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Real economic activity leading indicators: should we have paid more attention?

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The ability to predict business cycle activity is an invaluable skill for governments and policy makers alike, especially before an economy enters a downturn. We analyse causality relationships between key leading economic indicators and economic growth for three countries from 1970 to 2010. We find that while many indicators do not help explain current movements in GDP growth, lags of these indicators do. In addition, the direction of the change and the size of the change in the lagged economic indicators are very important in many cases. This is particularly true for housing indicators.

Keywords: business cycles; leading indicators; composite indicators; symmetric and asymmetric granger causality; co-integration

JEL Classifications: C32; E30; E32

1. Introduction

The notion that economic fluctuations could be flagged in advance and that this could thereby help to reduce the adverse effects of such fluctuations is a very appealing prospect. Signals or indicators of economic activity could then be used to predict activity in the business cycle. Attempts to develop such leading indicators of economic activity have been the source of much research since their development by Mitchell and Burns (1938). Particular focus has been on the ability of a series of individual indicators, or a composite leading index, to determine whether it has an effect on economic activity. Using such indicators to predict business cycle activity is generally seen as a useful exercise and acts both as a substitute and as a complement to standard macroeconomic models.

Determining forecasts for key economic variables is a critical element of economic planning. Anticipating movements in economic activity at the onset of recession and at recovery stage is an important pre-requisite for the appropriate design and implementation of monetary and fiscal policy. In particular, projections for economic growth are a critical aspect of government decision making, where the ability of an economy to reach its potential growth affects government income and revenue projections. Government budgeting and planning is thereby critically dependent on the ability to forecast economic growth and, in particular, the ability to predict significant changes in it. Developing such an ability thereby becomes a valuable planning tool for government.

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Predicting different stages of the business cycle is possibly most valuable before an economy enters a downturn and goes into recession. At this stage, governments can act in such a way as to reduce the severity of such a downturn, provided they know when it is likely to occur. Characteristics of previous recessions include lengths in the region of 12 months in duration, approximately a 2% drop in output, a procyclical performance between most macroeconomic variables and financial variables, with average duration becoming shorter and milder over time, and recessions often coincide with periods of credit contraction and declines in asset prices (Claessens *et al*., 2008).

The current financial upheaval – brought about initially by falling house prices in the US that then spread across the globe – bringing with it severe restrictions on credit and significant losses in equity markets, has become the most severe crisis since the Great Depression. Countries in both the developed and developing world have not escaped from its effects with most if not all countries suffering a significant contraction in economic activity. At least three significant questions emerge from these events; (i) why did this happen, (ii) why did we not see it coming, and (iii) can leading economic indicators give us any insight into future changes in economic growth?

This article examines causality relationships between key leading economic indicators and economic growth based on quarterly data from 1970:01 to 2010:03, covering the UK, France and the US. The goal is to determine relevant indicators of economic activity that will tell us whether a certain indicator has an effect on economic activity, defined by GDP. A wide range of indicators are examined, ranging from financial variables, such as asset prices, stock prices and interest rates, to confidence indicators, to standard macroeconomic variables of economic activity. Such indicators should be easy to interpret, communicate and compose for maximum effect. However, as Niemira and Klein (1994) and Sensiera *et al.* (2004) find, what may be a good indicator for one country may not work for another for either conceptual or data reasons.

The structure of this paper is as follows: following this introduction, Section 2 reviews some of the relevant literature on the use of leading indicators. Section 3 describes the data and methodology, Section 4 presents the analysis, and Section 5 summarises some key conclusions.

2. Use of indicators to predict economic activity

Indicators vary from country to country, and their selection is based on factors such as the make-up of an economy's GDP or on their general historical performance in advance of past swings. If economic indicators are in some way connected to aggregate economic activity, then an understanding of such variables is critical for monetary policy decisions made by Central Banks, government fiscal policy and for asset allocation and valuation decisions made by financial traders.

The use of indicators of economic activity is well established in the literature and it is often compared with regression-based approaches. Camba-Mendez *et al.* (2001) question whether the regression approach offers a satisfactory way of identifying a series of indicators to produce a forecast, since they claim it is relatively easy to explain past economic growth using a small number of well-chosen variables and associated lags. Instead, the authors call for a forecasting strategy rather than finding an equation that will fit the data. Banerjee and Marcellino (2006) examine the role of leading indicators in determining GDP growth and find that leading indicator models outperform autoregressive models ex post, the best indicators change over time and there are only a few indicators that have predictive power. Qin *et al.* (2008) compare the forecasting potential of

leading indicators and macroeconometric structural models to forecast GDP growth and inflation and find that the leading indicators outperform the structural models for forecasting one period ahead but this ability diminishes as the forecasting period increases.

The use of leading indicators in forecasting has increased in popularity due to the work of Stock and Watson (1989, 1991), who recognised co-movement among key economic variables throughout the business cycle. They advocated the use of a leading indicator or an index of coincident indicators for the US economy, from a large pool of potential variables. Camba-Mendez *et al.* (2001) follow a similar methodology to develop short-term GDP growth forecasts for selected European countries. Indicators of economic activity can typically be grouped into a number of categories, such as financial or asset variables, consumer confidence variables, housing variables and composite variables. These will be outlined below.

2.1. Financial variables

Claessens *et al.* (2008) study the link between macroeconomic and financial variables around business and financial cycles for 21 OECD countries from 1960–2007 and find that interactions between the macroeconomic and financial variables do play a significant role in determining both the severity and duration of recessions. In particular, they find recessions associated with periods of credit contraction, and house price busts tend to be deeper and longer than other recessions. Asset prices are generally recognised as leading the business cycle. For example, equity prices move up and down with GDP, but they also lead this cycle. Lee (1992) and Kim (2003) find evidence to support the positive relationship between stock returns and GDP. Interest rates follow a similar pattern; term spreads, for example, tend to be more highly correlated with future as against current GDP.

Estrella and Mishkin (1998) examine the usefulness of a series of financial variables to predict whether the US economy will be in recession anywhere between one and eight quarters in the future. Such variables include interest rates, interest rates spreads, stock price indexes, and monetary aggregates. Results indicate stock prices are useful with one to three quarter horizons, while beyond one quarter the yield curve is found to display the best ability.

2.2. Stock prices

Stock exchanges are expected to accelerate economic growth by increasing the liquidity of financial assets, making global risk diversification easier for investors, promoting wiser investment decisions, encouraging corporate managers to work harder for shareholders interests and channelling more savings to corporations. Stock markets contain a gauge of overall value of the highest capitalised publicly listed corporations within their respective economies. It is inevitable that a decrease in the aggregate market value of corporations will play a leading role on those corporations' performance. A decrease in sentiment towards publicly listed corporations is reflected in falling share prices. This gradually leads to less cash being available for corporate spending and investment, which subsequently affects corporate performance.

