in data provision are taken into account. Beside the lack of available monthly data on Greek aggregate economic activity,[1] the situation is aggravated by considerable delays in GDP data release, but most importantly, by discontinued revisions. All these factors render the timely observation and any potential use of current information to predict future developments on the basis of available GDP data impossible.

Against this background, the present work is concerned with the derivation of a robust measure at a monthly frequency, which should exhibit satisfying leading properties and could, hence, be inferred to as a baseline for the provision of reliable indications on future conditions in Greek economic activity. This can be achieved by reliance on available monthly indicators of economic activity and their incorporation in forecasting exercises. In any way, the idea of using monthly economic indicators with leading characteristics for economic activity prediction purposes in not new and it is not surprising that it continues to attract immense interest, be it on the level of enterprises, institutions, individuals and, not least, public authorities.

In the choice of leading variables and their use for predicting purposes, the present work relies on three basic considerations. The first refers to the argument that the reliance on multiple rather than on single indicators might present an advantage, in the sense that it can incorporate signals coming from different sectors of the economy. The idea is then to combine these signals into a single measure. The second fundamental concept is that the predictive power of this single measure has to be established, before it can be used as a means for the provision of forecasts. Third, it is assumed that important information which should not be neglected is incorporated into business expectation series which result from the conduction of surveys.

The project of taking into account the above presented basic considerations results in the following application steps of the present work. We first construct a

[1] This is of course a more general problem faced by most economies.

composite leading indicator of Greek economic activity on the basis of individual series with leading characteristics. To that end, we apply a dynamic factor model according to Stock and Watson (1998). The obtained composite indicator has to be tested for its forecasting ability and quality. We are interested in testing the power of the derived leading indicator to predict economic activity but also its ability to forecast recessions. For that purpose, we apply a bivariate VAR framework to check for the in- and out-of-sample forecasting properties of the established leading indicator and a probit model to estimate the accuracy of the indicator under consideration to forecast recessions. Due to data restrictions, we refer to the time period from January 2000 to March 2010. We use selected monthly indicators, including business expectation indices and the sentiment indicator, and quarterly GDP data. We also apply two different interpolation procedures to derive monthly GDP measures. To our knowledge, this is a novel attempt combining the above described steps to construct a composite leading indicator for Greek economic activity and test for its performance in forecasting growth and recessions. Our results indicate that the constructed leading indicator well captures and leads the movement in Greek economic activity during the time period under investigation, as implied by the absence of extreme variations before the outbreak of the recent recession, which is clearly reflected with a lead in the data of the leading indicator. Moreover, the derived indicator exhibits both satisfactory GDP growth predictive quality and forecasts the 2008 recession.

The rest of the present paper is organized as follows. In Section 2 we set the main concepts underlying the present work within the more general framework of the related literature. In Section 3 we present the applied empirical analysis and in Section 4 we describe the data used. Section 5 introduces the exact model specifications and presents the empirical results. Section 6 concludes.

2. Underlying concepts within the framework of the related literature

The main concepts underlying the present work, as outlined in the previous section, have all been extensively treated in the existing literature.[2] More specifically, both the issue of establishing leading indicators of economic activity and using indicators for economic activity forecasting purposes find a great number of applications in the related literature. At the same time, the question of the usefulness of business expectations data regarding their leading properties and forecasting quality has attracted the interest of researchers and institutions worldwide. One important factor significantly constraining related applications refers to data availability restrictions. For that reason, most work is concentrated on advanced markets, including similar investigations at a regional or state level,[3] and limited research can be found on developing economies.[4] But even in the case of advanced economies, there may still exist factors constraining the related analysis. Such factors may refer, for example, to the availability of aggregate economic high frequency data.[5] Still, despite the encountered difficulties and the existing extensive literature coverage, issues related to leading indicators and forecasting economic activity remain at the top line of interest, in particular against the background of the recent global recession.

The idea of working with single or synthetic leading indicators of economic activity is certainly not a new one and goes back to the pioneering work of Burns and Mitchell (1947) on business cycles in the early 1930s at the National Bureau of Economic Research (NBER). Starting with the methodologies developed at the NBER, which are still applied in many countries and by a significant number of researchers and organizations, a great number of applications has been established ever since, whether to provide series of leading indicators for early signaling of economic activity or predicting turning points, and recessions in particular.

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[2] As a result, the present reference cannot aim at covering the existing literature with all its applications. Its purpose can only be, instead, to accurately provide a guideline on the related subjects by referring to some basic work.

[3] See for example Megna and Xu (2003) for an application to the New York state, Clayton-Matthews and Stock (1998/1999numbtestx) for an application to Massachusetts.

[4] For research on developing economies and references to the encountered data difficulties see for example Simone (2001) for an application to Argentina or Mongardini and Saadi-Sedik (2003) for an application to Jordan.

[5] In many cases, various methodologies are developed to overcome difficulties referring to the lack of monthly aggregate economic data, such as for example mixed-frequency applications (see Mariano and Murasawa (2003), Kuzin et al. (2009).

