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TURNING POINTS IN THE INTERNATIONAL BUSINESS CYCLE: AN ANALYSIS OF THE OECD LEADING INDICATORS FOR THE G-7 COUNTRIES

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INTRODUCTION

The OECD routinely maintains a system of business cycle indicators pertaining to 22 of its Member countries (Nilsson, 1987). This system, which is in the line of analysis established by Burns and Mitchell (1986), comprises both a "coincident" or "reference" series which represents the cycle itself and in addition a leading indicator series. Timely recognition of the impending arrival of a business cycle turning point is of obvious value to policymakers. This paper provides an evaluation of the usefulness of the OECD's leading indicator series in making such predictions [1]. Specifically the paper provides an assessment of the OECD indicator system for the G-7 countries from the early 1960s. Since the value of a leading indicator series depends on the method used to extract information from it, the paper employs a method based on a sequential probability approach which has proven useful in several recent applications.

The paper contains five sections. The characteristics of the reference cycle chronology constructed for the G-7 countries by the OECD are described in the first section. In the second section, we describe the framework for treating turning point prediction as a problem of pattern recognition and the sequential probability model which is used to extract information contained in the leading indicators in order to predict turning points in the reference cycle. The results of applying this model to the leading indicators for the United States, Japan and Germany are presented in the third section (the remaining G-7 countries are covered in Annex 4). In the fourth section, in view of its particular interest, we focus on the performance of the method in predicting the recent troughs of the G-7 countries. An international comparison of the performance in predicting turning points for the G-7 countries is provided in the final section. The main text is completed by a summary of the main results and conclusions.

There are four annexes. In Annex 1 we graph the movements of the leading indicators together with the reference series for all the G-7 countries. A comparison of the OECD chronology and an alternative chronology is presented in Annex 2. Technical details of the sequential probability method are given in Annex 3. Turning point predictions for Canada, France, the United Kingdom and Italy are graphed in Annex 4.

THE OECD CHRONOLOGY

The reference chronology for the OECD indicator system is based upon cyclical movements in the monthly index of industrial production for each country over the period 1961:1 to 1994:2. The chronology itself abstracts from long-run movements in the economy and, in this respect, may be considered to represent expansionary and contractionary phases of the growth cycle for each country -- that is, fluctuations in the level of economic activity around its long-run trend. Thus, a contractionary phase of the reference cycle does not necessarily indicate an absolute fall in the level of economic activity but rather coincides with a reduction in the growth rate below its long-run value [2].

The OECD extracts cyclical movements in reference and leading indicator series from the underlying series through a series of adjustments. For the reference cycle, which is based on the index of industrial production, the adjustments simply involve an elimination of the trend through an application of a modified Phase-Average-Trend estimation procedure to the series [3]. The composite leading indicator index is constructed from several component series. Each of these series is smoothed in line with the month of cyclical dominance and normalised so as to standardise the amplitude of cyclical variation. Then the composite is produced as a simple average. Although the OECD system does not impose a standard set of component series for all countries, certain types of series recur regularly in the list of leading indicators for different countries. The most frequently used are series based on business surveys, together with monetary and financial data. The specific procedures used to establish the chronologies and the components used by the OECD are described in Nilsson (1987).

The most recent OECD chronology of the reference cycle for the G-7 countries is reproduced in Table 1; those turning points identified by the OECD as “minor” cycles are indicated there in unbolded. The movements in the growth cycle and the composite leading indicator together with the OECD chronology are graphed in Figures A1 to A7 in Annex 1 [4]. Table 2 sets out information on the duration (in months) of the cycles identified, whilst Table 3 provides a summary of the turning point information. Over the whole period covered (1961:1 to 1994:2), 103 turning points are identified for the G-7 countries, 24 of which mark minor cycles. A higher number of turning points is identified for the United States, Canada and Japan than for the European countries, though the balance is somewhat more even when the minor cycles are excluded. The chronology identifies cycles which exhibit a degree of asymmetry between phases: the average duration of the upturn phase is longer than that of the downturn phase in every country. The United States, for example, has an upturn duration, on average, of nearly 25 months compared with an average duration of only 17 months for the downturn. But there is considerable variance both over time and as between countries, Italy's 78-month upturn from trough 8 (T8) to peak 10 (P10), contrasting, for example, with the 5-month upturn experienced between T1 and P2 in the United States. However, the variance of downturn duration does appear to be somewhat less than that of the upturn in nearly every country.

Table 1. The chronologies and classifications of the G-7 reference cycles [1, 2]

Peak/Trough	United States	Canada	Japan	Germany	France	United Kingdom	Italy
P1 /T1	61M12/**62M12**	62M7/**63M8**	**62M1/62M12**	**61M3/63M2**	**-/63M3**	**-/63M1**	-/-
P2 /T2	63M5/64M10	-/-	**64M2/66M2**	**65M1/-**	**64M1**/65M1	**65M5/-**	**63M9/65M3**
P3 /T3	**66M10/67M7**	**65M12/68M2**	67M11/68M9	**-/67M5**	66M7/**67M10**	**-/67M8**	-/-
P4 /T4	**69M3/70M11**	**69M3/70M10**	**70M6/71M12**	**70M5/71M12**	**68M11/71M5**	**69M6/72M2**	**69M1/73M1**
P5 /T5	**73M10/75M3**	**74M 1/75M5**	**74M1/75M3**	**73M8/75M7**	**74M8/75M5**	**73M6/75M8**	**74M6/75M9**
P6 /T6	-/-	-/-	77M1/77M10	-/-	76M9/77M12	-/-	77M1/77M11
P7 /T7	**79M3**/80M7	**79M8**/80M6	**80M2/-**	**79M12/-**	**79M7/-**	**79M6/81M5**	**80M3*/-**
P8 /T8	81M7/**82M12**	81M4/**82M10**	**-/82M10**	**-/82M11**	-/-	-/-	**-/83M6**
P9 /T9	**84M7/86M6**	85M11/86M11	**84M10/87M5**	85M11/87M1	**-/85M1**	**84M1/84M8**	-/-
P10/T10	**89M3/91M4**	**88M5/92M7**	**90M10/-**	**91M6/-**	**90M7/-**	**89M4/92M5**	**89M12/93M11**

1. The chronologies and classifications of the G-7 reference cycles are supplied by OECD; unemboldened dates indicate "minor" cycle turning points.
2. "-" indicates no turning points.

Table 2. Duration of Downturn/Upturn Phase [1, 2]

months

	United States		Canada		Japan		Germany		France		United Kingdom		Italy	
Peak/Trough	Up	Down	Up	Down	Up	Down	Up	Down	Up	Down	Up	Down	Up	Down
P1 /T 1	-	12	-	13	-	11	-	23	-	-	-	-	-	-
P2 /T2	5	17	-	-	14	24	23	-	10	12	28	-	-	18
P3 M	24	9	28	26	21	10	-	28	18	15	-	27	-	-
P4 /T4	20	20	13	19	21	18	36	19	13	30	22	32	46	48
P5 /75	35	17	39	16	25	14	20	23	39	9	16	26	17	15
P6 /T6	-	-	-	-	22	9	-	-	16	15	-	-	16	10
P7 /T7	48	16	51	10	28	-	53	-	19	-	46	23	28	-
P8 /T8	12	17	10	18	-	32	-	35	-	-	-	-	-	39
P9 /T9	19	23	37	12	24	31	36	14	-	-66	32	7	-	-
P10/T10	33	25	18	50	41	-	53	-	66	-	56	37	78	47
Average Duration	24.5	17.3	28.0	20.5	24.5	18.6	36.8	23.7	25.9	24.5	33.3	25.3	37.0	29.5

1. "-" denotes the corresponding phase is not available (see notes in Table 1).
2. The durations are organised according to their end-point.

Table 3. Number of turning points in the G-7 countries (1961 : 1-1994 : 2)

	United States	Canada	Japan	Germany	France	United Kingdom	Italy	Total
All turning points	18	16	17	13	14	13	12	103
Minor turning points	5	5	4	2	4	2	2	24
Turning points excluding "minor" ones	13	11	13	11	10	11	10	81

METHODOLOGY

In this section we describe briefly the framework for treating turning point prediction as a problem of pattern recognition. More detailed information is given in Artis *et al*. (1994). Details of the sequential probability model proposed by Neftci (1982) are presented in Annex 3.

At the most intuitive level, what is involved is a procedure for quickly recognising the onset of a turning point in the leading indicator series; by definition this can be assumed to lead the corresponding turning point in the reference series. More formally expressed, we begin by assuming that there are two time series, Y_t and X_t, where Y_t denotes the composite leading indicator and X_t the reference series respectively. The pattern of movements in X_t comprises a downturn regime and an upturn regime. A turning point occurs when the regime shifts. Treating Y_t as the leading indicator implies that we anticipate the patterns in Y_t to be similar to those in X_t, but that these movements will occur with some lead in real time. The information contained in Y_t can therefore be used to predict the turning points in X_t. It is clear that there are two potential sources of delay in predicting turning points in the reference series: the delay in recognising that a turning point in the leading series has been reached (the "recognition lag"); and too small a lead time between turning points of the leading and the reference series ("signal lead time"). The two sources of delay involve a trade-off. Attempting to increase the signal lead time by reducing the recognition lag always runs the risk of issuing "false signals". This risk can be reduced by exploiting the cumulative information provided as observations come in to provide an indicator that builds in intensity, rather than simply flashing "on" or "off". With a variable-intensity indicator such as is provided by our use of the Neftci method, the user must ascertain at what value of the indicator he or she should determine that a turning point "call" be issued.

The quality of performance in turning point prediction may be considered to be related to three main factors which are familiar from the pattern recognition literature (see, for example, Fu, 1970). The first is referred to as *the separation problem*. This involves both the question of whether the regimes which are mixed in the whole population of Y_t can be clearly separated, together with the practical consideration of how such separation should be implemented. Following separation, we need to classify each new observation, Y_t, to the regime to which it best belongs. This is referred to as the *classification problem*. Finally, *a decision rule* is required which will indicate the circumstances under which a regime shift for Y_t may be said to occur. This decision rule provides the basis for issuing the signal of a corresponding turning point prediction for X_t [5].

In the current paper we base our predictor model on a *separation* of the leading indicator observations into two regimes, an upturn and a downturn. As our implementation of this model is a "real time" simulation, a learning process is assumed and the first cycle in the data is used as a training sample for initially separating the observations [6]. The sample is updated as each subsequent cycle is completed. In order to define these regimes in the leading indicator we apply a rule-based method to identify the turning points: ideally, this method should be consistent with the methods used by OECD to identify the cycle in the reference series, as the results presented in Annex 2 suggest that it is [7]. It is implicit that the learning process we are assuming is "under supervision", in that it is assumed both that the separation of the regimes would become known as each regime ends and that the distribution of observations within each regime is normal (see Fu, 1970, for a more general discussion).

