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## Short Term Macro Monitoring: Leading Indicator Construction - Mexico

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**Short Term Macro Monitoring:  
Leading Indicator Construction - Mexico**

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## **Abstract**

This project constructs a composite-leading indicator (CLI) to forecast economic activity/business cycles in Mexico. This cycle is the result of deviations of the economy from its long-term trend. Here, a contractionary phase means a decline in the rate of growth of the economy, and not necessarily an absolute decline in economic activity.

For this analysis it is necessary to select an indicator of economic activity (usually the Index of Industrial Production, IIP), as well as a group of variables that, when filtered/adjusted construct the CLI that forecasts the reference series. Selection of the components of the leading indicator is based on the forecast efficiency of the series and on their economic significance. Once selected, the relevant variables are aggregated into a single CLI that forecasts the detrended IIP. For detrending the series, the Hodrick-Prescott (HP) Filter method is applied. This method is a smoothing technique that decomposes seasonal adjusted series into cyclical and trend components. One of the advantages of the HP Filter is that provides a reasonable estimate of the long-term trend of a series.

## **Introduction: Leading Indicators and Forecasting Economic Activity**

This manual presents a forecasting method to predict growth cycles in economic activity, measured by the total industrial production.<sup>1</sup> The analysis of series that having a leading relationship to the reference series forms the basis of the prediction. These series are aggregated in a single composite-leading indicator (CLI) that predicts the path of the economy. A. Burns and W. Mitchell at the National Bureau of Economic Research developed this technique during the 1930s and 1940s. The composite index presented in the following sections is a variant of the one elaborated by the OECD, Statistics Division.<sup>2</sup> The modifications incorporate statistical techniques that simplify and enhance the estimation process.

To understand the interpretation of this index it is important to identify what is being predicted. The *growth cycle* is understood to be the result of deviations of the

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<sup>1</sup> The forecast variable is referred to as the “reference series.”

<sup>2</sup> The implementation of this technique for Mexico was made by Beziz & Petit (1997).

economy from its long-term trend.<sup>3</sup> Here a contractionary phase means a decline in the rate of growth in the economy and not necessarily an absolute decline in economic activity.<sup>4</sup>

The group of series that form the composite index share a leading relationship with respect to the growth cycle. They are usually selected from a large set of economic variables that include financial, monetary, real sector, and business survey data, taking into account their statistical and economic significance.

The system of leading indicators is widely used by the OECD to predict the growth cycles in the economies of their member countries. These exercises have been very effective in their forecasting ability and accuracy.<sup>5</sup> However, for this technique to work properly it is essential to have an adequate statistical system that provides a large set of economic variables, in a timely and precise manner, preferably on a monthly basis.

### **Description of the main procedures**

The methodology can be outlined as follows:

1. Selection of the reference series to be forecast (IIP).
2. Determination of the cycles on the reference series, after adjustments for seasonal and trend effects.
3. Selection of the components of the CLI. This selection is based on lead/lag tables, cross correlograms and inspection.
4. Estimation of seasonal adjusted versions of the selected series.
5. Detrending the seasonally adjusted component series of the CLI with the Hodrick-Prescott Filter.
6. Smoothing the cyclical components with Months for Cyclical Dominance (MCD) moving averages, and adjusting their average cyclical amplitude by means of standardization.
7. Aggregation of the components into the CLI.

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<sup>3</sup> Strictly speaking it is hard to decompose the trend-cycle component in a time series. Nevertheless, here it is assumed that this decomposition is possible by estimating a long-run trend. See annex on moving average decompositions.

<sup>4</sup> Burns and Mitchell (1946) provide one of the classic definitions of business cycle.

<sup>5</sup> See the exercises reported in OECD (1987) and Beziz & Petit (1997).

8. Comparison of the reference series and the CLI in their detrended version, and if desired, restore trend to the series.

### **Selection of the series**

#### *Reference Series*

The reference variable is the benchmark that indicates fluctuations in the economic activity, and is the variable to be forecast. Usually chosen is the Industrial Production Index, IIP, which has the advantage of being a monthly reported variable, available for many countries, and measures the real sector of the economy. For Mexico this was the variable selected in its seasonally adjusted version.

#### *Composite Indicator Series*

As previously mentioned, the essential feature taken into account for selecting a component of the CLI is that it leads the reference series with a similar cyclical profile. Other salient features are: the consistency of the lead of the indicator over the reference cycle at turning points, the absence of extra or missing cycles, smoothness, freedom from excessive revisions by the authorities, timeliness in delivery from the authorities, and availability of a long run of data of satisfactory reliability with no breaks. Monthly series are preferred.