The stock market has traditionally been viewed as an indicator or predictor of the economy, with large decreases in stock prices seen as reflective of a future recession, whereas large increases in stock prices suggest future economic growth. Theoretical reasons why stock prices might predict economic activity include the traditional valuation model of stock

prices. This traditional model suggests that stock prices reflect expectations about the future economy, and can therefore predict the economy. The wealth effect contends that stock prices lead economic activity by actually causing what happens to the economy. The stock market is seen as forward-looking, where current prices reflect the future earnings potential or profitability of corporations. Since stock prices reflect expectations about profitability and profitability is directly linked to economy activity, fluctuations in stock prices are thought to lead the direction of the economy.

Since fluctuations in stock prices have a direct effect on aggregate spending, the economy can be predicted from the stock market. When the stock market is rising; investors are wealthier and spend more. As a result, the economy expands. This results in faster economic growth. Beaudry and Portier (2006) show that the joint behaviour of stock prices and TFP favours a view of business cycles driven largely by a shock that does not affect productivity in the short run. One structural interpretation for this shock is that it represents news about future technological opportunities, which is first captured in stock prices. This shock causes a boom in consumption, investment, and hours worked that precedes productivity growth by a few years, and explains about 50% of business cycle fluctuations. Others have found that the stock market acts as a poor indicator of economic activity. Peek and Rosengren (1988), for example, indicate that between 1955 and 1986, while the S&P 500 declined 11 times, only six of these were followed by recessions.

2.3. Interest rates

One important leading indicator is that of Monetary Policy. If interest rates are falling, funding becomes cheaper and more money becomes available for spending within the economic system. This leads to an increase in economic activity and, as a result, borrowing becomes more expensive. As such, a variable for monetary policy incorporates an aspect of expected economic activity (Detken and Smets 2004). Stock and Watson (2005) showed that Monetary Policy performed above a benchmark average of 37 leading indicators in advance of the 2001 US recession.

Friedman and Kuttner (1992) find that the spread between the commercial paper rate and the Treasury bill rate contains information about subsequent movements in real income. This spread captures an investor's perception of private default risk, if this risk increases then corporations will have to pay more for the money they want to borrow. Therefore, it measures the perceived likelihood of future macro activity and the subsequent environment for corporations who rely on corporate debt for funding. Stock and Watson (2005) show the paper-bill spread acted as a leading indicator for early swings in US economic performance; however, Stock and Watson (2003) prove that this spread had no power for the 2001 US recession.

Bernard and Gerlach (1998) argue that Central banks are paying more attention to the term structure of interest rates as an indicator of monetary policy. There are two competing hypothesis as to why there is a relationship between the slope of the term structure and real economic growth. The first holds that the relationship stems from the effects of monetary policy, assuming the central bank tightens monetary policy by raising short-term interest rates. Since monetary contractions are temporary, agents raise their expectations of future short-term rates by less than the changes in the current short rate. Consequently, long interest rates also rise by less than the current short rate, leading to a downward sloping term structure. Since monetary policy affects output with a lag of one to two years, the argument continues that the tightening of policy is associated with a reduction of future growth and an increased probability of a recession.

The alternative hypothesis is that the relationship between the term structure and output reflects the expectations of final market participants on future economic growth. If people anticipate a recession, then since inflation rates tend to fall in a period of low real growth, such expectations are likely to lead to a fall in long interest rates and a downward sloping term structure. If expectations are correct on average, downward sloping term structures are likely to be associated with future recessions.

Bernake (1990) and Estrella and Hardouvelis (1991) show that the term structure of interest rates does contain information about the future path of real economic activity in the US, while Plosser and Rouwenhorst (1994) find evidence that term spreads are useful for predicting real economic growth in the US, Germany and Canada, but not in France and the UK.

2.4. Consumer/business confidence

Consumer confidence is often used as an indicator of economic activity in itself, because it represents public sentiment and a likelihood of whether or not consumers will spend more or less in the near future. It thereby accounts for sentiment that relates to the perceived safety of jobs and a willingness of consumers to spend. Taylor and McNabb (2007) use indicators of consumer and business confidence as predictors of movement in GDP for the UK, the Netherlands, France and Italy. Cross-correlation statistics are employed to indicate that both consumer and business confidence indicators are procyclical and do play a role in predicting recessions. Ivanova and Lahiri (2001) provide evidence that there is a direct link between consumer sentiment and subsequent aggregate consumption within an economy.

Other studies that value the use of consumer confidence as a leading indicators are Carroll *et al.* (1994), Matsusaka and Sbordone (1995) and Bram and Ludvigson (1998). Batchelor and Dua (1998) explored the role of consumer confidence in explaining the 1991 US recession, given the inability of standard macroeconomic variables to do so. They found consumer confidence would have improved forecasts for this particular recession but cannot generalise this result for all other downturns. Meanwhile Delorme *et al.* (2001) suggest that consumer confidence is less powerful at predicting business cycle activity for the US than it is for the UK.

The use of business confidence as a leading indicator is less well developed but in more recent times this indicator too has grown in popularity. Santero and Westerlund (1996) study the usefulness of consumer and business sentiment in assessing the cyclical position of the economy. Consumer confidence indicators generally were found not to show strong correlation with output in most countries, other than in Canada and Spain. For Spain, high correlation coefficients with lagged GDP pointed more to a link from output growth to consumer sentiment. Using Granger tests, Santero and Westerlund found that in most countries business sentiment indicators were useful in predicting output, especially when measured by industrial production, and also in countries where correlation coefficients were found to be low.

Conversely, where correlation between business confidence and output was found to be strong, such as in Spain, sentiment indicators did not help to predict output. Similarly, business confidence indicators were helpful in predicting the output in all countries examined, except for the Netherlands and Spain, even though in these two countries the correlation between business sentiment and output was quite strong. The paper concluded that sentiment indicators provided valuable information in predicting the economic cycle, but this relationship varied considerably across countries and sentiment measures. It is also found that consumer confidence indicators were much less useful than business confidence indicators for economic analysis.

2.5. Housing

Housing is also seen as playing a significant role in indicating business cycle activity. For example, Catte *et al.* (2004) focuses on the link between housing markets and the business cycle in ten OECD countries. They look at how differences in the level of resilience to economic shocks can be affected by the structural characteristics of housing and mortgage markets by analysing the transmission channel from housing wealth to consumption and estimate the marginal propensity to consume out of housing wealth. Factors behind house price variability were analysed in order to help determine whether housing played a stabilising role.

Catte *et al.* (2004) conclude that, (i) the relationship between house price movements and the business cycle is seen as a lagged effect, but in ways that differs significantly across countries and from one cycle to another; (ii) the effect of house prices on economic activity occurs mostly through wealth channels affecting personal consumption due to the traditional wealth effect as envisaged in lifecycle models, but also due to higher equity values that facilitated householders' access to finance; (iii) the behaviour of residential construction over the business cycle displayed important differences, with the volume response at turning points both stronger and more rapid in some countries than in others; and (iv) countries that had large, efficient and responsive mortgage markets also had the largest housing wealth effects on consumption. This effect was strongest where mortgage markets offered the greatest range of products and offered the possibility to withdraw housing equity.