By comparing the two normal probability densities, $f(Y_t \mid Y_t \in D)$ and $f(Y_t \mid Y_t \in U)$, *classification* for each new observation Y_t may be implemented, where U and D denote the upturn and downturn population available up to time t-1. The classification rule now involves associating Y_t with the downturn regime if $f(Y_t \mid Y_t \in D) \geq f(Y_t \mid Y_t \in U)$; and with the upturn regime if $f(Y_t \mid Y_t \in D) < f(Y_t \mid Y_t \in U)$. Accordingly, the population of the downturn or upturn regimes is updated at time t to classify the next observation.

A sequential probability model (SPM) due to Neftci (1982) is used as a *decision rule* to calculate the probability of a turning point. This procedure calculates the probability by using information about movements in the leading indicator series available at each point in time, together with the previous period's posterior probability. An immediate benefit of this particular dynamic characteristic is that the Neftci method provides an indication of the strength of signal relating to the prospective movements in the leading indicator series which is unavailable from other methods. As described in Niemira (1991), it is this particular dynamic characteristic of the Neftci method which represents an improvement over its predecessors; by providing additional information about the strength of the signal, the method promises to increase the possibility of screening out false signals. The formula for the SPM and explanations of its components are presented in Annex 3.

One of the key elements in predicting the turning point is the assumption that is made about the lifetime of the regime in the reference series. The issue is whether the upturn and downturn regimes are more likely to end as they become older. This can be expressed formally in terms of the conditional probability (“hazard”) with which a regime will end at time t, given that it has survived up to time t. If the hazard is increasing (decreasing) within a regime, there is said to be positive (negative) duration dependence in that regime. If the hazard function is constant, then there is said to be duration independence.

In a non-parametric investigation of duration dependence in the business cycle for the United States since 1854, Diebold and Rudebusch (1990) find little evidence of duration dependence in the complete sample of expansions and contractions considered separately, but do report some indication of duration dependence in pre-war expansions. McCulloch (1975) demonstrates that once a downturn in a business cycle has passed its historical minimum duration, the probability of a turning point is independent of duration. Meanwhile, Niemira (1991) assumes a constant hazard in his multi-country study of the growth cycle. In the current paper we follow Niemira in the assumption that the hazard of a regime shift is independent of the age of the regime [8].

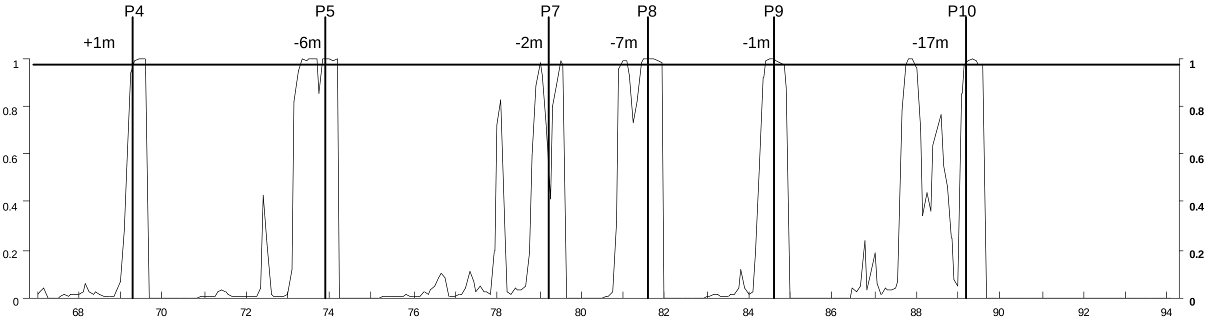
TURNING POINT PREDICTION FOR THE UNITED STATES, JAPAN AND GERMANY

In this section we discuss the turning point predictions only for the “G-3” - the United States, Japan and Germany; the results for the rest of the G-7 are presented without further discussion in Annex 4. The applications of the sequential probability model to the composite leading indicators for the United States, Japan and Germany are summarised in Figures 1 to 3. In each case we differentiate between peak and trough prediction; peak predictions are shown in the upper portion of the diagram, trough predictions in the lower. The sequential probability of a turning point in the leading indicator series is represented by the solid line running from left to right in each figure. The date of the i^{th} turning point in the reference cycle is denoted by a vertical line in the diagrams labelled P(i) or T(i). Lead times, calculated when a probability first crosses the 0.95 threshold are also shown in the diagrams; lead time (“-” denotes lead and “+” denotes lag), here represents the interval between the signal being issued and the subsequent appearance of a turning point in the reference cycle. In the figures the signal for a turning point is truncated six months after the reference date for that turning point.

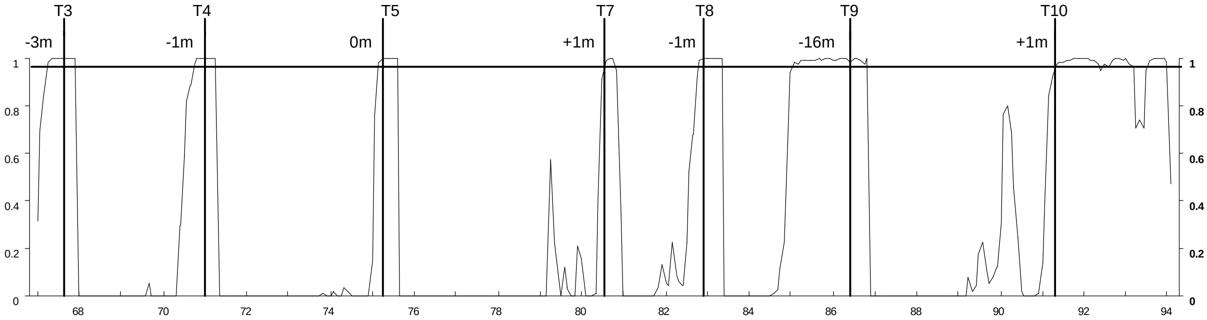
Inspection of Figures 1 to 3 reveals that a characteristic feature of the sequential probability model is the tendency for the signal to increase rapidly in advance of a turning point in the reference series [9]. Of course, neither a rapid rise in the probability nor a signal crossing a probability threshold, is sufficient to guarantee that a turning point will actually occur in the reference series and evidence of apparent false signals or of missing signals may also be found in the diagrams. In the current analysis, a false signal is declared if a turning point in the reference series does not occur within 24 months after issuing the turning point in the leading indicator; a missing signal is declared if there is no signal in the leading indicator within a range of from -24 months to +3 months of a turning point in the reference series [10].

Figure 1. **Sequential Probabilities Prediction for the US Turning Points**

Peak Prediction



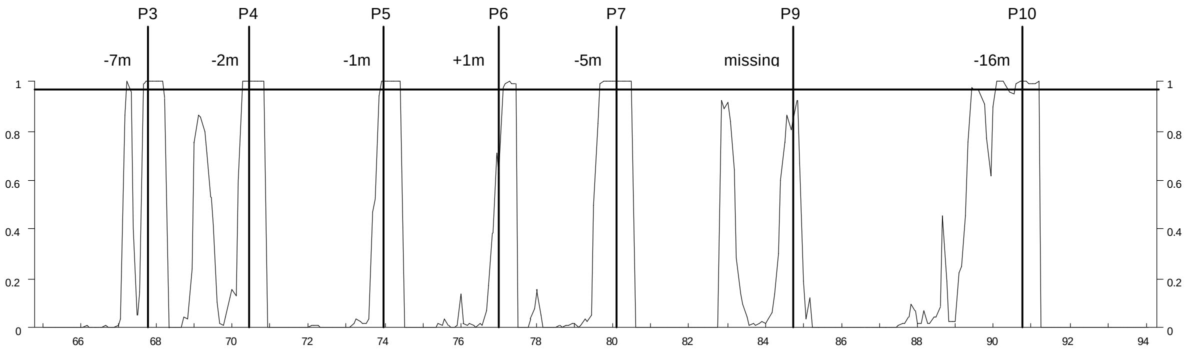
Trough Prediction



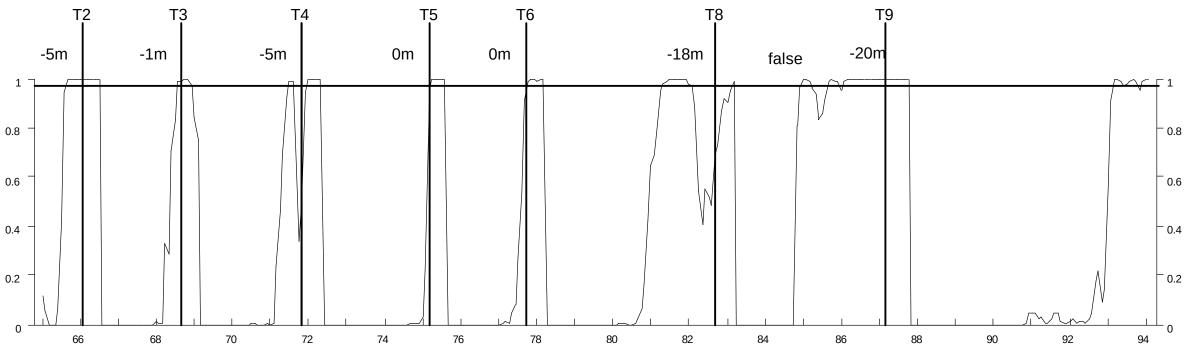
1. '-' denotes leads, '+' denotes lags.
2. Signal issued when the probabilities first cross the 95% threshold.

Figure 2. **Sequential Probability Prediction for the Japanese Turning Points**

Peak Prediction

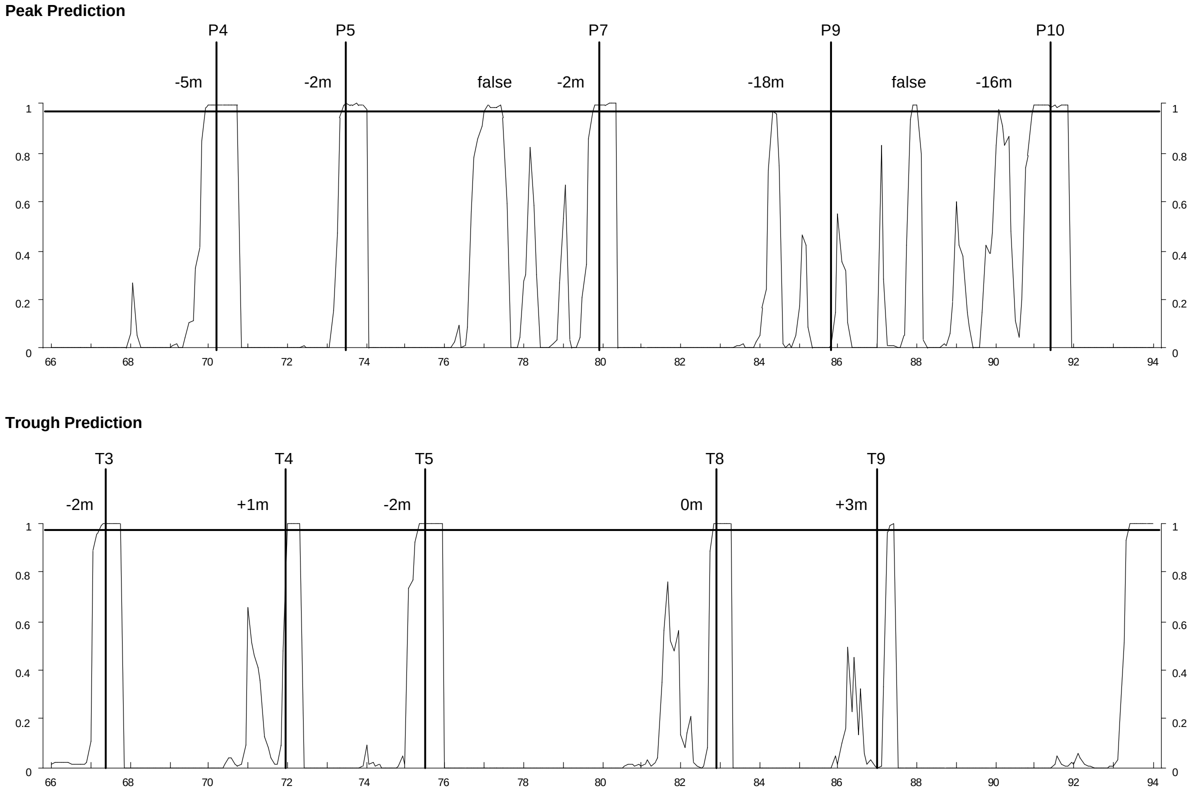


Trough Prediction



1. '-' denotes leads, '+' denotes lags.
2. Signal issued when the probabilities first cross the 95 per cent threshold.