Marcellino (2005) provides a comprehensive outline for the construction, use and assessment of individual or composite leading indicators, as well as an evaluation of the most relevant recent developments. Among the most popular procedures for the derivation of a composite indicator as a common factor extracted out of a number of underlying individual indicators is the Stock and Watson (1989) dynamic factor model, which refers to the type of model considered, for example, by Geweke (1977) and Sargent and Sims (1977). The Stock and Watson model has been extensively used in the empirical literature for the construction of composite coincident and leading indicators of economic activity.[6]

Of course, the consideration and derivation of leading indicators does not present, in most cases an exercise per se, but is instead directly connected to the concept of economic activity prediction. In other words, the natural extension of any exercise considering and/or constructing leading indicators is to test their accuracy at anticipating developments in economic growth or other economic measures. Given the significance of being able to make statements on the course of future economic activity, corresponding evidence is extensively provided in the related empirical literature. Even though the evidence is sometimes mixed, in more general terms a considerable degree of predictive power is assigned to leading indicators. Among the large number of more recent applications, Brischetto and Voss (2000) use three different leading indicators of Australian economic activity to compare their forecasting ability on GDP, employment and unemployment. On the basis of bivariate VAR specifications, the in-sample and out-of-sample forecast ability is evaluated. Camacho and Perez-Quiros (2002) use a variety of applications to test the predictive performance of the Conference Board Composite Leading Index and confirm its usefulness. McGuckin et al. (2003) investigate the performance of a more timely leading index for forecasting aggregate economic activity and industrial production. A large set of leading indicators is used by Banerjee et al (2003) in order to test their ability to forecast US inflation and GDP growth. Banerjee et al. (2005) investigate the forecasting performance of leading indicators for Euro-area inflation and GDP growth. For purposes of performance comparison, single indicators, common factors out of sets of indicators, groups of indicators or factors and pooled forecasts are

[6] Stock and Watson (1989) dynamic factor model applications such as the one followed in the present work for the construction of leading indicators can be found for example in Bandholz and Funke (2003) for German economic activity and Bandholz (2005) for Hungary and Poland.

considered. Robinzonov and Wohlrabe (2008) investigate the comparative predictive performance of nine leading indicators using a battery of forecasting techniques. Dovern and Ziegler (2008) consider single real or financial indicators, composite indicators and survey data in order to evaluate their power in predicting US growth rates of aggregate production (and also recessions). Ziegler (2009) tests the predictive ability of various leading indicators for Euro-area economic activity via bivariate VAR analysis on the basis of in- and out-of-sample forecasting experiments.[7] Fichtner et al. (2009) use OECD composite leading indicators to assess the ability of the individual country indicators to predict economic activity.

Even though the idea of forecasting economic activity attracts immense interest, one might in addition be interested in forecasting the state of the economy. More specifically, it is often crucial to be able to make a statement on the possibility that the economy will enter a recession in some time in the future. On defining recessions and expansions as different patterns of economic activity, this is equivalent to investigating whether or not the path of overall economic activity falls in a recessionary pattern some periods ahead.[8] This can be done by forecasting a binary variable, indicating whether the economy will be in a recession at a given point in time. Against this background, Estrella and Mishkin (1998) describe the use of the standard probit model with leading indicators to predict US recessions.[9] Within this framework, the question of the indicators to be included is not a negligible one; a variety of variables and combinations of indicators may be considered, whether single or composite and whether picturing real or financial activity.[10]

Finally, in searching leading indicators for assessing economic activity, the role of survey and sentiment indicators in forecasting exercises is often considered, since such indicators are assumed to directly reflect expectations on future economic developments. Their importance is demonstrated through their widespread use in related research during the last two decades. At the same time, the level of development of such indicators and their field of application differs significantly

[7] She also provides some references for similar work on Germany and the Euro-area.

[8] This is not to be seen as equivalent to forecasting turning points as, for example, in Neftci (1982).

[9] See also Stock and Watson (1992). In extending the work in Estrella and Mishkin (1998), Shoesmith (2003) applies the probit modeling for the prediction of state recessions.

[10] In time and depending on the contemporaneous economic conditions, the role of financial variables in predicting economic activity has attracted considerable interest, resulting in a large number of related empirical applications. In a more recent work, for example, Nyberg (2008) uses dynamic probit models to test the ability of various financial variables to predict the probability of a recession in the US and Germany.

across countries, since there does not exist in all cases a long tradition in working with survey data. The latter is, for example the case, for Germany and Switzerland and also for the Euro-area.[11]

3. Empirical analysis

The present empirical analysis is conducted in three basic steps. In the first step a dynamic factor model is applied to develop a composite leading indicator for Greek economic activity. The derived composite leading indicator is then incorporated into a bivariate VAR framework and its GDP growth forecasting performance is assessed. In a third step, we estimate a probit model in order to predict turning points in Greek economic activity during the time period under investigation. We believe this is a novel attempt to construct a leading indicator for the Greek economy using monthly series, including expectation and sentiment series, on the basis of the selected methodology and use the estimated leading indicator for forecasting purposes. In the following, we present the methodological steps of the present analysis in detail.

a. Dynamic factor model for the construction of a composite leading indicator for Greek economic activity

Following Stock and Watson (1989) for the construction of a coincident composite index,[12] we specify an unobserved single index model, or a dynamic factor model, using economic variables which are assumed to lead economic activity in

[11] For example, Hüfner and Schröder (2002) analyze the ability of four economic sentiment indicators to forecast economic activity in Germany. Bruno and Lupi (2003) apply data derived form business surveys in Germany, France and Italy to predict Euro-zone industrial production. Abberger (2007) uses more detailed results of business tendency surveys to forecast German GDP growth. The role of survey data, among other indicators under investigation, in forecasting Euro-area GDP is assessed by Bańbura and Rünstler (2007). Siliverstovs (2010) uses the KOF barometer, a leading indicator released by the KOF Swiss Economic Institute, for real GDP growth prediction in Switzerland. However, similar research is not constrained to Central European countries as indicated by the work of Meļihovs and Rusakova (2005), who investigate the usefulness of survey data in the short-term forecasting of Latvia's economic development or Mehrotra and Rautava (2008), who test for the usefulness of business sentiment indicators for forecasting the real economy in an application to the Chinese economy.