Leamer (2007) identify residential investment as offering the best early warning sign of an oncoming recession and sees housing as a much undervalued component of business cycle activity. Davis and Heathcote (2005) distinguish between housing and non-residential structures due to the different production technologies, different uses and because residential investment and non-residential investment exhibit different business cycle dynamics. They find that GDP, consumption, residential and non-residential investment co-move positively. They do not find support for the hypothesis that non-residential investment lags GDP, whereas they found residential investment did lead GDP. Ghent and Owyang (2010) analyse the relationship between housing and the business cycle for 51 US cities and find that declines in house prices are often not followed by declines in that city's employment. They find no consistent statistical relationships between a city's permits or prices and the city's business cycle and suggest the possibility that housing is merely a proxy for other consumption or wealth indicators.

2.6. Composite variables

An increasing number of studies combine a range of standard macroeconomic and financial variables to form composite indexes and then test these as predictors of economic growth and the business cycle. Sensiera *et al.* (2004) use a range of domestic, financial and composite indicators to predict business cycles in Germany, France, Italy and UK. Cycles in Germany were predicted reasonably well, followed (in order) by the UK, Italy and France. The importance of foreign variables for the composite leading indicators and interest rates of US and Germany is shown to underline the role of international influences in the business cycles of these European countries. Meanwhile, Clements and Galvao (2009) evaluate the predictive power of composite leading indicators to predict quarterly output growth in the US. The indicators were found to have significant predictive ability.

Paap *et al.* (2009) investigate the possibility that leading indicators have different lead times at business cycle peaks and troughs. They show that, on average, the Conference Board's Composite Leading Index leads the Composite Coincident Index by nearly 1 year at peaks but by only 1 quarter at troughs. Allowing for asymmetric lead times yields improved real-time dating and forecasting of business cycle turning points. For the Euro area, Ozyildirim et al. (2010) develop composite indexes (employment and industrial production and supplemented by the monthly data on manufacturing and retail trade) and evaluate how well they predict current economic activity and its major fluctuations. Leading composite indicators were found to give a significant improvement over coincident composite indicators. Finally, Yamada *et al.* (2010) compare two sets of composite indexes, one developed by the OECD and the other by the Japanese government, to detect Japanese business cycle turning points. They find the locations of the turning points of the indexes are almost the same but the OECD index generally provided earlier signals for the next turning point.

What we find from reviewing this literature is that not all indicators have strong predictive power for each country and or for each business cycle, indicating the need to investigate a range of indicators for several countries over different business cycles. This motivation for this paper is therefore to examine the relationship between changes in the business cycle and changes in the respective leading economic indicators. In particular, we outline the techniques used for determining the size and magnitude effects and the structure of the symmetric and asymmetric Granger causality tests.

3. Data and methodology

Farmer (2001) argues that GDP is the most important indicator of the productive capacity of an economy and therefore we select Real GDP as our measure of economic growth and hence of the business cycle. Next, we select a range of leading economic indicators so we can account for the many causes of economic booms and busts, including consumer confidence indicators, business cycle indicators, leading indicators, consumer spending and saving, new house starts, new car registrations, consumer price index, producer price index, industrial production, employment and unemployment rates, long and short-term government bond yields, stock prices, government consumption, gross fixed capital formation, changes in inventories, GDP deflator, exports, imports, foreign reserves, government budget balance and the $ to £ exchange rate. Quarterly data were collected for the United Kingdom, France and the United States from Thompson Datastream. While the general sample period is 1970:01–2010:03, there are some variations due to limited data availability (see Table 1 for a full data description).

3.1. Testing asymmetry

Much of the empirical literature focuses purely on linear regression analysis in order to examine the relationships between changes in the business cycle and leading economic indicators. Using an approach developed by Granger (1969) and augmented by Kim (2003), we examine the causal relations between the relevant variables using both linear and nonlinear regression analysis. In particular, we examine (1) whether leading economic indicators help us determine movements in the business cycle; (2) whether the direction of change in the leading economic indicator is important; and (3) whether the magnitude of change in the leading indicator is important. As this is a relatively new area in the literature, we begin by examining the methodology.

Table 1. Data summary.

Variable name		Definition	Constant prices	SADJ	Data start	Log	Diff
GDP	US	Gross Domestic Product	√	√	1970Q1		I(1)
	UK	Gross Domestic Product	√	√	1974Q1		I(1)
	FR	Gross Domestic Product	√	√	1972Q4		I(1)
Confidence	US	Consumer confidence indicator		√	1970Q1		I(0)
	UK	Consumer confidence index		√	1974Q1		I(0)
	FR	Household confidence indicator		√	1972Q4		I(0)
Bus Cycle	US	ISM purchasing managers index		√	1970Q1		I(1)
	UK	CBI enquiry: business optimism			1972Q1		I(1)
	FR	Manufacturing output level		√	1976Q2		I(1)
Cyclical	US	Conference Board Leading Indicator		√	1970Q1	√	I(1)
	UK	Composite leading indicator			1970Q1	√	I(1)
	FR	Composite leading indicator			1970Q1	√	I(1)
P. Cons	US	Personal consumption expenditures	√	√	1970Q1	√	I(1)
	UK	Consumer spending	√	√	1970Q1	√	I(1)
	FR	Consumer spending	√	√	1970Q1	√	I(1)
Gov Cons	US	Gov consumption & investment	√	√	1970Q1	√	I(1)
	UK	General gov consumption expend	√	√	1970Q1	√	I(1)
	FR	Collective government consumption	√	√	1970Q1	√	I(1)
Investment	US	Private domestic fixed investment	√	√	1995Q1	√	I(1)
	UK	Gross Fixed Capital Formation	√	√	1970Q1	√	I(1)
	FR	Gross Fixed Capital Formation	√	√	1978Q1	√	I(1)
Stocks	US	Change in private inventories	√	√	1970Q1		I(0)
	UK	Changes in inventories	√	√	1970Q1		I(0)
	FR	Increase in stocks	√	√	1978Q1		I(0)
Deflator	US	Implicit price deflator – GDP	√	√	1970Q1		I(1)
	UK	Implicit price deflator – GDP	√	√	1970Q1		I(1)
	FR	Implicit price deflator - GDP	√	√	1970Q1		I(1)
Export	US	Exports of goods & services	√	√	1970Q1	√	I(1)
	UK	Exports of goods &services	√	√	1970Q1	√	I(1)
	FR	Exports - goods & services	√	√	1970Q1	√	I(1)
Import	US	Imports of goods & services	√	√	1970Q1	√	I(1)
	UK	Imports of goods & services	√	√	1970Q1	√	I(1)
	FR	Imports - goods & services	√	√	1970Q1	√	I(1)
Stock price	US	Dow Jones industrials Index			1970Q1	√	I(1)
	UK	FT all share index			1970Q1	√	I(1)
	FR	SBF 250			1970Q1	√	I(1)
Long bond	US	Treasury yield constant maturity –20yr			1970Q1		I(1)
	UK	Gross redemption yield 20 year gilts			1970Q1		I(1)
	FR	Government guaranteed bond yield			1970Q1		I(1)
Short bond	US	Interbank rate - 3month			1970Q1		I(1)
	UK	Interbank rate - 3month			1970Q1		I(1)
	FR	Pibor/Euribor - 3-month			1970Q1		I(1)
Reserves	US	Foreign reserve assets	√		1970Q1	√	I(1)
	UK	Government gross reserve assets	√		1999Q3	√	I(1)
	FR	Official reserves	√		1972Q1	√	I(1)