Figure 3. **Sequential Probability Prediction for the German Turning Points**



1. "-" denotes leads, "+" denotes lags.
2. Signal issued when the probabilities first cross the 95 per cent threshold.

Turning Point Prediction for the United States

Allowing for availability of the leading indicator data and for the "training sample", the United States experienced a total of thirteen turning points over the complete prediction period. The principal features of turning point prediction for the United States may be summarised as follows:

The lead time of turning point prediction lies within a range from -7 months to +1 month with the exception of the two most recent turning points, the lead times of which are considerably longer: -17 months at P10 and -16 months at T9. For the total 13 turning points, there is no false signal nor any missing signal for any turning point including the "minor" turning points. Of the 13 signals issued for turning point predictions, 9 may be considered as early recognitions of the turning point and 3, being issued only one month after the turning point, could be considered as offering timely recognition. The average lead is -5.3 months for the peaks and -2.7 months for the troughs.

Turning Point Prediction for Japan

There are fourteen turning points over the prediction period in the Japanese economy. The performance of turning point prediction for Japan may be summarised as follows:

The lead time of turning point prediction is quite stable during the 1960s and 1970s. However, the lead time becomes much longer subsequently. The average lead time for predicting T8, T9 and P10 is -18 months, while the average lead time for the previous 10 turning points, from T2 to P7, is only -2.5 months. For the total 14 turning points, there is one missing and one false signal. For P9, although there is an early signal call, the probability of the signal does not reach the 0.95 threshold and therefore is treated as a missing signal. Predicting trough T9 is more complicated. The earliest signal issued comes -30 months before trough T9, then dropping below the 0.95 threshold and again crossing the 0.95 level at the lead time -20 months. On the rules adopted here the earliest signal may be regarded as a false one and the later one as genuine.

Overall, among the 14 turning points to be predicted there are 13 which may be regarded as having been signalled early or as having offered timely recognition, although the variation in lead time is considerable.

Turning Point Prediction for Germany

As mentioned before, there are noticeable differences between the European growth cycle and the cycle in the United States, Canada and Japan. Where there are 13 turning points in Germany over the full period of this study, there are 18 turning points in the United States and 17 in Japan. Figures A1 to A7 in Annex 1 also show that there is a less clear-cut difference between upturn and downturn regimes in the European growth cycle, particularly late in the period. Indeed, our study confirms that it is much more difficult to predict the European turning points than to predict the turning points in the United States, Canada and Japan. The performance of turning point prediction for Germany is described in Figure 3 and may be summarised as follows:

Allowing for the training sample, there are 10 turning points to be predicted; the average lead time is -8.6 months for the peaks and zero for the troughs. The variability in lead time is low for the troughs, but is considerable for the peaks. The signals are often not well sustained, the most notable instances being at P7, P9 and P10, for which the leading indicator "flashes" in advance either very briefly (for P9) or very often (for P7 and P10). The problem is that it is quite difficult to distinguish the genuine signals from the false ones after a sequence of false signals.

Overall, the performance of the predictor model in Germany seems quite poor on any criteria. The poor performance in predicting German turning points does not necessarily imply inadequacy in the method used. As explained in Niemira (1991), if a particular composite leading indicator does not seem to work well in calling turning points, this may be due to any one of three factors: *a)* the leading indicator was not properly constructed; *b)* the chronology used to compare the turning point signals is not a proper representation of the aggregate trend-adjusted cycle; *c)* the growth recession and recovery environments are not sufficiently differentiated from one another.

To summarise, the performance of the leading indicator in the United States and Japan is very satisfactory, especially when compared with the relatively poor performance of the leading indicators in the European countries (as described above for Germany and is apparent from the graphs in Annex 4 for the other European Countries). A number of factors may be adduced in explanation of this phenomenon. First, there is a well-known difference in the post-Second World War history of the American and European countries in that the latter economies were, for some time, driven by technological "catch up" and recovery. Classical business cycles, common for the United States, are less apparent in Europe in this period. Then, the economic size of the United States is much larger than that of the European countries and large economies can be expected to be more diversified and less volatile. The study by Gerlach (1988) shows that industrial production in the smaller, more open, economies is more variable and more open economies may be subject to more economic disturbances of extraneous origin. Industrial production is used as the reference series in the current study and volatility in this series will certainly reduce the prediction power of the leading indicator series. Finally, a further explanation could be that the method of constructing the composite leading indicator series and the selection of different components, mainly developed by NBER for the US economy, may not serve best for the European countries.

PREDICTION OF THE RECENT TROUGHS FOR THE G-7

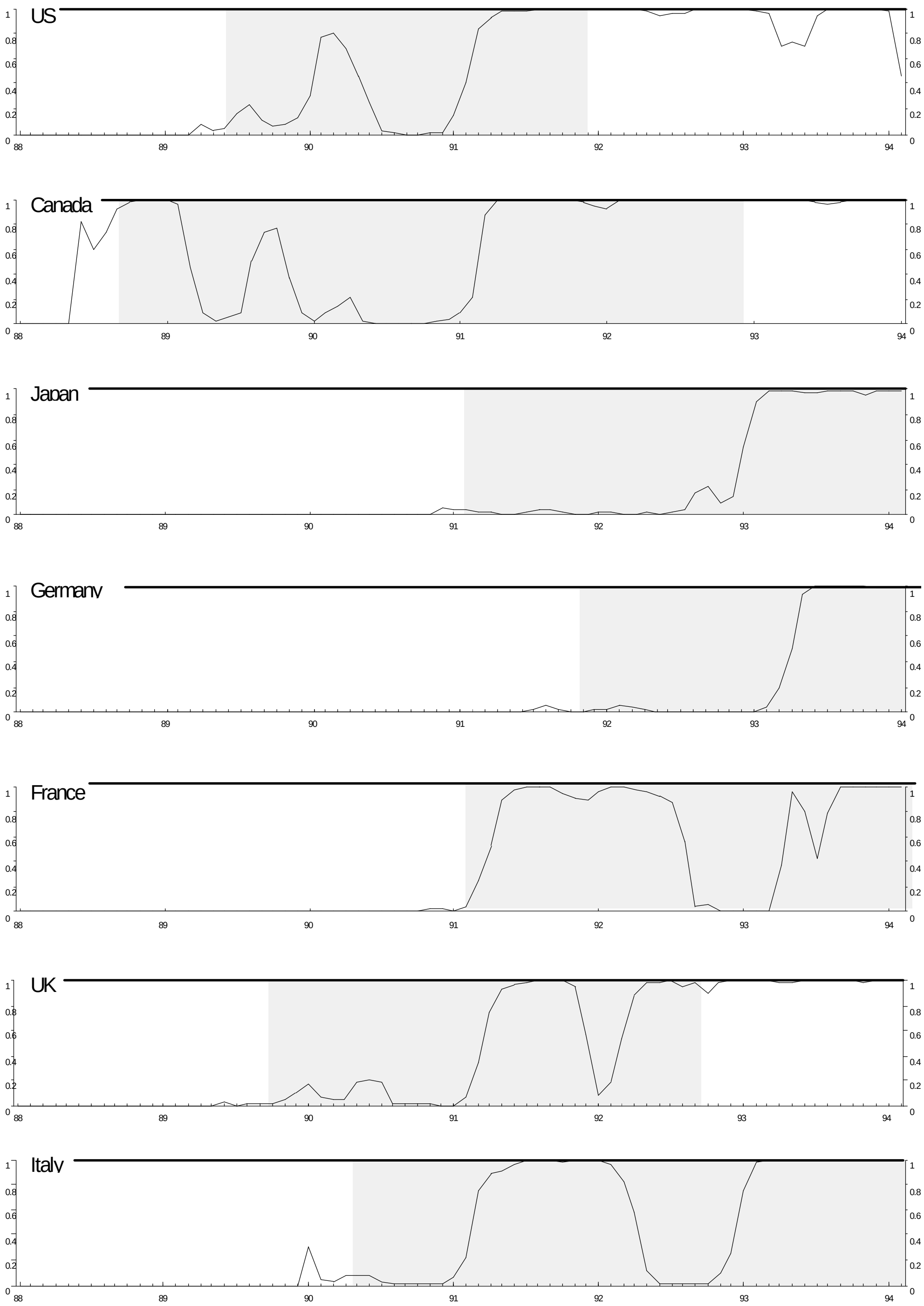
In view of the critical policy interest of the latest cycle we devote this section to an examination of the performance of the leading indicators in predicting the most recent troughs in the G-7 economies. Figure 4 provides a graphical evaluation of these predictions. The dates of the latest turning points, together with the dates at which the trough signals (again, using a sequential probability score of 0.95 as the trigger) would have been issued, are presented in Table 4.

It is of interest to note that the trough signals for the United States, Canada, the United Kingdom, France and Italy emerged almost simultaneously in the second quarter of 1991. It proved later that the United States economy reached the trough one month earlier than the signal, and that the Canadian economy bottomed out 15 months later, whilst the United Kingdom economy turned the corner 11 months later. The signals for France and Italy proved to be premature and therefore are treated as false signals [11]. Although these signals were quite sustained and lasted more than one year, they eventually disappeared in the second and third quarter of 1992. The second simultaneous trough calls appeared in February to June 1993 and they were for Germany, France, Italy and Japan, one of which, the Italian trough in November 1993, was identified by the OECD. The rest either remain to be confirmed or have not yet been associated with a particular date.

In predicting the current troughs for the G-7, it is clear that the international growth cycle is in phase within, but not across, certain groups of countries. The current cycle in the United States, Canada and the United Kingdom are in phase and those in Germany, France and Italy form another group, while the current Japanese cycle is in phase with the European countries rather than with the United States cycle. This also shows that the growth cycle was not synchronous between the groups. The phase in the current United States cycle and the cycle in the European countries was shifted by almost one regime [12].