[12] Note that in Stock and Watson (1989) the proposed leading index is constructed as the estimate of the growth of the derived unobserved coincident factor over the next six months, by the use of a set of leading variables.

Greece. The composite leading indicator is extracted as the common component out of the selected economic variables with leading characteristics.[13] Letting Y_{it} be the vector of exogenous indicators, C_t the unobservable factor to be extracted and defining $\Delta y_{it} = \Delta Y_{it} - \Delta \overline{Y_i}$ and $\Delta c_t = \Delta C_t - \delta$, the model can be formulated in deviations from means as follows:[14]

$$\Delta y_{it} = \gamma_i(L)\Delta c_t + e_{it}, \qquad i = 1,2,... \tag{1}$$

$$\phi(L)\Delta c_t = v_t, \qquad v_t \sim i.i.d.N(0,1), \tag{2}$$

$$\psi_i(L)e_{it} = \varepsilon_{it}, \qquad \varepsilon_{it} \sim i.i.d.N(0,\sigma_i^2). \tag{3}$$

In equation (1) the (deviations from mean of the) selected leading economic variables, Δy_{it}, are expressed as functions of the growth rate of the common factor, Δc_t, and hence the composite leading index, which is described by equation (2). The lag operator is denoted by L and γ_i are unknown parameters to be estimated. The idiosyncratic components e_{it}, described by equation (3), and Δc_t are assumed to be mutually uncorrelated at all leads and lags so that co-movements of the different series arise from a single source. Moreover, the disturbances v_t and ε_{it} are assumed to be mutually and serially uncorrelated. The variance of v_t is set equal to unity for purposes of identification. For the estimation, the above system (1) to (3) is cast into state space and estimated by maximum likelihood using the Kalman filter.[15]

b. Bivariate VAR model with the leading indicator for real Greek GDP forecasting exercise

We use a bivariate VAR model in order to test the forecasting ability of the constructed leading indicator. More generally, within such a framework, all variables incorporated are endogenous and depend on own lags and on the included lags of the

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[13] Note that the variables under consideration are pre-selected in assuming their leading properties. Such properties are investigated and established (see Section 4).

[14] This is necessary to ensure model identification, since otherwise the means of the processes are overdetermined.

[15] See also Harvey (1993).

other system variables. Hence, dynamic interdependencies among the included variables are allowed for, something that presents a desirable feature, since we do not want to assume dependency running only from the leading indicator to economic activity, but also dependency of the leading indicator on economic conditions. At the same time, the application of such a VAR structure does not presuppose setting structural assumptions on the exact relationship between economic activity and the leading indicator under investigation.[16]

In vector form and for the case of p included lags of the endogenous variables, the bivariate VAR can be expressed as

$$Z_t = A_0 + \sum_{i=1}^{p} A_i Z_{t-1} + \varepsilon_t \,, \tag{4}$$

where Z_t is the 2×1 vector of the two endogenous variables, i.e. GDP growth and the constructed leading indicator. The constant terms vector is given by A_0 and the A_i describes the coefficient matrix for lag i. The vector of innovations ε_t may be contemporaneously correlated but uncorrelated with own lags and the right-hand side variables. The lag order can be chosen on the basis of information criteria such as the Akaike Information Criterion or the Schwarz Criterion.

On the basis of the VAR model, the in-sample and out-of-sample predictive ability of the derived leading indicator is assessed. As a preliminary step and a part of the in-sample analysis, cross correlations are calculated for a specific number of leads of GDP growth on the leading indicator. A high correlation coefficient at a lead implies a leading property and indicates the specific lead by which the indicator leads the reference series. As a second indication provided by in-sample analysis, VAR Granger causality tests can be performed to test for the existence of a forecasting relationship, on the basis of explanatory power. In other words, Granger causality is applied to indicate whether the lags of the leading indicator contain additional information and are, hence, useful in predicting GDP growth.

The predictive power of the derived leading indicator is further established via out-of-sample analysis. We apply both a rolling window and a recursive estimation procedure. In the first case, a time window is determined by using a specific number

[16] See also Dovern and Ziegler (2008).

of the available observations for VAR model estimation. The forecasting horizon is pre-specified and the forecast exercise is conducted repeatedly until the data sample is exhausted, while keeping the time window fixed by subtracting in each step one observation at the beginning and adding one observation at the end of each underlying data sample. In contrast, the recursive estimation procedure relies on underlying data sample enlargement in each step of the forecasting exercise, since each time one observation is added at the end of the sample until the available sample is exhausted. In both cases, the resulting forecasts are used to calculate the root mean squared errors for each period of the selected forecast horizon, which are then compared to the root mean squared errors of forecasts based on a naïve model, which does not include the indicator values. A smaller root mean square error value for the VAR indicates that the derived leading indicator improves the forecast.

c. Probit model for predicting recessions using the leading indicator

In some cases, we may not be interested in predicting GDP growth, but instead we might want to make an estimate on whether the economy will be entering a recession period in some time in the near future. For the prediction of recessions, especially in the light of the recent developments in the Greek Economy, a probit model is estimated in order to quantify the predictive power of the constructed leading indicator. Following Estrella and Mishkin (1998), the estimated model is given by

$$P(R_{t+k} = 1) = F(\beta' x_t)\,, \tag{5}$$

where P, which is the probability forecast of a recession k periods ahead, is given by the cumulative normal distribution function F. The vector of coefficients is given by β and the vector of the independent variables, including a constant, the leading indicator and GDP growth in our case, is given by x_t. The recession indicator R_t, as a binary variable, is described by

$$R_t = \begin{cases} 1, & \textit{if the economy is in recession in } t \\ 0, & \textit{otherwise,} \end{cases}$$

since it can only take two possible values, depending on whether the economy is in recession or not.[17] The model is estimated by maximum likelihood. The fitted values from the estimation of equation (5) can be interpreted as the estimated recession probabilities.