(*Continued*)

Table 1. (*Continued*)

Variable name		Definition	Constant prices	SADJ	Data start	Log	Diff
CPI	US	CPI- all urban: all items	√	√	1970Q1	√	I(1)
	UK	CPI harmonised European union	√	√	1988Q1	√	I(1)
	FR	CPI	√	√	1990Q1	√	I(1)
PPI	US	PPI - finished goods	√	√	1970Q1	√	I(1)
	UK	PPI - output of manufactured products	√		1970Q1	√	I(1)
	FR	PPI domestic market	√		2005Q1	√	I(1)
Employ	US	Total civilian employment		√	1970Q1	√	I(1)
	UK	Workforce jobs		√	1978Q1	√	I(1)
	FR	Employment		√	1978Q1	√	I(1)
Unemploy	US	Unemployment rate		√	1970Q1	√	I(1)
	UK	Unemployment rate		√	1970Q1	√	I(1)
	FR	Unemployment rate		√	1970Q1	√	I(1)
P. Exp	US	Personal consumption expenditures	√		1970Q1	√	I(1)
	UK	Consumer spending	√		1970Q1	√	I(1)
	FR	Consumer spending	√		1970Q1	√	I(1)
Saving	US	Personal saving as % of DPI	√	√	1970Q1	√	I(1)
	UK	Household savings ratio	√	√	1970Q1	√	I(1)
	FR	Savings - households & private		√	1978Q1	√	I(1)
IP	US	Industrial production - total index	√	√	1970Q1	√	I(1)
	UK	Index of production -all prod industries	√	√	1970Q1	√	I(1)
	FR	Industrial production exc construction	√	√	1970Q1	√	I(1)
IP-Manu	US	Industrial production - manufacturing	√	√	1972Q1	√	I(1)
	UK	Industrial production - manufacturing	√	√	1970Q1	√	I(1)
	FR	Industrial production - manufacturing	√	√	1970Q1	√	I(1)
Prod	US	Output per hour - business sector	√	√	1970Q1	√	I(1)
	UK	Productivity - whole economy	√	√	1970Q1	√	I(1)
	FR	Productivity - GDP per employed pers	√	√	1970Q1	√	I(1)
Capacity	US	Capacity utilization rate - all industry		√	1970Q1	√	I(1)
	UK	CBI enquiry: % working < capacity			1970Q1	√	I(1)
	FR	Survey: industry- utilisation rate		√	1976Q2	√	I(1)
H. Starts	US	New private housing units started	√		1970Q1	√	I(1)
	UK	House building started			1990Q1	√	I(1)
	FR	Housing started			1994Q1	√	I(1)
Car Reg	US	New passenger cars - total reg			1975Q1	√	I(1)
	UK	Car registrations			1970Q1	√	I(1)
	FR	New car registrations			1970Q1	√	I(1)
Budget	US	Federal government budget balance			1970Q1		I(1)
	UK	Public sector net cash requirement			1984Q2		I(1)
	FR	Overall budget balance			1994Q3		I(1)
Exchange	US	$ TO 1			1970Q1	√	I(1)

Note:
- Data series ends in 2010:03 and is sourced from Thompson Datastream.
- Constant price = a $\surd$ indicates that the series is in constant prices.
- SADJ = Seasonally adjusted, a $\surd$ indicates that the series is seasonally adjusted.
- Log = a $\surd$ indicates that the series is in logs.
- Diff = refers to the stationarity of the series in question, I(0) refers to a series which is stationary in levels, while I(1) refers to a series which is stationary in first differences. These results were generated using the Dickey–Fuller Unit Root test statistic and the Kwiatkowski, Phillips, Schmidt and Shin unit root test statistic with a constant but without a time trend – results available on request.

To examine the relationship between GDP growth (i.e. the business cycle) and each economic indicator we begin by examining a simple linear regression:

$$\Delta LGDP_t = \alpha + \beta X_t + \gamma I_{\{\Phi\}}(\Delta x_t) \tag{1}$$

where $\Delta LGDP_t$ refers to GDP growth, X_t refers to the leading economic indicator in question, Δ refers to a change and $I_{\{\Phi\}}(\Delta x_t)$ can be defined as:

$$I_{\{\Phi\}}(\Delta X_t) = \begin{cases} 1, & \text{if } \Delta X_t \in \Phi \\ 0, & \text{otherwise} \end{cases} \tag{2}$$

Φ is a set of real numbers, which determines the kind of asymmetry assumed under the null hypothesis. We follow Kim (2003) in examining two types of asymmetry:

$$\Phi = \{\Delta X_t | \Delta X_t \in (0, \infty)\} \tag{3}$$

$$\Phi = \{\Delta X_t | |\Delta X_t| \in (\theta, \infty)\} \tag{4}$$

The first type of asymmetry examines the sign of the variable in question, whilst the second type of asymmetry examines whether the magnitude of change in the independent variable is significant. This is a threshold regression with a threshold parameter, . The estimate of is chosen by maximising the t-value for the coefficient $\hat{\gamma}$. To search for this value we use a grid search method over $\theta \in [\theta_{\min,}\theta_{\max}]$, where $\theta_{\min}$ is the minimum value of the coefficient associated with $\hat{\gamma}$, $\theta_{\max}$ is the maximum value of the coefficient associated and we use a step of $(\theta_{\min} - \theta_{\max})/\delta$ where δ is set as 10.

3.2. Granger causality test

To examine if leading economic indicators help us determine movements in the business cycle we use begin by specifying the following autoregressive models:

$$\Delta LGDP_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta LGDP_{t-i} + u_{0t} \tag{5}$$

$$\Delta LGDP_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta LGDP_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta X_{t-i} + u_{1t} \tag{6}$$

where $\Delta LGDP_t$ represents GDP growth, X_t represents the leading economic indicator in question, p represent the number of lags selected using Akaike Information Criteria, and u represents the error term.

We calculate the mean squared errors terms MSE_0 and MSE_1 from equations (5) and (6) respectively as:

$$MSE_0 = MSE\{\hat{E}[\Delta LGDP_{t+s}|\Delta LGDP_t, \Delta LGDP_{t-1}, ...]\}$$
$$MSE_1 = MSE\{\hat{E}[\Delta LGDP_{t+s}|\Delta LGDP_t, \Delta LGDP_{t-1}, ..., X_t, X_{t-1}, ...]\}$$

If $MSE_0 > MSE_1$ then we can say that X is Granger-causal to $\Delta LGDP$. Under the null hypothesis of Granger non-causality, namely H_0: $\beta_1 = \beta_2 = \ldots = \beta_p = 0$, the likelihood ratio statistic (based on an Ordinary Least Squares regression) is:

$$F_{(p,\ T-2p-1)} = \frac{(T-2P-1)(RSS_0 - RSS_1)}{p * RSS_1} \tag{7}$$

where RSS_0 is the restricted sum of squares from the restricted regression (5), $RSS_0 = \sum_{t=1}^{T} \hat{u}_{0t}^2$, and RSS_1 is the restricted sum of squares from the unrestricted regression equation (6), that is $RSS_1 = \sum_{t=1}^{T} \hat{u}_{1t}^2$.