An evaluation of the quality of the predictive performance of the indicators through the latest recession is difficult. On the one hand, all four troughs identified by OECD in our data set were offered early or timely recognition by the indicators and, if we assume that the recessions in France, Germany and Japan are over by now, their troughs also will have been recognised in advance by the system. But the warnings offered by the indicator system do not come with a precise time horizon against them and the principal qualification, and for some a decisive negative point, is that the lead time of the warnings issued in the latest recession was in many cases quite long. For two out of the four troughs so far identified, for example, the lead time afforded was over a year. Whilst there seems to be obvious technical merit in this, the position of those announcing the turn may be rendered incredible by too long a lead time. As time passes without the turn appearing, the credibility of the announcement wanes. Moreover, in this latest recession, there will in fact have been three instances of a "false dawn", where the signal for a recovery has flashed quite clearly, only to fade again before being followed by a another signal for recovery closer to the actual turn. It may be difficult enough to sustain credibility in the context of a warning that turns out in fact to be far-sighted -- although in this instance those making the announcement could reap large gains by sticking to their guns -- it must become nearly impossible to do so when evidence comes in that false warnings have been advertised.

Figure 4. **Sequential Probability Prediction for the Latest Trough**



Note: Shaded areas are the latest downturns.
Source: OECD.

Table 4. **Prediction of the latest troughs**

	US	Canada	Japan	Germany	France	UK	Italy
Latest identified peak	89:3	88:5	90:10	91:6	90:7	89:4	89:12
Trough called at:		88:10					
	91:5	91:4			91:6	91:6	91:6
			93:3	93:6	93:5		93:2
Latest identified trough	91:4	92:7	--	--	--	92:5	93:11

AN EVALUATION

An evaluation of sequential probability predictions for the G-7 countries is given in Table 5: this employs the definitions of false signals and missing signals given in the previous section. Although we do not penalise signals for turning points as being "premature" provided the lead time does not exceed two years, general considerations pertaining to the credibility of a signal suggest that signals which are so early that they might possibly be regarded as premature should be separately distinguished. Thus, in Table 5 we also report as "early signals" those which might fall in this category, signals issued between the range of -24 months and -13 months in advance of a turning point in the reference series. False and missing signals are two distinct types of error and it is possible to reduce one type of error at the expense of increasing the frequency of another. Since it is not clear which type of error is the more damaging, the two types of error are treated equally in this paper. In the last row of the table, the error rate denotes the ratio of the number of errors over the total number of peaks (troughs) to be called.

Comparing across countries, it is apparent that a clear line can be drawn between the European and non-European members of G-7, regardless of whether "early" signals are treated as false ones or not [13]. Error rates in the United States, Canada and Japan are the lowest among the G-7, while that in Italy is the lowest within the European countries. In the United States, no errors are found in calling 13 turning points, while 2 errors are found in calling 5 peaks in Germany, France and the United Kingdom respectively. The standard deviation of the lead time for peaks in Germany, France and the United Kingdom is the largest among the G-7. A similar result -- that the Neftci probabilities worked best for the United States and worst for the United Kingdom -- was also observed by Niemira (1991). Although the standard deviation of lead time in trough prediction in Germany is quite small, the lead time itself is zero. (Although this may still be treated as providing timely recognition of the turning point compared with that provided by conventional statistical information, Germany's zero lead time contrasts with leads of 3-7 months in other G-7 countries).

Comparing the performance of predictions across peaks and troughs, it is apparent that performance in predicting peak and trough in the United States, Canada and Japan is quite similar in terms of lead time and its standard deviation. In the European countries, the performance of trough prediction is better than that of peak prediction. The peaks since 1980 in Germany, France and the United Kingdom prove to be equally difficult to predict. The graphical evidence (Figure 4-1 to 4-4 in Annex 4) is particularly clear. For P7, P9 and P10 in Germany, P7 and P10 in France and P7, P9 and P10 in the United Kingdom, the predictions feature either a sequence of false calls, very early signals or complete misses. It is clear that the performance of peak prediction in the European countries has deteriorated since 1980. During this period, the four European countries all experienced their longest upturns although this was not the experience of the United States, Canada or Japan. Separation between regimes in the period since 1980 became less clear than in the earlier period and this may have reduced the power of prediction in the leading indicator series.

Table 5. Turning point prediction for the G-7[1, 2]

	United States		Canada		Japan		Germany		France		United Kingdom		Italy	
Peak/Trough	Peak	Trough	Peak	Trough	Peak	Trough	Peak	Trough	Peak	Trough	Peak	Trough	Peak	Trough
P2 /T2	n.d.	n.d.	. .	. .	n.d.	-5	n.d.	. .	n.d.	n.d.	n.d.	. .	n.d.	n.d.
P3 /T3	n.d.	+3	n.d.	-9	-7	-1	. .	-2	n.d.	-1	. .	-5	. .	. .
P4 /T4	+1	+1	+2	0	-2	-5	-5	+1	+2	-3	-3	-14	n.d.	-15
P5 /T5	-6	0	-8	-2	-1	0	-2	-288	-15	-1	-4	-4	-7	-6
P6 /T6	. .	. .	. .	. .	+1	0	. .	. .	-1	+1	. .	. .	0	-2
P7 /T7	+2	+1	-5	+2	-5	. .	-2	. .	m	. .	-14	-3	-4	. .
P8 /T8	+7	-1	+2	-1	. .	-18	. .	0	. .	. .	. .	. .	. .	-4
P9 /T9	+1	-16	-17	-4	m	-20	-18	+3	. .	-23	m	m	. .	. .
P10 /T10	+17	+1	-6	-15	-16	. .	-16	. .	-16	. .	-17	-11	-10	-9
Average leads	+5.3	-2.7	-5.3	-4.1	-5.0	-7.0	-8.6	0	-7.5	-5.4	-9.5	-7.4	-5.3	-7.2
Sta. deviation	6.5	6.0	7.1	5.9	6.1	8.5	7.8	2.1	9.3	9.9	7.1	4.8	4.3	5.1
Early signal	1	1	1	1	1	2	2	0	2	1	2	1	0	1
Missing signal	0	0	0	0	1	0	0	0	1	0	1	1	0	0
False signal	0	0	1	1	0	1	2	0	1	0	1	0	0	1
Total number of turning points	6	7	6	7	7	7	5	5	5	5	5	6	4	5
Error rate	0	0	.17	.14	.14	.14	.40	0	.40	.20	.40	.17	0	.20

1. "-" denotes leads; "+" denotes lags; "m" denotes missing signal.
2. ". ." indicates no turning points to be predicted.

CONCLUSIONS

This paper has examined the performance of the sequential probability method in predicting turning points in the growth cycles of industrial production in the G-7 countries over the period from 1966 to 1994. Unlike conventional business cycles, the growth cycle is expressed in terms of the pattern of fluctuation in deviations of economic activity from trend. Contractions in the growth cycle for the individual countries therefore mark a period of output below trend but not necessarily an absolute fall in economic activity. Summarising the broad results of the paper we find that:

Growth cycle frequency within the sample varies across countries, with a maximum of eight complete cycles being observed for Japan while only five are observed for Italy. More cycles are apparent in this period in the United States, Canada and Japan than in the European countries.

Cycle duration varies similarly. The range, however, is considerable. The minimum duration is 5 months in the US upturn phase, while the four longest upturn durations, all located in the upturn of the mid-late 1980s, were experienced by Germany, the United Kingdom, France and Italy. The longest is 78 months. Asymmetry in terms of duration between the upturn and downturn phases is observed for almost all of the G-7 countries. The variability of duration of the downturn phase is less than that of the upturn phase.

A characteristic feature of the sequential probability method is the tendency for the signal to increase rapidly in advance of a turning point in the industrial production. On average, the recognition lag in the leading indicator series is 4 months and is relatively stable both across countries and between peaks and troughs. The variance of the signal lead time is much greater in both respects.

The paper also confirms that there is an "international business cycle" in the sense that the growth cycle is in phase at least within groups of the countries perhaps reflecting interdependence through trade. Turning point signals emerge almost simultaneously for several countries. This suggests that the quality of prediction for any particular country could well be improved by taking account of the experience of other countries.

A key feature of the results relating to turning point prediction is the apparent difference between the European and non-European G-7 members. The performance of the method proves to be most satisfactory in the case of the United States, Canada and Japan, with few false or missing signals. In contrast, relatively poor performance is associated with Germany, France, the United Kingdom and Italy. This phenomenon may be explained by one or more of the factors adduced by Niemira (1991) viz., that if a particular composite leading indicator does not seem to work well in calling turning points, this is due to: *a)* bad construction of the leading indicator; *b)* a poor fit of the chronology used to compare the turning point signals to the aggregate trend-adjusted cycle; *c)* insufficient difference between the recession and the recovery phases of the cycle.

Further explanations for the different performance of the method as between the European and non-European G-7 countries could be that: *a)* the economic size of the United States (and Japan) is greater than that of the European countries and large economies are expected to be more diversified and less volatile; *b*) industrial production in the smaller, more open, economies is more variable; *c)* the method of constructing the composite leading indicator series and the selection of different components, mainly developed by NBER, which may be suitable for the US economy, may not serve best for the European countries.

Constructing composite leading indicators itself is a learning process by which the statistical properties and economic behaviour of the components may be better understood and new series may replace the old ones, so that over time the quality of prediction may be improved. The results and methods adopted in the paper may be used as clues to search for improvements.

NOTES

1. Papers by Diebold and Rudebusch (1991) and Bladen-Hovell and Zhang (1994) explore ways of integrating leading indicator information in more general forecasting models.

2. In business-cycle jargon, the "growth" cycle needs to be distinguished from the "classical" business cycle. Whilst the latter is defined in terms of absolute declines and increases in economic activity, the former is defined relative to trend.

3. This procedure is described by Boschan and Ebank (1978); Bry and Boschan (1971) describe the program for turning point selection.

4. The method we use in this paper for making predictions of the cycle requires us to establish a turning point chronology for the leading indicator series also. The rule-based method we use to do this is described in Annex 2, where it is applied to produce an alternative chronology of the reference cycle. There is a close agreement between this alternative chronology and the OECD's dating. Thus the latter can be closely approximated by the consistent application of a set of mechanical rules.

5. The three consecutive decline (3CD) rule proposed by Vaccara and Zarnowitz (1977) is a simple, but frequently used decision rule for detecting a turning point. According to this rule, a signal for a peak at time t would be issued if $Y_t < Y_{t-1} < Y_{t-2} < Y_{t-3}$; whilst a signal for a trough would be issued when searching for a trough if $Y_t > Y_{t-1} > Y_{t-2} > Y_{t-3}$. The 3CD rule ignores other information in the data, such as the age of the regime and, despite its popularity and simplicity, is prone to issue false signals.

6. Our simulation is "real time" in the sense that any prediction attributed to time t is based only on information available up to time t. However, the *ex post* information in the current study for the leading indicator series and the chronology is based on the latest available data.

7. Annex 2 applies the rule-based method to data on the reference cycle and establishes that there is a high degree of agreement between the methods used by OECD to identify the cycle and those embodied in our set of rules.