All series are analyzed using their trend-eliminated version. The analysis proceed by performing a graphical inspection of the cyclical profile of the series, reinforced by a turning point analysis (see Annex 4), with special attention to mean or median leads at turning points. A cross correlogram of the series completes the initial review.

The series analyzed for Mexico come from Bank of Mexico database, INEGI, and the MEI Database via the OECD's OLISnet service. From these databases approximately 100 series were selected for graphical inspection. Many were rejected because of incomplete or insufficient data (less than two years) or cyclical patterns seemingly inconsistent with that of the reference variable (IIP). Twenty variables passed this first filter, among them: measures of employment, finance, interest rates, prices, production and trade. The seasonally adjusted version of these variables was analyzed in greater detail by means of cross-correlations and graphical inspection.

Seven series were selected out of this universe and were tested for inclusion in the CLI. These series:

- Changes in manufacturing employment
- Production. Tendency (business survey)
- Stocks of finished goods. Tendency (business survey)<sup>6</sup>
- Employment. Tendency (business survey)
- Real Effective Exchange Rate
- US long term interest rate<sup>6</sup>
- Cost to banks of managing deposits in national currency (CPP rate)<sup>6</sup>

Although some of the preceding series may not be included in the final index, all exhibit a close cyclical relation with industrial production and were tested for inclusion in the CLI.

### **Detrending the Series: Hodrick-Prescott Filter**

The Hodrick-Prescott Filter is a smoothing technique commonly used to estimate the long-run trend of a series. This technique decomposes seasonally adjusted time series into two components: the trend and the cycle, and provides a smoothed trend as a solution to a minimization problem (see Annex 3).

Given the extensive use of the HP Filter as an estimate, here it is used as a substitute of the Phase Average Trend method, originally applied in this forecasting exercise. Both techniques provide similar estimates, but the HP Filter has the advantage of being included as a built-in command in EViews. The detrending of the reference series and the components of the CLI is done using this filter.

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<sup>6</sup> Use the reciprocal

### **Seasonal adjustment of the series**

Elimination of the seasonal component of the series is done with the X-11 census moving average procedure. This method consists of routines using a ratio-to-moving average decomposition, adjusted for trading day and holiday variations. One of the advantages of this approach (compared with other moving averages that remove seasonality) is that it allows seasonal factors to change from year to year.

### **MCD smoothing of CLI components**

Smoothing the variability of the components of the CLI requires application of a moving average to each component. The procedure used here is the months of cyclical dominance (MCD) moving average. This procedure has the advantage of determining the length of the moving average necessary to control fluctuations in the irregular component of the series, with a minimal loss of values in the beginning/ending of the series (see Annex 1).

MCD is defined as the number of months needed for the average change in the irregular component to become smaller than the average change in the trend component. Changes in the irregular component dominate those in the trend-cycle during the first months. However, as the time span increases, changes in the trend cycle will become larger and dominate those in the irregular component. Once the MCD scalar has been obtained for each series, it will be used as the length of a moving average<sup>7</sup> that removes the irregular component of the series.

### **Normalization and aggregation of the series**

With the MCD smoothed series we construct the CLI. It is necessary to normalize the series prior to aggregation, thus standardizing their amplitude. The normalized series are aggregated into a single leading indicator by a simple averaging process (see Annex 3). In case one of the series presents missing values for some period, no linking factor is used when averaging.<sup>8</sup> This may generate jumps in the composite index, though a closer

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<sup>7</sup> For practical reasons the length of this MA it is usually restrained in between 1 and 6 periods.