To test for non-asymmetric Granger Causality we estimate the following equations using Ordinary Least Squares:

$$\Delta LGDP_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta LGDP_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta X_{t-i} + u_{1t} \tag{8}$$

$$\Delta LGDP_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta LGDP_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta X_{t-i} + + \sum_{i=1}^{p} \phi_i I_{(\Phi)}(\Delta X_{t-i}) + u_{2t} \tag{9}$$

We can calculate MSE_1 and MSE_2 from equations (8) and (9) respectively:

$$MSE_1 = MSE\{\hat{E}[\Delta LGDP_{t+s}|\Delta LGDP_t, \Delta LGDP_{t-1}, ..., X_t, X_{t-1}, ...]\}$$

$$\mathrm{MSE}_2 =$$

$$MSE\{\hat{E}[\Delta LGDP_{t+s}|\Delta LGDP_t, \Delta LGDP_{t-1}, ..., X_t, X_{t-1}, ..., I_{\{\Phi\}}(\Delta X_t), I_{\{\Phi\}}(\Delta X_{t-1}), ...]\}$$

If $MSE_0 > MSE_1 = MSE_2$ then the leading indicators are symmetric Granger-causal GDP growth, whereas if $MSE_0 > MSE_1 > MSE_2$ the leading indicators are asymmetric Granger-causal to GDP growth. Under the null hypothesis of symmetric Granger causality, namely H_0: $\phi_1 = \phi_2 = ... = \phi_p = 0$ the likelihood ratio statistic is:

$$F_{(p,\ T-3p-1)} = \frac{(T-3P-1)(RSS_1 - RSS_2)}{p * RSS_2} \tag{10}$$

where RSS_1 is the restricted sum of squares from the restricted regression (8), $RSS_1 = \sum_{t=1}^{T} \hat{u}_{1t}^2$, and RSS_2 is the restricted sum of squares from the unrestricted regression equation (9), that is $RSS_2 = \sum_{t=1}^{T} \hat{u}_{2t}^2$.

4. Empirical results

We ask whether financial and macroeconomic variables can act as early warning signals in periods of economic boom and bust. If these variables provide timely insights into the direction an economy is taking and the associated impacts on monetary and fiscal policy, stock and bond markets then they can act as useful measures for policy makers. The aim of this section is to examine the value of the information tied up in these indicators. In particular, using quarterly data for the United States, the United Kingdom and France, we examine if movements in these indicators can provide us with insights into the direction an economy is taking. This section begins by testing the stationarity of the data, next we examine the relationship between the leading economic indicators and the business cycle and finally we examine whether these leading economic indicators Granger cause changes in the business cycle.

4.1. Preliminary data analysis

Before examining the relationship between real GDP growth and the respective indicators we begin by examining whether the data are stationary. We use the Dickey–Fuller (1981) test for the null hypothesis that the series in question is I(1) and the Kwiatkowski *et al*. (1992) test for the null hypothesis that the series in question is I(0). If the null hypotheses of the Dickey–Fuller test is not (is) rejected but the null of the KPSS is (is not) rejected, then the variable is considered non-stationary (stationary). These results are reported in Table 1.[1] The appropriate lag length for each test was selected using Akaike Information Criterion. With the exception of the consumer confidence indicators and the change in stocks/inventories all variables are first difference stationary.

4.2. Impact of economic indicators on GDP growth

To examine the relationship between each of the economic indicators and real GDP growth we begin by estimating the following series of regressions:

$$\Delta LGDP_t = \alpha + \beta X_t + u_t \tag{11}$$

$$\Delta LGDP_t = \alpha + \beta X_t + \gamma I_{\{\{\Delta X_t | \Delta X_t \in (0,\infty)\}\}}(\Delta X_t) + u_t \tag{12}$$

$$\Delta LGDP_t = \alpha + \beta X_t + \gamma I_{\{\{\Delta X_t || \Delta X_t | \in (\theta,\infty)\}\}}(\Delta X_t) + u_t \tag{13}$$

where $\Delta LGDP_t$ represents real economic growth, X_t represents the leading economic indicator in question and ΔX_t refers to the first difference of the leading indicator.

Equation (11) examines the relationship between real economic growth and the leading indicator in question, while equation (12) examines the additional information provided by a change in the direction of the leading economic indicator and equation (13) examines the additional information provided by a large change (positive or negative) in the leading economic indicator. The results are presented in Table 2.

Turning firstly to equation (11), we notice that different relationships exist in the United States, the United Kingdom and France. Only four variables are significant in all three regions at the 5% level of significance, these are the business cycle indicators; the measure of capacity utilization, the number of new house starts and the number of new car registrations. It is interesting that at least three of these measures can be seen as

Table 2. Coefficient estimates examining the impact of economic indicators on GDP growth.

	Equation (11)		Equation (12)			Equation (13)		
Xt	R^2	X_t	R^2	X_t	$I[0,\infty]^*(\Delta X_t)$	R^2	X_t	$I[\theta,\infty]^*(\Delta X_t)$
				Confidence				
US	0.16	0.0000	0.32	0.0000	0.0000	0.21	0.0000	0.0000
UK	0.18	0.0000	0.03	0.0306	0.9863	0.03	0.0443	0.6113
France	0.00	0.8025	0.00	0.5845	0.8587	0.00	0.3313	0.2265
				Bus Cycle				
US	0.36	0.0000	0.40	0.0000	0.0005	0.36	0.0000	0.1752
UK	0.24	0.0000	0.26	0.0000	0.5774	0.27	0.0000	0.0000
France	0.40	0.0000	0.39	0.0000	0.0175	0.38	0.0000	0.0000
				Cyclical				
US	0.27	0.0000	0.32	0.0000	0.0000	0.28	0.0000	0.0000
UK	0.00	0.2551	0.14	0.0000	0.0000	0.07	0.0017	0.0000
France	0.03	0.0154	0.27	0.0000	0.0000	0.18	0.0000	0.0001
				P. Cons				
US	0.44	0.0000	0.49	0.0000	0.0018	0.44	0.0000	0.0000
UK	0.00	0.5800	0.45	0.0000	0.2890	0.44	0.0000	0.5184
France	0.11	0.0000	0.42	0.0000	0.0000	0.38	0.0000	0.2438
				Gov Cons				
US	0.02	0.0812	0.04	0.5843	0.0324	0.08	0.0337	0.0003
UK	0.00	0.2727	0.01	0.1406	0.3085	0.01	0.2052	0.2492
France	0.12	0.0000	0.00	0.0752	0.7495	0.01	0.0484	0.0004
				Investment				
US	0.58	0.0000	0.59	0.0000	0.0886	0.62	0.0000	0.0129
UK	0.00	0.5801	0.13	0.0000	0.1382	0.15	0.0000	0.0000
France	0.03	0.0420	0.53	0.0000	0.5057	0.53	0.0000	0.1812
				Stocks				
US	0.14	0.0000	0.20	0.0000	0.0000	0.13	0.0000	0.3067
UK	0.14	0.0000	0.14	0.0000	0.1908	0.15	0.0000	0.0000
France	0.11	0.0001	0.13	0.0002	0.0341	0.17	0.0001	0.0000
				Deflator				
US	0.03	0.1011	0.03	0.1918	0.5099	0.10	0.0055	0.0000
UK	0.00	0.5064	0.06	0.0420	0.5964	0.11	0.0056	0.0097
France	0.13	0.0000	0.00	0.3468	0.4271	0.08	0.0645	0.0000
				Exports				
US	0.17	0.0000	0.18	0.0000	0.7634	0.19	0.0000	0.1831
UK	0.00	0.5945	0.18	0.0001	0.6785	0.19	0.0001	0.5289
France	0.10	0.0000	0.43	0.0000	0.0252	0.42	0.0000	0.1975
				Imports				
US	0.23	0.0000	0.25	0.0000	0.0121	0.22	0.0000	0.0488
UK	0.00	0.5922	0.19	0.0000	0.0002	0.11	0.0001	0.5483
France	0.10	0.0000	0.50	0.0000	0.0004	0.50	0.0000	0.0000
				Stock Price				
US	0.01	0.3131	0.05	0.0453	0.0081	0.01	0.1926	0.0000
UK	0.00	0.7597	0.00	0.6771	0.4195	0.00	0.9952	0.3242
France	0.05	0.0038	0.05	0.0557	0.0328	0.04	0.0517	0.0000
				Long bond				
US	0.05	0.0023	0.05	0.0055	0.6389	0.07	0.0015	0.0952
UK	0.00	0.3343	0.00	0.8807	0.5669	0.00	0.7629	0.1973
France	0.00	0.4128	0.04	0.0121	0.2660	0.04	0.0214	0.1398