8. More precisely, the hazard function may be defined as $\lambda_{(t)} = F'_{(t)}/S_{(t)}$, where $F_{(t)}$ and $S_{(t)}$ respectively represent the distribution function and the survivor function. Our assumption of independence is reflected in the use of the exponential as the distribution function, $F_{(t)} = 1 - \exp(-\Gamma_t)$, with corresponding hazard Γ. The parameter Γ is calculated separately for the upturn and downturn regimes and the estimate is updated as more regimes in the reference series become available.

9. On average, the recognition lag, which represents the time needed to recognise a turning point in the leading indicator series is 4 months.

10. These definitions for false and missing signals are arbitrary and quite relaxed. Tougher rules for judging the performance of a leading indicator series are set by Hymans (1973) and Silver (1991).

11. Some may argue that sterling's departure from the ERM allowed the United Kingdom economy to recover much earlier than the French and German economies; but Italy's simultaneous departure had no comparable effect on Italy's recovery. It is worth noting also that the United Kingdom economy came into recession much earlier than any of the other ERM countries: that is, 8, 15 and 26 months earlier than the Italian, French and German economies respectively. Recovering in May 1992, the United Kingdom economy had already suffered its longest recession since the second World War (see Table 2). Other research we have undertaken into international business cycle linkages also shows that the United Kingdom growth cycle is in phase more often with the US cycle rather than with the German cycle. Continuation of this differential linkage is consistent with the United Kingdom's current recession ending earlier than the European countries'.

12. The de-linking of the British from the German cycle surely helps explain the pressure for a de-linking of monetary policies which led to the departure of sterling from the ERM.

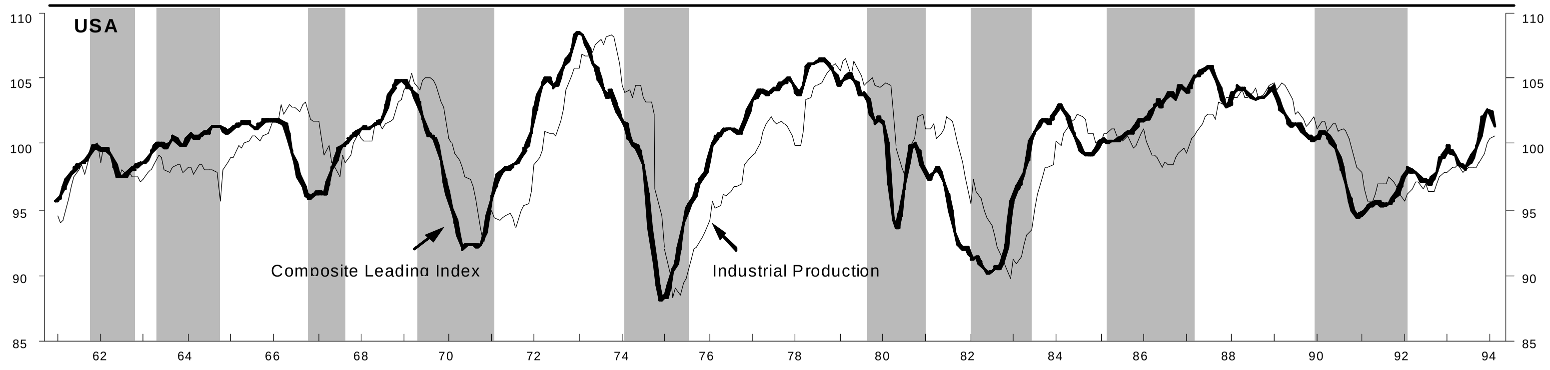
13. Taking account of the number of "early signals" and the total number of turning points to be predicted across the G-7 in Table 5, it is apparent that the performance of turning point prediction in the European countries worsens compared with the non-European members of the G-7, if the "early signals" are treated as false signals.

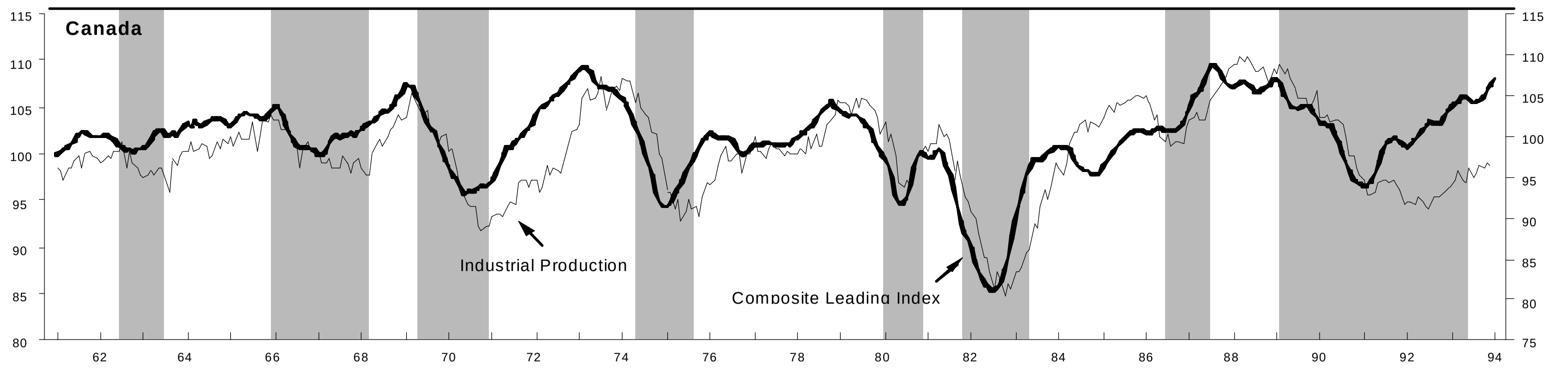
ANNEX 1

Movements In The Composite Leading Index
And Industrial Production

Annex 1 **Movements in the composite leading index and industrial production**

Figures A1/A2



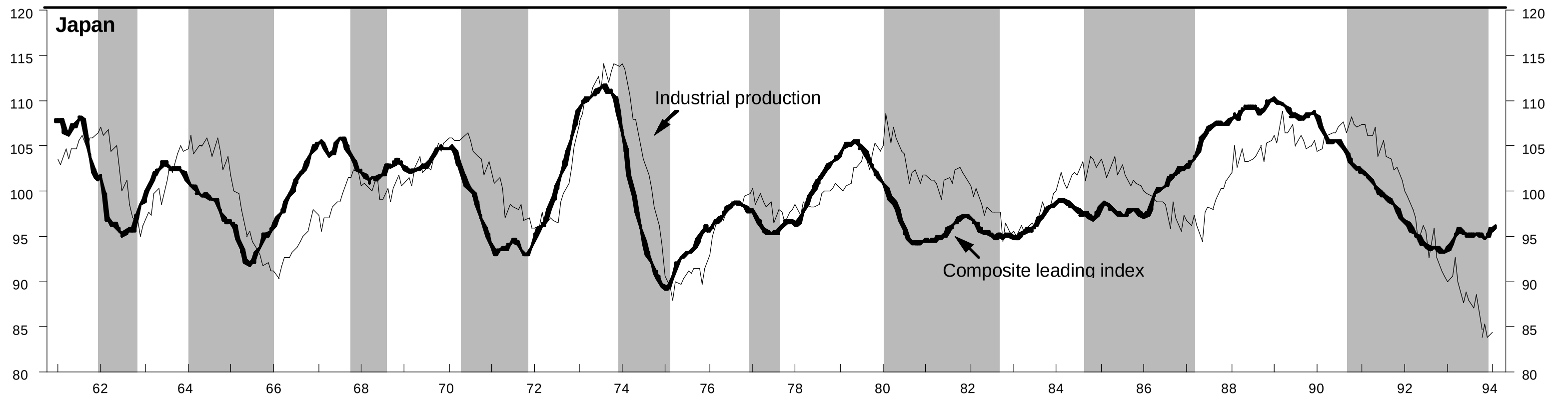


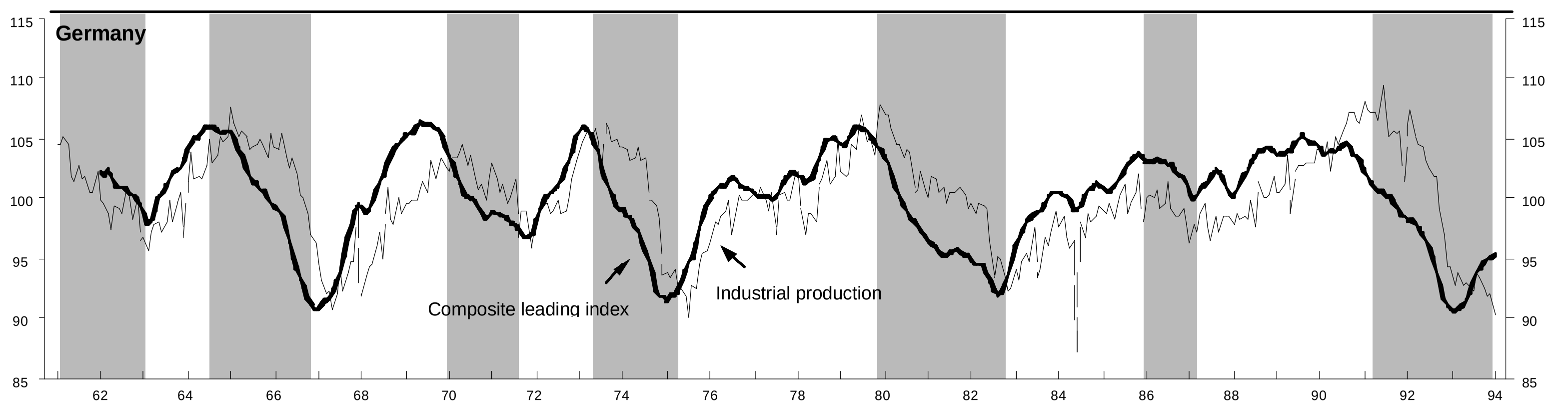
Note: Shaded area is the downturn of industrial

Source: OECD.