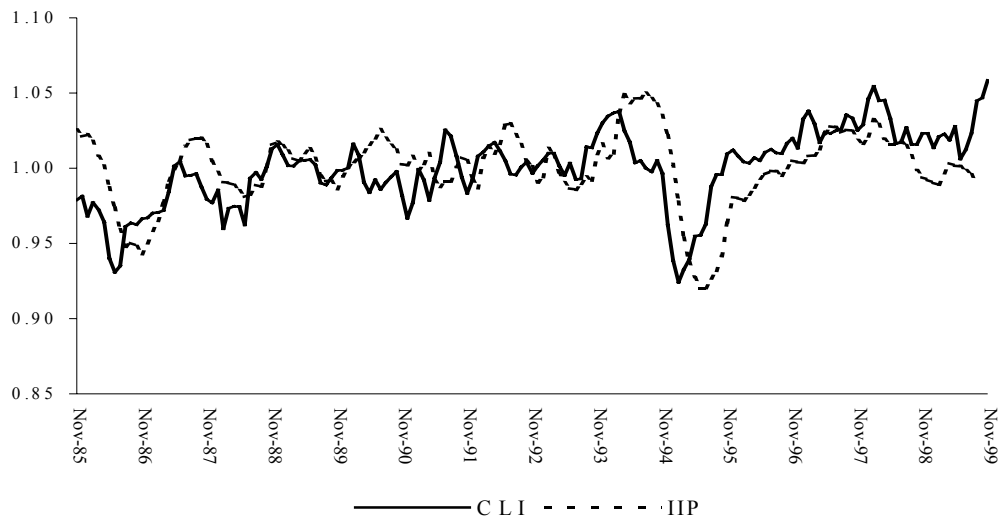
<sup>8</sup> A *linking factor* is used to link an index with incomplete series to the body of the complete index. Its estimation involves applying the growth-rate of the incomplete index to the last point of the full index (see OECD, 1987).

inspection of the simple average shows that there is no significant bias in the final estimation.<sup>9</sup>

### Results for the Mexican case

The seven series selected, for their close relationship with the IIP, can be combined in several ways in the construction of the composite index. In this exercise the CLI is composed of all the variables because of their effectiveness in predicting recent movements in the reference series. It is important to re-evaluate the relevance of these components from time to time, based on their predictive ability. Series (other than the seven previously listed) must be examined to see if they present cyclical patterns that are consistent with the IIP cycle. Figure 1.1 presents the CLI and reference series estimated in November 1999.

**Figure 1.1 Composite Leading Indicator and IIP, 1985:11-1999:11**

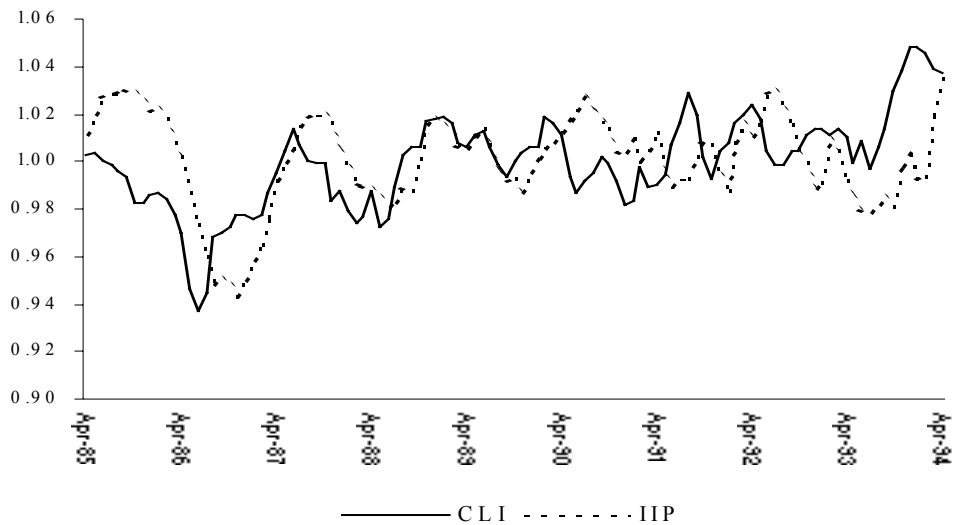


It is interesting to see that the CLI predicted in March 1994 the downturn in industrial production that would take place in August of that year. To see the effectiveness of the CLI in predicting the cycles of the Mexican economy it is useful to make a backcast estimation, where the forecasting ability of the composite index is tested

<sup>9</sup> It must be kept in mind that the introduction of a linking factor may also generate a bias because of the

against cycles that are known to have happened. This exercise is displayed in Figure 1.2. Once again it can be seen that the composite index predicted the 1994 industrial downturn by the beginning of the year.

**Figure 1.2 Composite Leading Indicator and IIP, 1985:04-1994:04**



### **The execution and update of the CLI program**

The main steps involved in the execution and update of the CLI program are sketched below:

**Step 1.** It is necessary to update the monthly database in the Excel file MEXDATA1.XLS. The updating process consists of adding the most recent value of each variable to the file. Some variables, such as the Real Effective Exchange Rate, are subject to revisions and corrections, therefore updating then requires the replacement of the whole series.