(*Continued*)

Table 2. (*Continued*)

	Equation (11)		Equation (12)			Equation (13)		
				Short bond				
US	0.10	0.0005	0.11	0.0003	0.1666	0.12	0.0000	0.0756
UK	0.01	0.1344	0.02	0.0262	0.2749	0.02	0.0719	0.2592
France	0.00	0.8277	0.12	0.0000	0.1014	0.11	0.0007	0.2280
				Reserves				
US	0.00	0.4118	0.00	0.8831	0.4183	0.00	0.3894	0.0000
UK	0.05	0.0390	0.04	0.2818	0.2409	0.00	0.6271	0.0003
France	0.11	0.0027	0.00	0.5226	0.8214	0.02	0.4455	0.0006
				CPI				
US	0.00	0.6411	0.00	0.6707	0.9669	0.07	0.1516	0.0000
UK	0.00	0.3082	0.05	0.0607	0.2073	0.04	0.1704	0.0615
France	0.00	0.3370	0.00	0.7665	0.8769	0.02	0.7209	0.0867
				PPI				
US	0.00	0.6501	0.00	0.8505	0.1996	0.16	0.0105	0.0000
UK	0.00	0.6508	0.06	0.3741	0.1066	0.13	0.1011	0.0000
France	0.15	0.0066	0.40	0.0004	0.2749	0.49	0.1902	0.1436
				Employ				
US	0.35	0.0000	0.34	0.0000	0.6030	0.34	0.0000	0.4636
UK	0.02	0.0711	0.21	0.0000	0.7593	0.20	0.0000	0.6923
France	0.05	0.0162	0.33	0.0000	0.0007	0.30	0.0000	0.0000
				Unemploy				
US	0.48	0.0000	0.48	0.0000	0.6251	0.49	0.0000	0.0000
UK	0.01	0.2331	0.31	0.0000	0.0003	0.30	0.0000	0.0000
France	0.00	0.5108	0.08	0.0014	0.9793	0.10	0.0024	0.1729
				P. Exp				
US	0.44	0.0000	0.49	0.0000	0.0018	0.44	0.0000	0.0000
UK	0.00	0.1781	0.45	0.0000	0.2890	0.09	0.0000	0.5184
France	0.12	0.0000	0.42	0.0000	0.0000	0.38	0.0000	0.2438
				Savings				
US	0.00	0.1722	0.00	0.1417	0.4565	0.00	0.1590	0.2037
UK	0.00	0.5800	0.00	0.7572	0.4672	0.45	0.3014	0.0000
France	0.06	0.0036	0.00	0.1237	0.2747	0.00	0.2682	0.0487
				IP				
US	0.59	0.0000	0.59	0.0000	0.1634	0.60	0.0000	0.1115
UK	0.01	0.4483	0.58	0.0000	0.0019	0.58	0.0000	0.0000
France	0.04	0.0008	0.60	0.0000	0.0984	0.59	0.0000	0.0000
				IP – Manu				
US	0.58	0.0000	0.58	0.0000	0.3752	0.59	0.0000	0.1994
UK	0.00	0.3680	0.62	0.0000	0.0897	0.63	0.0000	0.0000
France	0.05	0.0037	0.62	0.0000	0.0930	0.62	0.0000	0.0000
				Prod				
US	0.38	0.0000	0.38	0.0000	0.4201	0.38	0.0000	0.3891
UK	0.00	0.8283	0.69	0.0000	0.9790	0.69	0.0000	0.3727
France	0.02	0.0731	0.78	0.0000	0.0205	0.77	0.0000	0.2414
				Capacity				
US	0.54	0.0000	0.55	0.0000	0.2042	0.55	0.0000	0.1694
UK	0.00	0.0152	0.13	0.0000	0.0052	0.11	0.0007	0.2683
France	0.06	0.0074	0.22	0.0000	0.0201	0.20	0.0000	0.0000
				New House Starts				
US	0.13	0.0002	0.20	0.0000	0.0086	0.16	0.0000	0.0000
UK	0.43	0.0000	0.06	0.0816	0.1529	0.03	0.1132	0.2093
France	0.00	0.6076	0.06	0.0919	0.2021	0.22	0.4539	0.0000

(*Continued*)

Table 2. (*Continued*)

	Equation (11)		Equation (12)			Equation (13)		
				Car registrations				
US	0.06	0.0073	0.09	0.0007	0.0515	0.07	0.0039	0.0000
UK	0.01	0.0568	0.01	0.0768	0.1167	0.00	0.2217	0.2382
France	0.00	0.2998	0.00	0.6431	0.7988	0.01	0.9252	0.0000
				Gov Surplus/ Deficit				
US	0.00	0.0978	0.04	0.0031	0.0030	0.02	0.1020	0.0021
UK	0.25	0.0000	0.08	0.6551	0.0376	0.29	0.0144	0.0000
France	0.04	0.0309	0.00	0.0854	0.0896	0.00	0.4746	0.0148
				Exchange rate				
US	0.00	0.5649	0.01	0.2943	0.1501	0.00	0.4858	0.1096
UK	0.01	0.2095	0.01	0.3312	0.4345	0.00	0.3961	0.0152
France	0.06	0.0036	0.03	0.0497	0.2662	0.03	0.0552	0.0083

measures of inflation. For example, capacity utilization refers to the relationship between actual output that 'is' produced with the installed equipment and the potential output that 'could' be produced with it, if capacity was fully used. It is believed that when utilization rises above somewhere between 82% and 85%, price inflation will increase.