4. Data

In the present analysis, selected monthly indicators and quarterly real GDP data are used for the time period January 2000 (2000 Q1) to March 2010 (2010 Q1). The monthly series chosen are seen, on the one hand, to reflect future economic activity through encompassing the developments in series with assumed leading characteristics. On the other hand, such leading features are seen to be incorporated in series picturing the expectations on future economic activity.[18] More specifically, the monthly data sample includes the Athens Stock Exchange General Index, private building activity, industry new orders, business expectations indices in retail trade, manufacturing, and construction and the economic sentiment indicator.[19] All series are indexed and seasonally adjusted. Table 1 offers more detailed information on all data series and their source.

[17] Note that there is no official business cycle dating for the Greek economy. In the present work, the underlying recession indicator is based on Tsouma (2010), where a business cycle chronology for the Greek economy and the exact turning points are established. In this work, April 2008 is derived as the peak date of the latest expansion.
[18] Leading properties are investigated in the following.
[19] Note that data selection and the time period under consideration are to a significant extent dictated by data availability restrictions. Most importantly, the officially available adjusted GDP data are provided only back to 2000. Furthermore, industry new orders are available from January 2000. At the same time, the 'business expectations in services' series starts in January 2002 and, hence cannot be included. Moreover, consumer credit, initially considered, was later discarded, since the outstanding balances series provided by the Bank of Greece is not seen to reflect the exact variation in consumer credit. Moreover, a real-time analysis would not be possible since no real-time data series are provided.

Table 1 Variables description

Series	Frequency	Description	Source
General Index	monthly	Closing price, last day of the month	Naftemporiki
Private building activity	monthly	Volume in thousand m^3, based on building permits	Hellenic Statistical Authority, Bank of Greece
Industry new orders	monthly	Manufacturing new orders received	Eurostat
Business expectations in retail trade	monthly	Survey data index	Foundation for Economic and Industrial Research
Business expectations in construction	monthly	Survey data index	Foundation for Economic and Industrial Research
Business expectations in manufacturing	monthly	Survey data index	Foundation for Economic and Industrial Research
Economic sentiment indicator	monthly	Survey data index	Eurostat
Real GDP	quarterly	Market prices	Hellenic Statistical Authority, Eurostat

The General Index is included on the basis of the view that the stock market reflects the expectations of the agents as to future real economic activity through current stock prices. Private building activity based on issued permits is furthermore seen to reflect future building activity, which is related to the real economy. In the same sense, new orders received in manufacturing are seen to be directly connected to future production projects. With regard to the business expectation indices, the expectations of the economic agents with regard to the developments in retail trade, construction and manufacturing are also seen to be related to future economic activity.

In using the above described variables, some specific issues have to be taken into account which may affect the underlying series without being related to developments in real economic activity. In particular, with regard to the General Index, the conducted analysis incorporates the 2000-2002 burst of the 1999 Stock Exchange bubble (see the model specification in Section 5). Moreover, for the private building activity series a correction for outliers through replacement by a fitted value is carried out for the December 2005 value.[20]

[20] This outlier was triggered by the government announcement of an upcoming vat tax imposition on all private buildings with permits issued after the 31st of December 2005 which caused a flow of building permits issuance during this specific month.

With reference to GDP data, since no monthly GDP series is available for Greece and our data sample does not include too many observations to rely on quarterly data application, monthly GDP series is derived by an automatic interpolation procedure and by interpolation according to Chow and Lin (1971)[21].

In order to investigate some features of the underlying variables, all series are checked for stationarity and order of integration. Table 2 reports the stationarity test results for the variables under consideration. Except for private building activity, the unit root hypothesis is accepted for series in levels and rejected for series in first differences.

Table 2 Phillips-Perron unit root tests

Variable	**Levels**	**First differences**
Real GDP		
-ChowLin interpolated	-1.517	-29.642
	(0.522)	(0.000)
-automatically interpolated	-2.227	-4.510
	(0.198)	(0.000)
General Index	-2.074	-10.757
	(0.256)	(0.000)
Private building activity	-8.461	-43.191
	(0.000)	(0.000)
Industry new orders	-2.329	-17.595
	(0.165)	(0.000)
Business expectations in	-1.272	-9.349
retail trade	(0.641)	(0.000)
Business expectations in	-1.202	-10.251
construction	(0.672)	(0.000)
Business expectations in	-1.114	-9.711
manufacturing	(0.709)	(0.000)
Economic sentiment indicator	-1.025	-9.555
	(0.743)	(0.000)

Notes: The equations include an intercept. The Phillips-Perron test statistics are provided with the probability values in parentheses. The test critical values for the test in levels in levels are -3.484653, -2.885249 and -2.579491 for the 1%, 5% and 10% level, respectively and for the test in first differences -3.485115, -2.885450 and -2.579598 for the 1%, 5% and 10% level, respectively.