Annex 1. (con't) **Movements in the composite leading index and industrial production**

Figures A3/A4

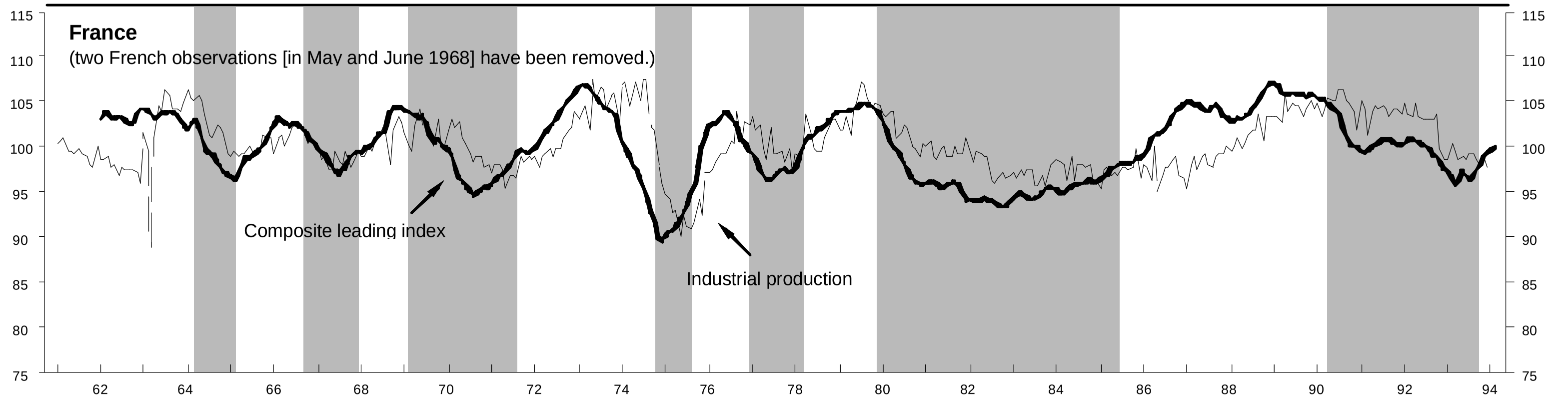


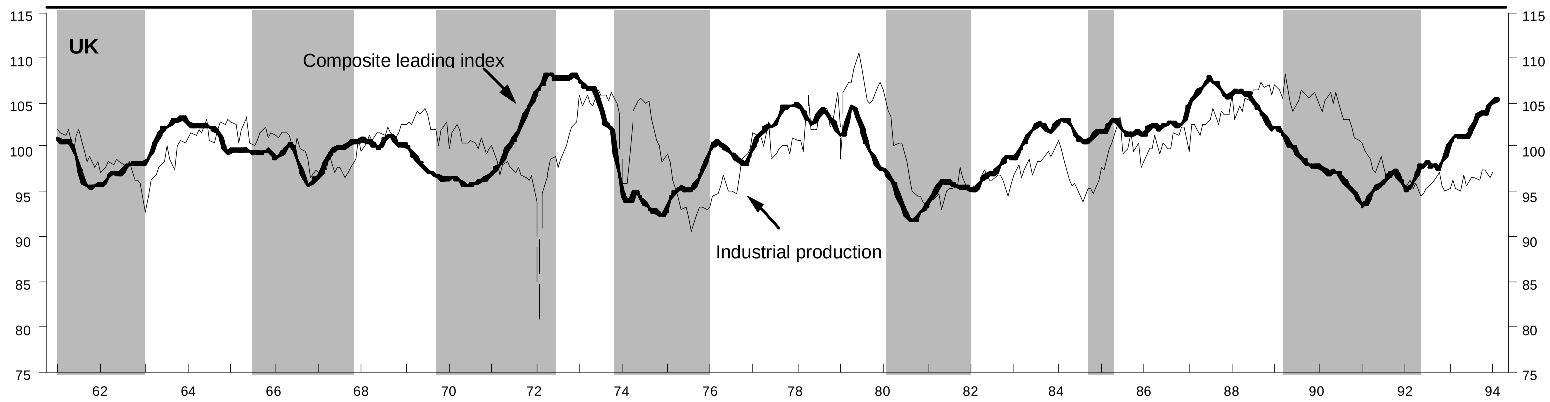


Note: Shaded area is the downturn of industrial production.
Source: OECD.

Annex 1.(con't) **Movements in the composite leading index and industrial production**

Figures A5/A6

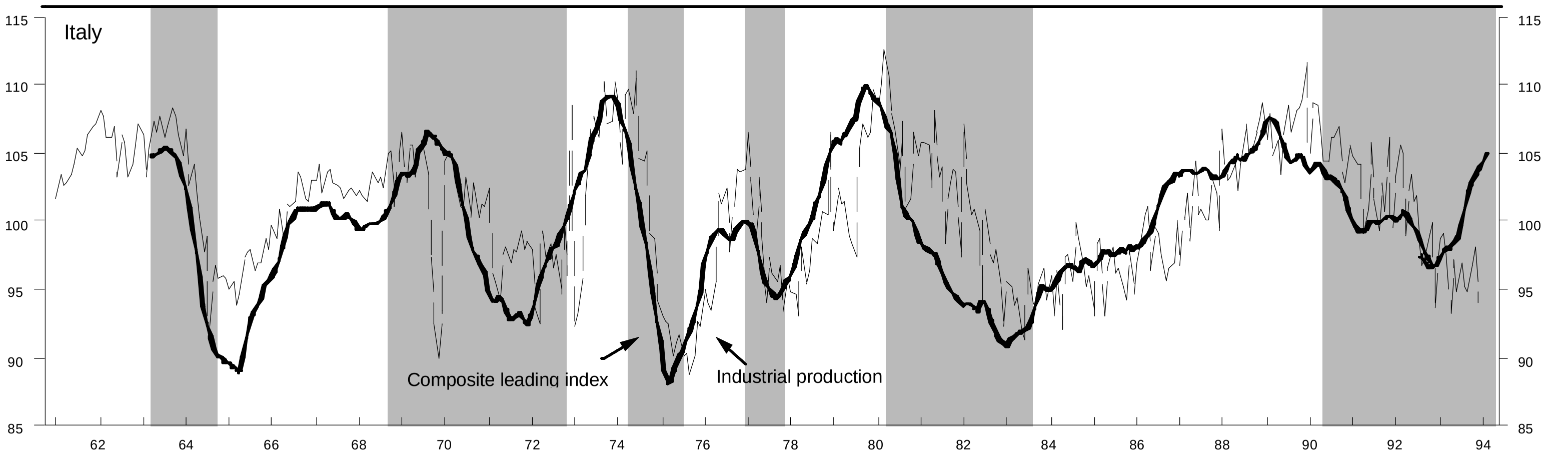




Note: Shaded area is the downturn of industrial production.
Source: OECD.

Annex 1.(con't) **Movements in the composite leading index and industrial production**

Figure A7



Note: Shaded area is the downturn of industrial

Source: OECD.

ANNEX 2

A Comparison Of The OECD Chronology And The Alt Chronology

In order to implement the sequential probability method for turning prediction, as explained in the text, it is essential to establish a chronology for the leading indicator series. To do this we employed a rule-based method which, for convenience, we refer to as ALT. It is desirable that the ALT method would be consistent with that employed to date the reference series cycle itself. To establish how consistent these methods are, a comparison of the OECD and the ALT chronology was carried out. Below, we first set out the ALT rules and then present the results of the comparison. The ALT procedure searches for turning points on the basis of the following five rules:

- Peak and trough follow one another in succession.
- The minimum length required between any two consecutive turning points (a phase) is 9 months[1].
- The minimum length required for any two alternate turning points (a cycle of peak to peak or trough to trough) is 24 months[2].
- The turning point is located at the extreme value in the intervening phases. If more than one extreme value is found in one phase, the latest observation is chosen as the turning point.
- An observation which coincides with a known non-economic event (strike, natural disaster, etc. [3]) or an outlier[4, 5] will be ignored for the purpose of dating analysis unless the turning point subsequently defined is located immediately adjacent to that observation.

The chronology produced by the application of these rules is compared with the OECD chronology in Table A1. The ALT dating procedure reproduces almost identically the OECD turning point dates for four countries (the United States, Japan, Germany and the United Kingdom) with the exception of a few minor cycle turning points. The ALT procedure identifies 94 turning points for the G-7 countries in the period from January 1960 to December 1993, compared with 103 OECD turning points. The ALT dating procedure omits eight OECD minor turning points (four for the United States, two for Canada and two for the United Kingdom) and one further trough (Italian trough in November 1993). Although the ALT procedure does not identify any additional turning point, there are 13 ALT dates which are different from the OECD dates. Given the volatility in the reference series and the different rules used in the two dating procedures we consider that the two chronologies are reasonably close.

Table A1. A comparison of the OECD Chronology with the ALT [1, 2]

	United States		Canada		Japan		Germany	
Peak/Trough	OCDE	ALT.	OCDE	ALT.	OCDE	ALT.	OCDE	Other.
P1 /T1	<u>61M12</u>/62M12	61M12/62M12	<u>62M7</u>/63M8	62M7/63M8	62M1/62M12	62M1/62M12	61M3/63M2	61M3/63M2
P2 /T2	<u>63M5/64M10</u>	-/-	-/-	-/-	64M2/66M2	64M2/66M2	65M1/-	65M1/-
P3 /T3	66M10/67M7	65M12/68M2	65M12/68M2	65M12/68M2	<u>67M11/68M9</u>	67M11/68M9	-/67M5	-/67M5
P4 /T4	69M3/70M11	69M3/70M11	69M3/70M10	69M3/70M10	70M6/71M-12	70M6/71M12	70M5/71M12	70M5/71M12
P5 /T5	73M10/75M3	73M10/75M3	74M1/75M5	**73M7**/75M5	74M1/75M3	74M1/75M3	73M8/75M7	73M8/75M7
P6 /T6	-/-	-/-	-/-	-/-	<u>77M1/77M10</u>	77M1/77M10	-/-	-/-
P7 /T7	79M3/<u>80M7</u>	79M3/-	79M8/<u>80M6</u>	**79M7/-**	80M2/-	80M2/-	79M12/-	79M12/-
P8 /T8	<u>81M7</u>/82M12	-/82M12	<u>81M4</u>/82M10	-/82M10	-/82M10	-/82M10	-/82M11	-/82M11
P9 /T9	84M7/86M6	84M7/86M6	<u>85M11/86M11</u>	85M11/**86M8**	84M10/87M5	84M10/87M5	<u>85M11/87M1</u>	85M11/87M1
P10/T10	89M3/91M4	89M3/**91M3**	88M5/92M7	88M5/92M7	90M10/-	**89M3/-**	91M6/-	91M6/-

	France		United Kingdom		Italy	
Peak/Trough	OCDE	ALT	OCDE	ALT	OCDE	ALT
P1 /T1	-/63M3	-/63M3	-/63M1	-/63M1	-/-	-/-
P2 /T2	64M1/<u>65M1</u>	64M1/**65M8**	65M5/-	65M5/-	63M9/65M3	63M9/**64M8**
P3 /T3	<u>66M7</u>/67M10	**66M7**/67M4	-/67M8	-/67M8	-/-	-/-
P4 /T4	68M11/71M5	**69M5**/71M5	69M6/72M2	69M6/72M2	69M1/73M1	69M1/72M3
P5 /T5	74M8/75M5	**74M7**/75M5	73M6/75M8	73M6/75M8	74M6/75M9	74M6/75M9
P6 /T6	<u>76M9/77M12</u>	76M9/77M12	-/-	-/-	<u>77M1/77M11</u>	77M1/78M3
P7 /T7	79M7/-	79M7/-	79M6/81M5	79M6/81M5	80M3/-	80M3/-
P8 /T8	-/-	-/-	-/-	-/-	-/83M6	-/83M6
P9 /T9	-/85M1	**-/86M5**	<u>84M1/84M8</u>	-/-	-/-	-/-
P10/T10	90M7/-	90M7/-	89M4/92M5	89M4/92M5	89M12/93M11	89M12/-

1. The underlined dates are defined as "minor turning" points by OECD.
2. The bold figures are ALT dates which are different from the OECD dates.