The leading economic indicators seem to provide more information about the United States markets than either of the other two markets, with adjusted R^2 ranging from 0% to 59% and with variables such as the confidence and cyclical indicators, personal consumption, investments, changes in stocks, exports, imports, long and short government bond yield, employment and unemployment rates and industrial production providing information about economic growth. The indicators seem to be much less important in the United Kingdom where only consumer confidence, the change in stocks, government gross reserve assets and public sector net cash requirement, in addition to the four common variables mentioned above, are contemporaneously related to economic growth.

Equation (12) allows us to examine whether a positive change in the economic indicator is related to real GDP growth. Again we find a similar pattern to above in that the leading indicators seems to provide a stronger information set in the United States where a positive change in the consumer confidence indicator, the business cycle indicator, the cyclical indicator, personal consumption, new house starts, government consumption, Federal government budget balance stock return, imports and housing starts is found to be significant. Only positive changes in the cyclical indicator, imports, industrial production, capacity utilization and government gross reserve assets are related to contemporaneous economic growth in the United Kingdom, while positive changes in the business cycle and cyclical indicators, personal consumption, new house starts, stock returns, imports, exports and employment are related to economic growth in France.

Finally, turning to equation (13) we examine whether a large (positive or negative) change in the economic indicator provides additional information about economic growth. Here, we note that this variable displays greater contemporaneous significance than either of the above measures. For example, in the United States, large movements in the consumer confidence indicator, the cyclical indicator, personal consumption, new house starts and car registrations, government consumption, investment, the GDP deflator, CPI inflation and PPI inflation, the Federal government budget balance and stock returns are found to be significant. It is interesting that only large changes in the GDP deflator, CPI and PPI are related to movements in economic growth, as measured by real GDP growth,

rather than the direction of the movement in these indicators. Similarly, in France, large changes in the consumer confidence, business and cyclical indicators, government consumption, government budget balance, foreign reserves, stocks, industrial production, capacity utilisation, new house starts and car registrations, employment levels, savings levels and interestingly the $/£ exchange rate are associated with changes in economic growth.

Concentrating on the variables with the most explanatory power (i.e. those with R^2 values greater than 50%), we conclude that relatively few economic indicators are strongly connected with contemporaneous changes in economic growth. The key indicators in the United States include the levels, directional changes, and large changes in investment, industrial production and capacity utilisation. The only variable with an R^2 greater than 50% in the United Kingdom is the directional change in industrial production, while the key variables in France are the directional changes in investment, and the directional and magnitude changes in industrial production.

Table 3. Granger-causality test results.

	United States		United Kingdom		France	
	Lags	F_1 P-value	Lags	F_1 P-value	Lags	F_1 P-value
Consumer Confidence	3	0.0002	3	0.0000	4	0.0000
Business Cycle	4	0.0000	3	0.0000	2	0.0000
Cyclical & Activity	3	0.0000	3	0.0000	4	0.0000
Personal Cons	3	0.0000	3	0.0867	2	0.0528
Gov Cons	1	0.0826	2	0.2341	4	0.2113
Investment	1	0.0000	2	0.0579	2	0.0000
Changes in Stocks	2	0.0006	3	0.0443	2	0.0000
GDP Deflator	4	0.2059	1	0.0984	4	0.8650
Exports	2	0.0090	1	0.9618	4	0.5365
Imports	1	0.0036	2	0.0002	4	0.6512
Stock returns	2	0.0000	4	0.0012	2	0.0007
Long Gov bond	2	0.0009	3	0.0138	2	0.2915
Short Gov bond	2	0.0000	3	0.1009	2	0.0349
Foreign reserves	2	0.8734	2	0.0000	2	0.0324
CPI	3	0.0672	4	0.0000	2	0.0000
PPI	3	0.0333	3	0.4469	2	0.0000
Total Employment	3	0.0420	1	0.0000	2	0.0000
Unemployment rate	2	0.0007	4	0.0092	2	0.0000
Personal Expenditure	3	0.0000	3	0.0867	2	0.0528
Personal Savings	2	0.0282	3	0.0432	1	0.0000
Industrial Production	2	0.0001	4	0.0939	4	0.7227
Industrial Prod-Manu	1	0.0000	2	0.1145	4	0.5375
Productivity	2	0.0157	3	0.0217	2	0.0000
Capacity Utilisation	2	0.0001	1	0.0060	2	0.0000
New Housing starts	2	0.0000	4	0.0000	3	0.0000
Car registrations	4	0.0000	4	0.3193	4	0.7133
Gov Surplus/ Deficit	4	0.7456	4	0.0000	3	0.0000
Exchange rate	1	0.4504	1	0.8473	2	0.2875

Notes:

- Lags refers to the number of lags selected using Akaike Information Criterion in a VAR of GDP growth and each respective leading economic indicator.
- F_1 refers to the F-test $F_{(p,\ T-2p-1)} = \frac{(T-2P-1)(RSS_0-RSS_1)}{p*RSS_1}$ where RSS_0 and RSS_1 come from $\Delta LGDP_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta LGDP_{t-i} + u_{0t}$ and ΔLGDPt=α+∑i=1pβiΔLGDPt-i+∑i=1pγi ΔXt-i+u1t respectively.

To further examine the importance of these connections we examine whether these indicators, and lags of these indicators Granger-cause movements in economic growth in each of the three countries under examination.

4.3. Symmetric causality test results

In this section we examine whether the leading economic indicators examined above Granger-cause movements in economic growth in the United States, the United Kingdom or France. We examine three forms of the Granger Causality test as developed by Granger (1969) and augmented by Kim (2003), see Section 3 above for a detailed discussion of the methodology.

We begin by estimating equations (5) and (6), reprinted below, and asking whether each economic indicator Granger-causes changes in economic growth.

$$\Delta LGDP_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta LGDP_{t-i} + u_{0t}$$

$$\Delta LGDP_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta LGDP_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta X_{t-i} + u_{1t}$$

where $\Delta LGDP_t$ represents real economic growth and X_t represents the leading economic indicator in question.

Next, using an F-test we examine whether the addition of lagged value of the leading economic indicator variable improves our estimate of current economic growth. The number of lags included in each regression is selected using Akaike Information Criterion applied to a VAR containing $\Delta LGDP_{t\text{-}i}$ and $\Delta X_{t\text{-}i}$. The results are displayed in Table 3.

In the majority of cases, lagged values of the economic indicator Granger-cause changes in the log of real gross domestic product at the 5% level of significance. The only indicators that do not Granger cause changes in GDP in the United States are government consumption, the GDP deflator, foreign reserves, the budget balance and the $/£ exchange rate. The indicators are not as powerful/meaningful in the United Kingdom where personal consumption, government consumption, investment, the GDP deflator, exports, the short term government bond, the producer price index, personal expenditure, industrial production, car registrations, and the /$ exchange rate do not Granger-cause movements in the business cycle. In France, the indicators that are insignificant include the GDP deflator, exports, imports, the long-term government bond yield, industrial production, car registrations and the budget balance. These exceptions noted, many of our leading indicators Granger-cause economic growth including the three consumer and business cycle indicators, stock returns and the short-term government yield as suggested by the literature.