With regard to the leading properties of the individual variables, cross correlations with GDP growth are calculated. The exercise is conducted for both

[21] We apply the interpolation procedure proposed by Chow and Lin (1971) using quarterly GDP data and selected monthly frequency series, such as industrial production, retail sales and the consumer price index. For this application see also Tsouma (2010). With reference to the second procedure, we apply an automatic low-to-high frequency conversion procedure. On the construction of several monthly European real GDP series, see also Mönch and Uhlig (2004).

automatically and ChowLin interpolated GDP series. The respective highest coefficients and the corresponding leads are presented in Table 3. The presented results imply that the considered series do exhibit leading characteristics in the case of both methodologies for monthly GDP derivation. The leads at which the indicators have the highest correlation with GDP growth vary, but still appear to concentrate between the fourth and the seventh leads, indicating that the underlying series lead GDP growth mostly by 4 to seven months. At the same time, the calculated correlation coefficients are higher for the case of the automatically interpolated GDP, while private building activity and business expectations in manufacturing present the indicators with the highest coefficients in the case of both methodologies for monthly GDP derivation.

Table 3 Cross correlations

Variable	**Correlation coefficient** [lead] (based on automatically interpolated GDP)	**Correlation coefficient** [lead] (based on ChowLin interpolated GDP)
General Index, *log differences*	0.1728 [8]	0.1273 [9]
	0.1413 [4]	0.0947 [8]
Private building activity	0.3118 [4]	0. 1825 [2]
	0.2332 [5]	0. 1560 [4]
Industry new orders, *log differences*	0.1672 [4]	0.1720 [6]
	0.1384 [6]	0.1356 [4]
Business expectations in	0.2728 [7]	0.1812 [6]
retail trade, *log differences*	0.2429 [0]	0.1169 [1]
Business expectations in	0.2715 [6]	0.1624 [6]
construction, *log differences*	0.2127 [5]	0.1355 [5]
Business expectations in	0.3089 [6]	0.2296 [2]
manufacturing, *log differences*	0.3002 [2]	0.1400 [7]
Economic sentiment	0.2980 [6]	0.2108 [2]
indicator, *log differences*	0.2648 [7]	0.1537 [7]

Notes: Twelve leads are included in the calculations.

5. Model specifications and empirical results

Following the outline of the methodological analysis described in Section 3, this section presents the specific underlying model specifications and the obtained empirical results. We first describe the exact dynamic factor model specification and then introduce the derived leading indicator. The detailed VAR specification which incorporates the constructed leading indicator is presented and the VAR analysis forecasting evidence is offered. Finally, the specific probit application is outlined and the resulting evidence on forecasting recessions for Greek economic activity is presented.

a. The construction of a composite leading indicator for Greek economic activity

We estimate the dynamic factor model with three different combinations of the differences of the logs of the selected leading series in order to establish a composite leading index for Greek economic activity. In all cases, we select a second order specification for both the growth rate of the common factor and the idiosyncratic terms, while one lag of the growth rate of the common factor enters the series equations. In the first specification we include all variables under consideration, in the second we exclude the sentiment indicator and in the third we exclude both the expectation series and the sentiment indicator and estimate the model with the remaining three series (the General Index, private building activity and orders in manufacturing). The estimation evidence favors the specification which excludes just the sentiment indicator but includes the expectation series, on the basis of the significance of the expectation series and the insignificance of the sentiment indicator in the presence of the expectations series. As a result, and in including a dummy variable in the equation for the General Index in order to take into account the 2000 - 2002 burst of the 1999 Greek Stock Exchange bubble, the chosen dynamic factor model specification is given by

$$\Delta y_{1t} = \gamma_1 \Delta c_t + \delta d_1 + e_{1t}, \tag{6}$$

$$\Delta y_{it} = \gamma_i \Delta c_t + e_{it}, \qquad i = 2,...,6 \tag{8}$$

$$\Delta c_t = \phi_1 \Delta c_{t-1} + \phi_2 \Delta c_{t-2} + v_t, \tag{8}$$

$$e_{it} = \psi_{i1} e_{it-1} + \psi_{i2} e_{it-2} + \varepsilon_{it}, \tag{9}$$

where $v_t \sim i.i.d.N(0,1)$ and $\varepsilon_{it} \sim i.i.d.N(0,\sigma_i^2)$. Equation (6) describes the process for the General index which includes the dummy variable, with

$$d_1 = \begin{cases} 1, & for\ t: January 2000 - December 2002 \\ 0, & otherwise, \end{cases}$$

while equation (7) describes the processes for the remaining five selected series in the following order: private building activity $(i = 2)$, orders in manufacturing $(i = 3)$, business expectations in manufacturing $(i = 4)$, business expectations in retail trade $(i = 5)$ and business expectations in construction $(i = 6)$. The resulting estimated coefficients are presented in Table 4. According to this evidence, the first autoregressive coefficient of the common factor is highly significant and displays significant persistence. The factor loadings picturing the sensitivity of the selected indicators to the business cycle are in all cases positive and in all but one cases significant. The highest coefficients are recorded in the business expectations in manufacturing and business expectations in retail trade equations, followed by the coefficients in the General Index and business expectations in construction equations. Moreover, the dummy variable coefficient is negative and significant. At the same time the idiosyncratic components exhibit in most cases negative serial correlation.[22]

Figure 1 depicts the derived monthly leading indicator for Greek economic activity during the time period from February 2000 to March 2010 together with the respective (trend restored) leading indicator series constructed by the OECD. The constructed leading indicator appears to very well capture a continuing expansionary regime until the year 2007, where a period of decreasing economic activity begins, signaling already during the year 2007 the beginning of a recessionary regime. The comparison between the derived leading indicator and the (trend restored) OECD leading indicator reveals a significant degree of coherence. Still, there are two basic features distinguishing the two indicators. The first refers to the fact that the leading indicator constructed in the present work exhibits higher growth compared to the OECD leading indicator from half-2005 until the outburst of the crisis. The second refers to the point that the OECD indicator apparently leads the leading indicator constructed on the basis of the dynamic factor model.