NOTES

1. Only 2 out of 96 phases defined by OECD fail to pass this rule. The durations of these two phases are 5 and 7 months, respectively (see Table 2).

2. Only two cycles in the OECD chronology fail to pass this rule, one US cycle (T1 to T2) and one Canadian cycle (P7 to P8), the durations of which are 22 and 20 months, respectively (see Table 2).

3. In practice, six observations are found to coincide with known noneconomic events. They are two French observations in May and June 1968 ("les événements") and four Italian ones from September to December 1969 (four-month-long strike). No turning point is found to be located immediately adjacent to these observations.

4. An outlier, Y_t, is declared if $| \Delta \log Y_t | \geq 3.0$ x s.d. and $| \Delta \log Y_{t+1} | \geq 3.0$ x s.d. where s.d. denotes the standard deviation.

5. Non-economic events and outliers are not mutually exclusive and, in fact, most non-economic events may easily be detected by applying the outlier test.

ANNEX 3

The Sequential Probability Method

The sequential probability method proposed by Neftci (1982) may be considered a variant of the standard Bayesian forecasting method. In Neftci's model, the probability of a turning point is calculated sequentially using current information, Y_t, together with the previously estimated posterior probability. The decision rule determining when a regime shift has come about may be associated with this method by appending a critical threshold value for the sequential probability. Crossing this threshold then provides the basis for the signal to "flash". The posterior probability for a peak may be calculated as:

$$P_t = \frac{[\,P_{t-1} + (1-P_{t-1})\,\Gamma^u_{t-1}\,]\,f(\,Y_t \mid Y_t \in D_{t-1}\,)}{[\,P_{t-1} + (1-P_{t-1})\,\Gamma^u_{t-1}\,]\,f(\,Y_t \mid Y_t \in D_{t-1}\,) + (1-P_{t-1})\,(1-\Gamma^u_{t-1})\,f(\,Y_t \mid Y_t \in U_{t-1}\,)}$$

where $f(Y_t \mid Y_t \in D_{t-1})$ and $f(Y_t \mid Y_t \in U_{t-1})$ denote the conditional probability densities of the latest observation Y_t coming from either a downturn regime, D, or an upturn regime, U, and Γ^u_t denotes the probability of a peak at time t conditional upon a peak having not already occurred. For trough prediction we simply need to exchange $f(Y_t \mid Y_t \in D)$ for $f(Y_t \mid Y_t \in U)$ and replace Γ^u_t by Γ^d_t, the probability of a trough at time t conditional upon a trough having not already occurred. The critical threshold underlying the decision-rule involved in calling a turning point is a value 0.95 for this probability.[1]

As described in the text, the turning point prediction may be applied as follows:

1. *Separation*: The leading indicator series may be separated into two regimes by using the method described in Annex 2. Since the whole historical series of leading indicator values is not available when starting real time prediction, the first cycle is treated as a training sample to be separated into two regimes, U and D, and observations belonging to the two regimes are assumed to be normally distributed.

1 The probability needs to be reset once it reaches a value of unity. To effect this, we follow Diebold and Rudebusch (1989) in the current study and adopt a convention which places an upper limit of 0.95 on the lagged value of the posterior probability in the above question.

2. *Classification*: By calculating the two normal probability densities, $f(Y_t \mid Y_t \in D_{t-1})$ and $f(Y_t \mid Y_t \in U_{t-1})$, for each new observation Y_t, the values of probability densities in the Neftci formula can be obtained. At the same time, the classification may be also implemented, with each new observation being associated with a particular regime on the basis of a maximum likelihood method. The population of the upturn or downturn regimes is updated for the next observation.

3. *A priori*: The probability density mentioned above is the information contained in the leading indicator series. The further information needed in the Neftci formula is *a priori* about the lifetime of the current regime in the reference series. This is expressed as a conditional probability (hazard) in the Neftci formula (see note 8 for the technical details). Although we assume that the hazard is constant, the probability of a turning point is cumulated in the formula when a regime becomes older.

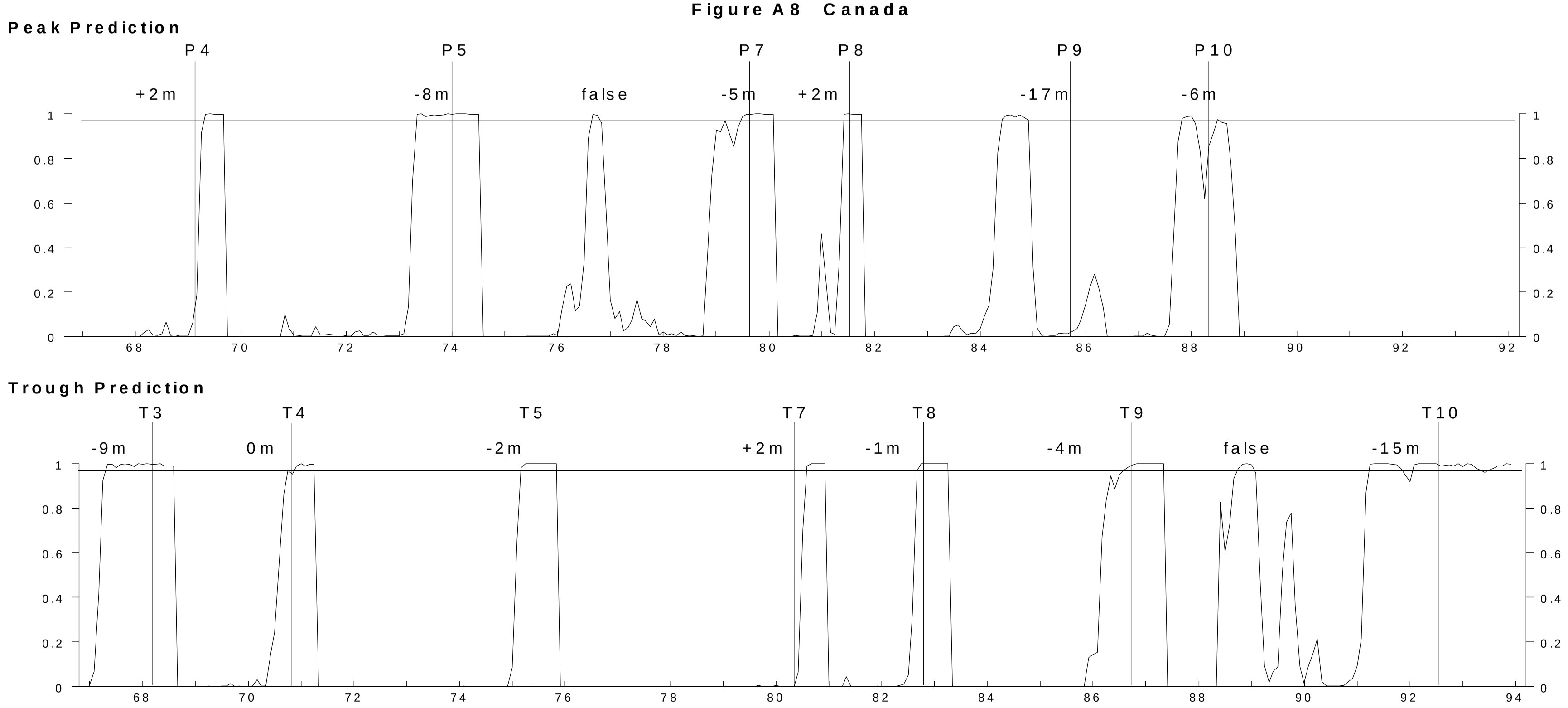
4. *Decision rule*: The Neftci formula used as a decision rule to calculate the probability of a turning point may be applied since we have already calculated all its components. The value of P_t is set to zero when starting the prediction and a signal for a turning point will be issued when the cumulative probability P crosses a threshold, say 95 per cent. The probability P is reset to zero when searching for the next turning point.

ANNEX 4

Sequential Probability Prediction For Canada, France, The United Kingdom And Italy

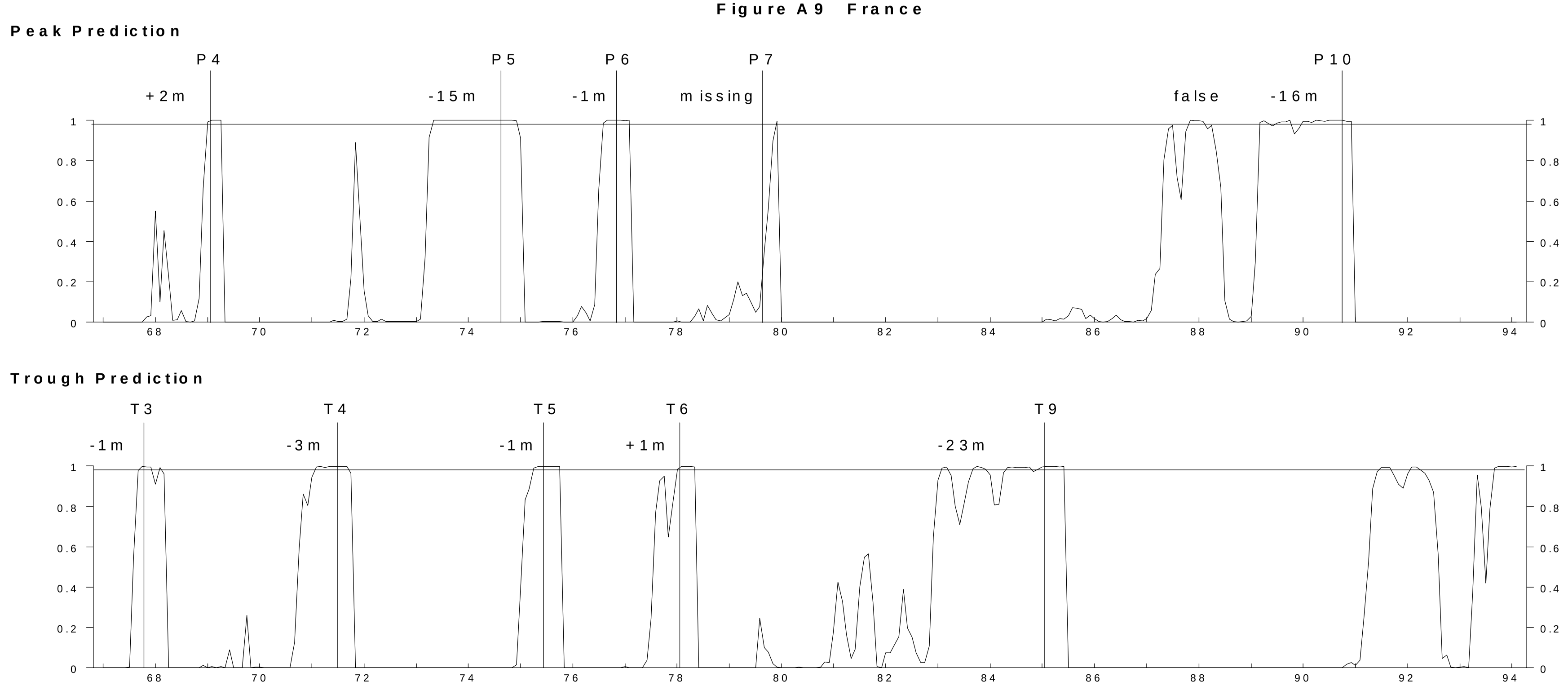
Annex 4 Sequential Probability Prediction for Canada, France, the UK and Italy