Turning to the information contained in the direction and magnitude of the changes in the economic indicators we estimate equations (8) and (9), reprinted below, and again test whether the additional information contained in these variables is significant.

$$\Delta LGDP_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta LGDP_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta X_{t-i} + u_{1t}$$

$$\Delta LGDP_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta LGDP_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta X_{t-i} + + \sum_{i=1}^{p} \phi_i I_{(\Phi)}(\Delta X_{t-i}) + u_{2t}$$

The results are presented in Table 4.

F_2 in Table 4 refers to an F- test based on the direction of change while F_3 refers to an F-test based on the magnitude of the change in each underlying economic indicator. The number of lags included in each regression is as shown in Table 3 above. In all cases we find that a lagged change in the direction of the economic indicator Granger-causes changes in real gross domestic product. This is especially true in the United States where

Table 4. Granger-causality size and sign test results.

	United States		United Kingdom		France	
	F_2Prob	F_3Prob	F_2Prob	F_3Prob	F_2Prob	F_3Prob
Consumer Confidence	0.0000	0.0003	0.0000	0.2810	0.0000	0.0005
Business Cycle	0.0000	0.0718	0.0000	0.0000	0.0000	0.0119
Cyclical & Activity	0.0000	0.0010	0.0387	0.0632	0.0000	0.7660
Personal Cons	0.0000	0.0000	0.0002	0.0000	0.0221	0.4621
Gov Cons	0.0572	0.2277	0.1903	0.7840	0.0613	0.6620
Investment	0.0000	0.3307	0.0160	0.9503	0.0000	0.5683
Changes in Stocks	0.0004	0.8458	0.0027	0.1149	0.0000	0.0437
GDP Deflator	0.0105	0.3505	0.0498	0.4545	0.1669	0.2029
Exports	0.0005	0.0419	0.3239	0.1985	0.1549	0.6531
Imports	0.0007	0.3714	0.0001	0.0001	0.4218	0.0075
Stock returns	0.0000	0.0289	0.0002	0.3672	0.0006	0.1400
Long Gov bond	0.0000	0.0022	0.0001	0.0501	0.1583	0.7728
Short Gov bond	0.0000	0.0149	0.0021	0.0016	0.0070	0.3528
Foreign reserves	0.0501	0.0658	0.0000	0.3215	0.0115	0.0066
CPI	0.0001	0.0007	0.0000	0.6800	0.0000	0.3574
PPI	0.0000	0.0243	0.0000	0.1367	0.0000	0.1219
Total Employment	0.0007	0.0321	0.0000	0.3994	0.0000	0.4853
Unemployment rate	0.0000	0.0556	0.0000	0.0080	0.0000	0.0000
Personal Expenditure	0.0000	0.0000	0.0002	0.0000	0.0221	0.4621
Personal Savings	0.0052	0.1511	0.0000	0.0068	0.0000	0.1835
Industrial Production	0.0000	0.0369	0.0481	0.0998	0.2418	0.0569
Industrial Prod-Manu	0.0000	0.1791	0.0336	0.0474	0.0532	0.2453
Productivity	0.0003	0.0083	0.0030	0.0043	0.0000	0.3199
Capacity Utilisation	0.0000	0.0359	0.0043	0.2890	0.0000	0.0470
New Housing starts	0.0000	0.0016	0.0000	0.0409	0.0000	0.0012
Car registrations	0.0000	0.8318	0.1497	0.3133	0.2828	0.3690
Gov Surplus/ Deficit	0.1770	0.2114	0.0000	0.0016	0.0000	0.9555
Exchange rate	0.1667	0.4845	0.2903	0.6931	0.1030	0.7492

Notes:

- The number of lags included is the same as shown in Table 4.
- F_2 and F_3 refer to F-tests of the form $F_{(p,\ T-3p-1)} =$ where RSS_1 comes from $\Delta LGDP_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta LGDP_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta X_{t-i} + u_{1t}$ and RSS_2 is obtained from $\Delta LGDP_t = \alpha + \sum_{i=1}^{p} \beta_i \Delta LGDP_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta X_{t-i} + + \sum_{i=1}^{p} \phi_i I_{(\Phi)}(\Delta X_{t-i}) + u_{2t}$ where for F_2 we examine the size impact by defining $\Phi = \{\Delta x_t | \Delta x_t \in (0, \infty)\}$ and for F_3 we examine the size impact by defining $\Phi = \{\Delta x_t || \Delta x_t | \in (\theta, \infty)\}$.

changes in the direction of the economic indicator Granger-cause changes in output in all bar three cases (Government consumption, Government budget balance and the $/£ exchange rate). We find similar results for the United Kingdom where changes in the direction of the economic indicator Granger-causes movements in economic growth in all bar four cases (government consumption, exports, car registrations and the $/£ exchange rate) and in France where all except seven indicator Grange-cause movements in GDP (see Table 4).

Lastly we find evidence that large lagged changes in the underlying economic indicator are not as useful a predictor as lagged changes in the direction of the economic indicator. For example, only in 15 cases in the United States, 12 cases in the United Kingdom and only in nine cases in France does the addition of this variable to the regression model reduce the residual sum of squares. Comparing the importance of these indicators across the regions, only magnitude changes in one indicator consistently Granger-cause changes in economic growth; that is, lagged changes in the number of new house starts. Additional magnitude changes are important in the different regions, for example in France lagged magnitude changes in consumer confidence, stocks, imports, foreign reserves, unemployment and industrial production all Granger-cause changes in real gross domestic product. Similarly, in the United Kingdom, large changes in the business cycle in the business cycle indicator, personal consumption, imports, the long and short government bond yields, the unemployment rate, personal expenditure and savings, manufacturing industrial production and productivity all Granger-cause change in real gross domestic product with lags of between 1 and 4 quarters.

5. Conclusions

In this paper we examined the causal relationship between so-called leading economic indicators and GDP growth in the United States, the United Kingdom and France from 1970:01–2010:03. Our findings indicate that while many of the indicators do not help to explain current movements in GDP growth, the lags of these indicators Granger-cause changes in gross domestic product. In addition, the direction of the change and the size of the change in the lagged economic indicator are important in many cases. This is particularly true for the variable measuring the number of new house builds. This variable significantly Granger-causes changes in gross domestic product in the United States, the United Kingdom and France. From this analysis, we show that economic indicators are country and time specific. Furthermore, policy makers should be paying more attention to consumer and confidence indicators rather than focusing on traditional monetary and macroeconomic indicators.

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Note

1. Note in some cases the DF and KPSS tests are not in agreement. In these cases we select the result selected by the KPSS test as Kwiatkowski *et al*. (1992) argue that Dickey–Fuller tests fail to reject a unit root because they have low power against relevant alternatives.

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