[22] In order to check for the goodness of fit of the implied specification, we conduct serial correlation and normality tests on the estimated residuals ε_{it}. The tests indicate that there are no signs of remaining autocorrelation in all but one (the case of the building activity series) cases. At the same time, the normality hypothesis is rejected for the case of the building activity and the business expectations in retail trade series, while not rejected in all other cases.

Table 4 Dynamic factor model parameter estimates

Parameter	Estimate	Stand. errors
c_t		
ϕ_1	0.78	0.21
ϕ_2	-0.02	0.18
y_{1t}		
γ_1	0.28	0.07
δ	-0.42	0.15
ψ_{11}	-0.09	0.10
ψ_{12}	-0.00	0.00
σ_1^2	0.78	0.11
y_{2t}		
γ_2	0.04	0.03
ψ_{21}	-0.65	0.09
ψ_{22}	-0.11	0.03
σ_2^2	0.68	0.09
y_{3t}		
γ_3	0.13	0.04
ψ_{31}	-0.57	0.10
ψ_{32}	-0.08	0.03
σ_3^2	0.73	0.10
y_{4t}		
γ_4	0.45	0.10
ψ_{41}	-0.19	0.12
ψ_{42}	-0.01	0.01
σ_4^2	0.50	0.10
y_{5t}		
γ_5	0.41	0.09
ψ_{51}	-0.13	0.13
ψ_{52}	0.06	0.13
σ_5^2	0.58	0.10
y_{6t}		
γ_6	0.21	0.07
ψ_{61}	0.01	0.09
ψ_{62}	0.00	0.00
σ_6^2	0.88	0.12
Log likelihood		-276.873

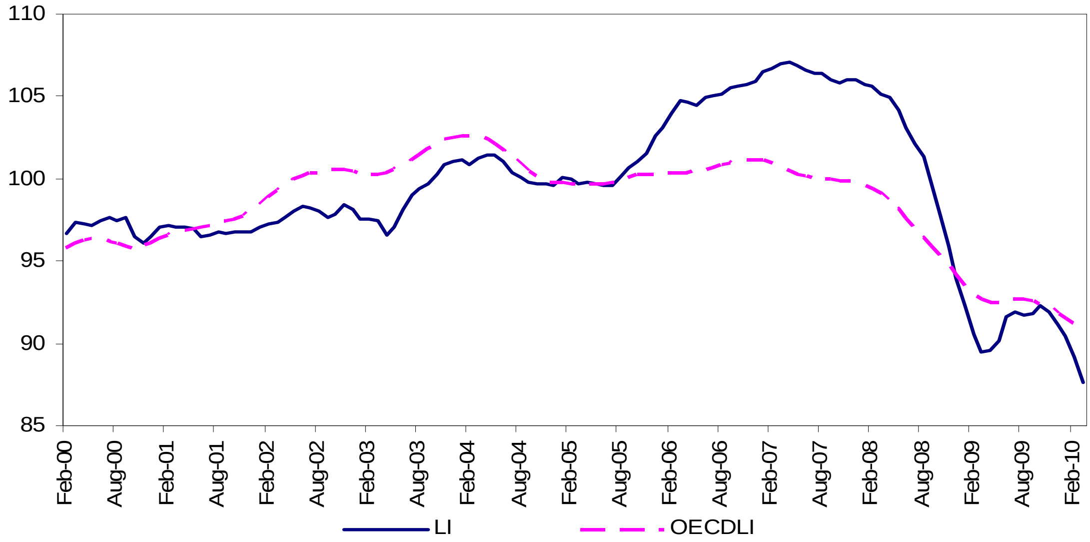

Figure 1: Derived leading indicator and OECD leading indicator for Greece

Our leading indicator for Greek economic activity for the time period February 2000 to March 2010 is plotted in Figure 2 together with the two interpolated monthly GDP series used in the present work. The evolution of the constructed leading indicator appears to agree in general terms with the evolution of the GDP series, since there are no extreme variations in the indicator until the year 2007. The leading property of the indicator appears to be evident, especially with reference to the beginning of the 2008 recession, which is clearly signaled by the indicator already during the year 2007.

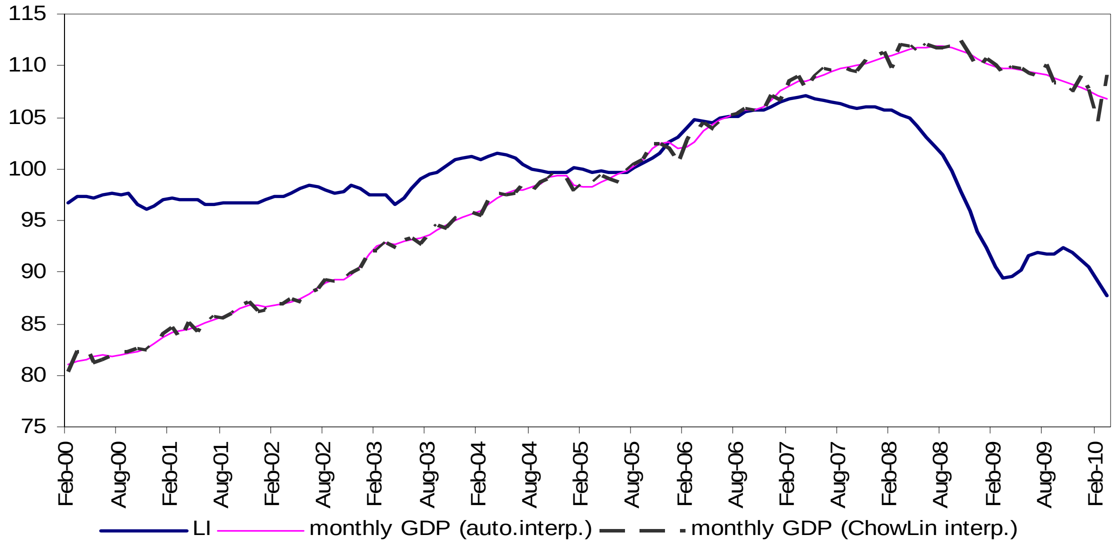

Figure 2: Derived leading indicator and monthly GDP

b. Testing the ability of the constructed leading indicator in forecasting GDP growth