Figure A8 Canada



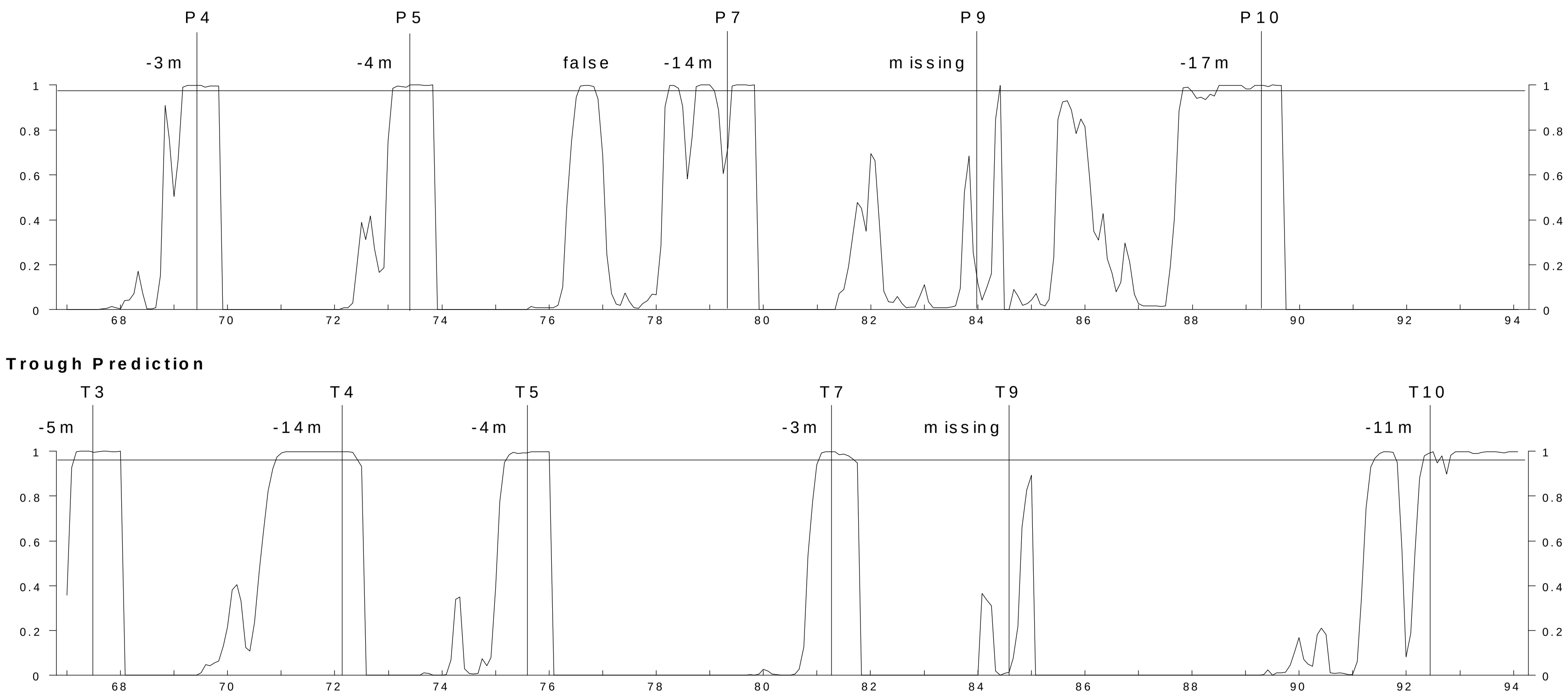
1. "-" denotes leads, "+" denotes lags.
2. Signal issued when the probabilities first cross the 95 per cent threshold.

Figure A9 France



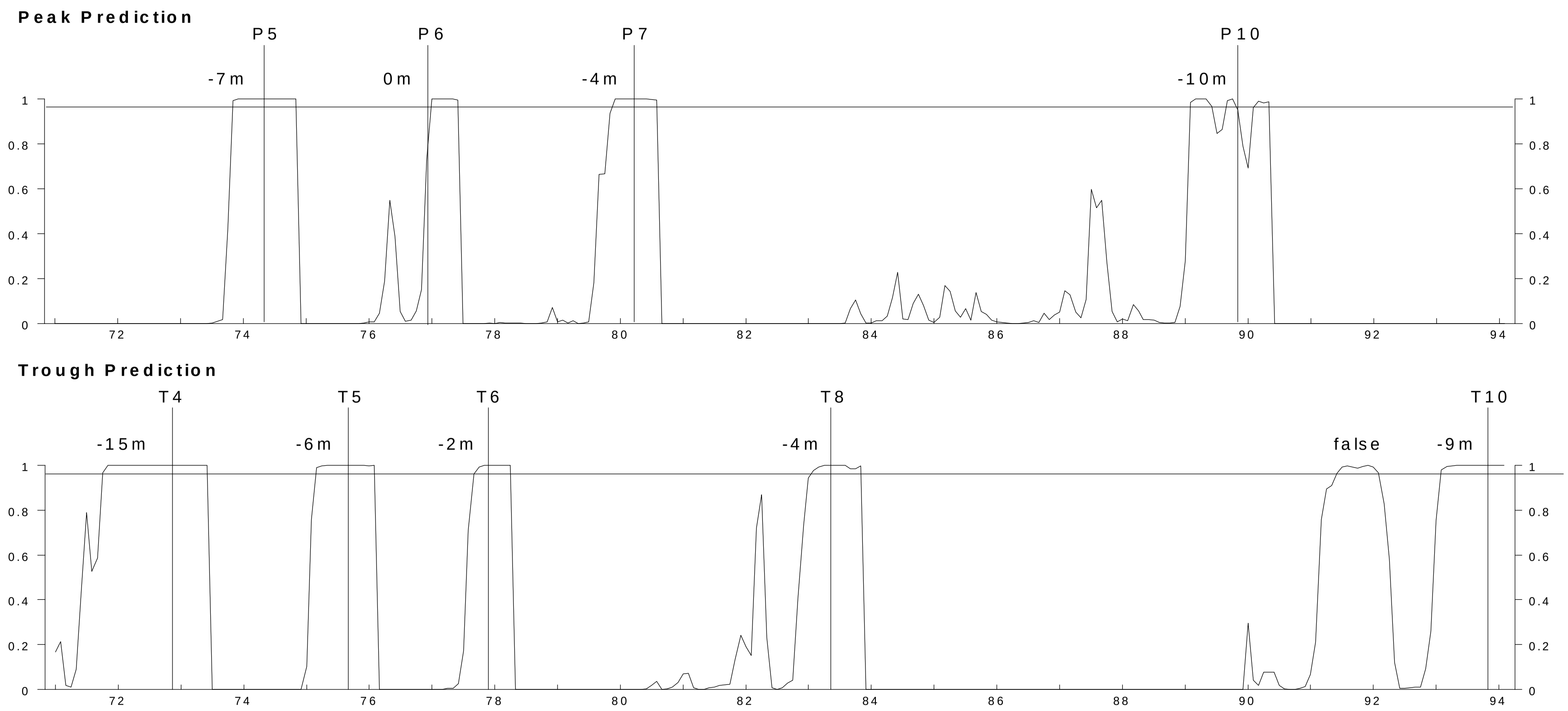
1. "-" denotes leads, "+" denotes lags.
2. Signal issued when the probabilities first cross the 95 per cent threshold.

Figure A10 UK



1. "-" denotes leads, "+" denotes lags.
2. Signal issued when the probabilities first cross the 95 per cent threshold.

Figure A11 Italy



1. "-" denotes leads, "+" denotes lags.
2. Signal issued when the probabilities first cross the 95 per cent threshold.

BIBLIOGRAPHY

ARTIS, M.J., R.C. BLADEN-HOVELL, D.R. OSBORN, G. SMITH and W. ZHANG (1994), "Turning point prediction for the UK using CSO leading indicators", *Oxford Economic Papers* (forthcoming).

BLADEN-HOVELL, R.C. and W. ZHANG (1994), "Evaluating the performance of leading indicators for predicting economic activity in a BVAR framework for the G-7 countries", Economic Discussion Paper No. 101, University of Manchester.

BOSCHAN, C. and W.W. EBANKS (1978) "The phase-average trend: a new way of measuring growth", In *Proceedings of the Business and Economic Statistics Section*, Washington D.C.: American Statistical Association.

BRY, G. and C. BOSCHAN (1971), *Cyclical Analysis of Time Series: Selected Procedures and Computer Programs*, New York: Columbia University Press.

BURNS, A.F. and W.C. MITCHELL (1946), *Measuring Business Cycles*, NBER Studies in Business Cycles No.2, New York: Columbia University Press.

DIEBOLD, F.X. and G.D. RUDEBUSCH (1989), "Scoring the leading indicators", *Journal of Business*, Vol. 98, Vol. 62, pp. 369-391.

DIEBOLD, F.X. and G.D. RUDEBUSCH (1990), "A nonparametric investigation of duration dependence in the American business cycle", Journal *of Political Economy*, Vol. 98, No. 3, pp. 596-616.

DIEBOLD, F.X. and G.D. RUDEBUSCH (1991), "Forecasting output with the composite leading index: a real time analysis", *Journal of the American Statistical Association*, Vol. 86, pp. 369-391.

FU, K.S. (1970), "Statistical pattern recognition", in J.M. Mendel and K.S. Fu (eds.), *Adaptive, Learning and Pattern Recognition Systems*, New York: Academic Press.

GERLACH, H.M.S. (1988), "World business cycles under fixed and flexible exchange rates", *Journal of Money, Credit, and Banking*, Vol. 20, No. 4, pp. 621-632.

HYMANS S.H. (1973), “On the use of leading indicators to predict cyclical turning points”, *Brookings paper on Economic Activity,* 2, pp. 330-375.

MCCULLOCH, J.H. (1975), “The Monte-Carlo cycle in business activity”, *Economic Inquiry*, Vol. 13, No. 3, pp. 303-321.

NEFTCI, S. (1982), “Optimal prediction of cyclical downturns”, *Journal of Economic Dynamics and Control*, Vol. 4, August, pp. 225-241.

NIEMIRA, M.P. (1991), “International application of Neftci's probability approach”, in K. Lahiri and G.D. Moore (eds), *Leading Economic Indicators: New Approaches and Forecasting Records*, Cambridge University Press.

NILSSON, R. (1987), “OECD leading indicators”, *OECD Economic Studies*, No. 9, Autumn, 1987, OECD, Paris, pp. 105-146.

SILVER, S.J. (1991), “Forecasting peaks and troughs in the business cycle”, in K.Lahiri and G.D.Moore (eds), Leading *Economic Indicators: New Approaches and Forecasting Records*, Cambridge University Press.

VACCARA, B.N. and V. ZARNOWITZ (1977), “How good are the leading indicators?”, Proceedings of the Business and Economic Statistics Section, American Statistical Association, pp. 41-50.