The ability of the derived indicator to forecast the 2008 fall in Greek economic activity cannot be assessed solely on the basis of graphical inspection. We first control for the cross correlations between GDP growth and the leading indicator.[23] The leading characteristic of the composite series is indicated, since for both interpolated GDP series, the respective highest coefficients are recorded at the sixth lead and amount to 0.4001 for the automatically interpolated and 0.1855 for the ChowLin interpolated GDP series. The VAR methodology is then applied in order to check for the in-sample and out-of-sample predictive power of the constructed leading indicator with reference to GDP growth. We try several applications with varying lag orders p and finally choose a lag order of nine by using the Schwarz criterion. Accordingly, the specific bivariate VAR structure is described by

$$\begin{bmatrix} LI_t \\ GDPgr \end{bmatrix} = \begin{bmatrix} a_{01} \\ a_{02} \end{bmatrix} + \begin{bmatrix} a_{1,1} & a_{1,10} \\ a_{2,1} & a_{2,10} \end{bmatrix} \begin{bmatrix} LI_{t-1} \\ GDPgr_{t-1} \end{bmatrix} + \begin{bmatrix} a_{1,2} & a_{1,11} \\ a_{2,2} & a_{2,11} \end{bmatrix} \begin{bmatrix} LI_{t-2} \\ GDPgr_{t-2} \end{bmatrix} + \ldots +$$

$$\ldots + \begin{bmatrix} a_{1,9} & a_{1,18} \\ a_{2,9} & a_{2,18} \end{bmatrix} \begin{bmatrix} LI_{t-9} \\ GDPgr_{t-9} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}. \qquad (10)$$

Using the VAR estimations and within the framework of the in-sample analysis we perform Granger causality tests to test for the joint significance of the coefficients on the included lags of the leading indicator in the GDP growth equation. For both GDP interpolated series, even though at the margin for the automatically interpolated GDP series, the results indicate the existence of Granger causality running from the leading indicator series to GDP growth. This is a first indication of the information content or the predictive ability of the constructed leading indicator.

We then proceed with the out-of-sample analysis, as described in Section 3. The base estimation sample is given by the first seven years of the total sample, from February 2000 to January 2006. We perform twelve-period-ahead forecasts. For the rolling window estimation the sample remains constant, as in each step the sample is

[23] We also perform the Phillips-Perron unit root test for the constructed leading indicator and find that the null of a unit root is not rejected for the series in levels and rejected for the series in first differences. In the following we use first differences of the logs of the leading indicator.

extended by one period at the end, while the first observation is deleted. For the recursive estimation, one observation is added each time at the end of the sample, so that the sample gets larger by each step. Both exercises are repeated and the forecasts are calculated until the available sample is exhausted. The resulting root mean squared errors are compared with the respective ones resulting from two benchmark specifications, an AR(1) and an ARMA(1,1) model. A ratio of the VAR root mean squared error to the benchmark model error smaller than one indicates better forecasting performance of the VAR model, hence, indicating the usefulness of the leading indicator in forecasting GDP growth.

The results of the out-of-sample exercise are presented in Table 5.[24] The VAR/ARMA root mean squared error ratios are in most cases lower than unity, indicating that the models including the leading indicator mostly outperform the simple models at forecasting one to twelve periods ahead. This holds for both the rolling and the recursive applications. At the same time, the forecasting performance one and two periods ahead of the leading indicator seems to be high, while an improving forecasting performance is also observed for the sixth to the ninth forecasting horizons.

Table 5 VAR/ARMA root mean squared error ratios of out-of-sample forecasts

Forecast horizon	**GDP automatic interpolation**		**GDP ChowLin interpolation**	
	rolling	recursive	rolling	recursive
$h = 1$	0.798	0.783	0.769	0.754
$h = 2$	0.749	0.753	0.971	0.973
$h = 3$	0.905	0.907	1.022	1.012
$h = 4$	0.936	0.920	1.000	0.979
$h = 5$	0.989	0.950	0.957	0.941
$h = 6$	0.929	0.874	0.951	0.921
$h = 7$	0.944	0.893	0.824	0.822
$h = 8$	0.956	0.914	0.920	0.899
$h = 9$	0.980	0.943	0.837	0.821
$h = 10$	0.967	0.933	1.024	0.998
$h = 11$	0.955	0.922	0.985	0.988
$h = 12$	0.967	0.936	0.940	0.934

[24] We report only the VAR/ARMA root mean squared error ratios. The VAR/AR ratios are similar.

c. Using the constructed leading indicator to predict recessions in Greek economic activity

In light of the recent developments in Greek economic activity and the beginning of a recessionary regime during the year 2008, the prediction of business cycle turning points and recessions, in particular, has once again gained in importance. Against this background, we estimate a probit model in order to assess the predictive quality of the established leading indicator in forecasting recessions. The lag selection procedure results in the inclusion of six (for the automatically interpolated) or seven (for the ChowLin interpolated) lags of GDP growth and seven lags of the leading indicator, so that the explicit probit model can be described by

$$P(R_t = 1) = F(\alpha_0 + \alpha_1 GDPgr_{t-1} + ... + \alpha_{6(or7)} GDPgr_{t-6(or-7)} + \alpha_{7(or8)} LI_{t-1} + ... + \alpha_{13(or14)} LI_{t-7}) \quad (11)$$

A number of selected test statistics together with the fitted probabilities for a recession indicate good recession predictive power of the models.[25] More specifically, the McFadden R-squared, used as a goodness-of-fit measure indicates with values of 0.820 and 0.803 (for the automatically interpolated and the ChowLin interpolated GDP, respectively) good predictive performance. The same holds as to the Quadratic Probability Score accuracy measure which amounts to 0.031 and 0.030 (for the automatically interpolated and the ChowLin interpolated GDP, respectively).[26]

[25] Note that due to the specific sample period under investigation, we do not expect and hence, cannot compare the quality of the model with respect to past recessions for Greek economic activity. Still, the indication on the latest recession alone presents an important issue for the investigation of the developments in Greek economic activity.

[26] The McFadden R-squared is given by $R^2 = (1 - LL(B)/LL(0))$, where $LL(B)$ stands for the log likelihood of the full model which includes the explanatory variables while $LL(0)$ stands for the base model, including only a constant and without any explanatory variables. The Quadratic Probability Score measure is given by $QPS = 1/T\sum_{t=1}^{T}(P_t - R_t)^2$, where P_t describes the forecast probability made at time t and R_t is the realization at t.

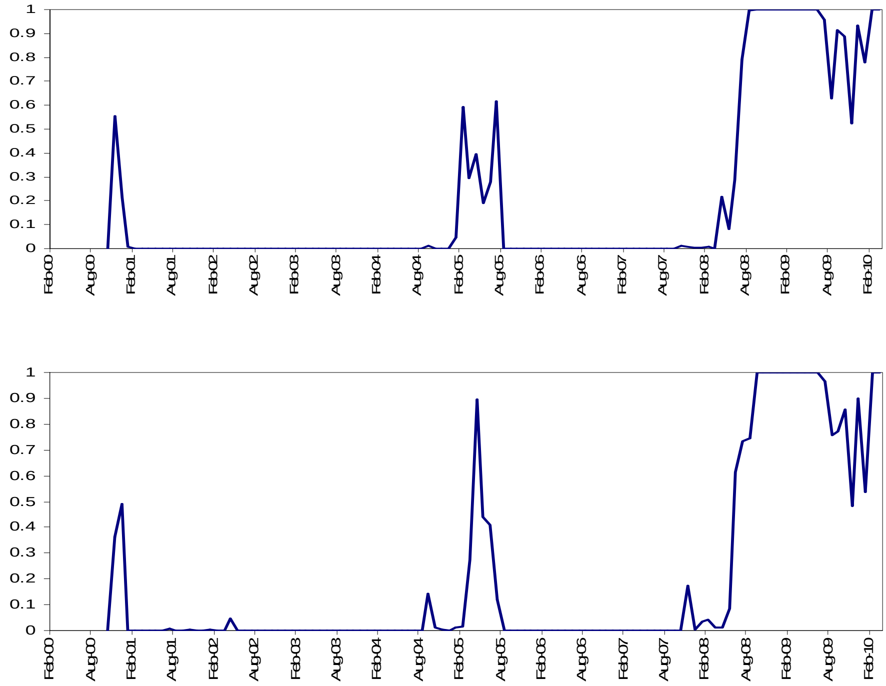

Figure 3: Fitted recession probabilities

Figure 3 pictures the fitted recession probabilities from the probit model estimation. In both cases, the 2008 recession is correctly pointed out.[27] At the same time particularly high recession probabilities are forecasted already at the onset of the recent recession. Particularly high recession probabilities can be furthermore observed at the end of the sample, implying the continuation of the recessionary regime.

6. Conclusions

In the present work we exploit the information incorporated in monthly indicators of Greek economic activity, covering different sectors of the economy, to construct a composite leading indicator. Business expectation indicators appear to be significant in the construction of the indicator. For the time period under examination, the established indicator exhibits satisfactory properties, in the sense that it does not produce any extreme movements in Greek economic activity beside the indication of

[27] Note that there appears to be a false signal for an upcoming recession, which was not materialized, at the beginning of 2005. In the case of the ChowLin interpolated GDP, the corresponding forecasted probability is particularly high.

entering the latest recession and remaining within a recessionary regime ever since. Since graphical inspection is not sufficient for accurately establishing the leading properties of the derived indicator, this is done within the context of VAR analysis and a probit specification. In the first case, both the in-sample and out-of-sample analysis imply satisfactory forecasting ability of the indicator, since it is shown to be useful in predicting GDP growth. However, we are also interested in the quality of the indicator with regard to the prediction of recessions, especially in the light of the recent global and domestic developments, in particular. The results show a significantly high forecasted recession probability already during the beginning of the 2008 recession. As a whole, we can conclude that the constructed indicator is a helpful tool in forecasting Greek economic conditions.

Since the problem of the availability of a monthly measure of the current aggregate economic situation in Greece remains, it would present an interesting exercise to construct a coincident indicator and subsequently test the ability of the derived leading indicator to forecast the coincident index. This may offer a solution to the lack of monthly GDP data and at the same time enforce the forecasting quality of the established leading indicator.

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