After the database is updated, the EViews program *mexprog1.prg* must be run.

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risky assumption that the incomplete series follows the same growth pattern that the rest of the series.

**Step 2.** It is necessary to specify the period in the program. To do so, the first line of the program must be modified:

```
WORKFILE a:\MEXCYCLES M 1985:1 1999:11
```

With this command the EViews workfile *Mexcycles* is created on drive a:\ (this drive path can be modified), from January 1985 to November 1999. As the file is updated the last date in the command must be changed.

**Step 3.** Another item to be specified is the location of the file that contains the original data set (in this case MEXDATA1.XLS). In the command below the default location is drive a:\

```
READ(E,a2) a:\MEXDATA1.XLS 8
```

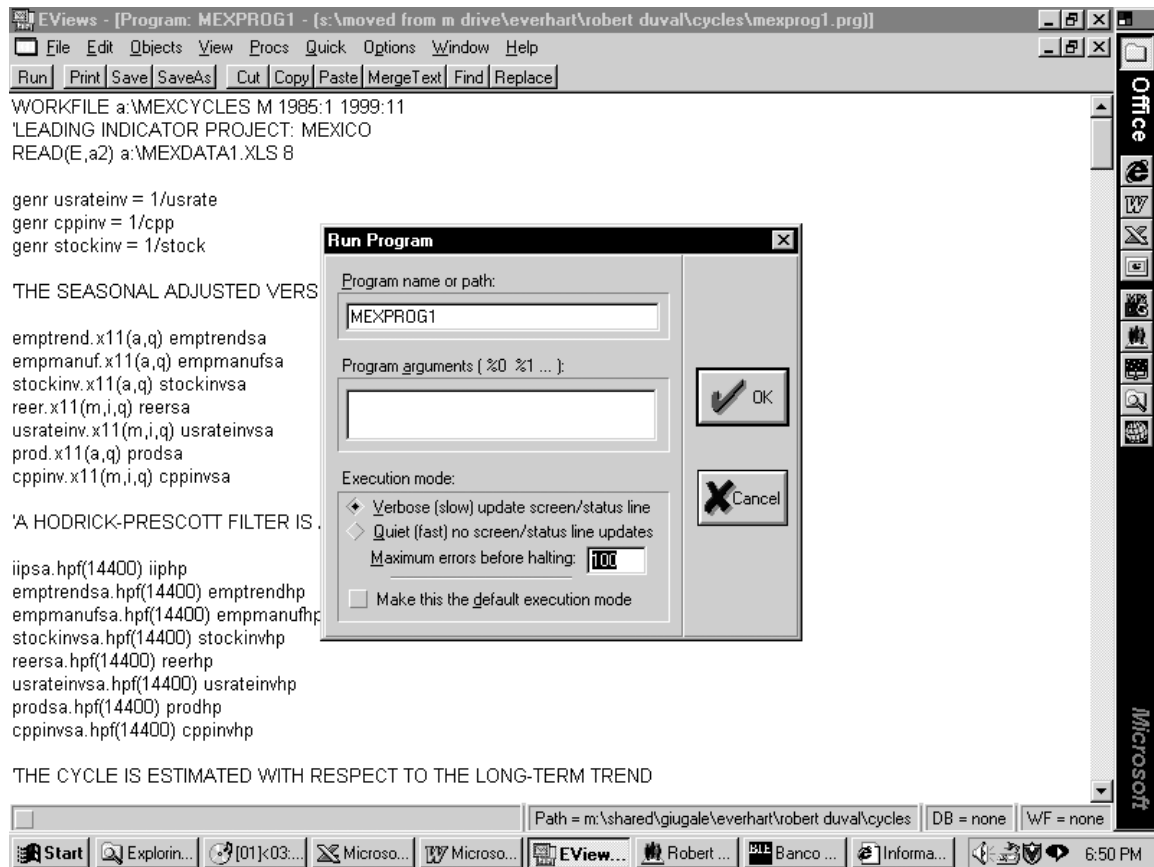
The number 8 at the end of the command denotes the number of series in the MEXDATA1 database. This number is modified only in case one variable is added (deleted).

**Step 4.** Once the basic date adjustments have been completed, the program can be run by hitting the “Run” button in the choice menu at the top of the screen. The software will open a “Run Program” window where the operator must specify the maximum number of errors to be tolerated before halting (see Figure 1.3). This option can be arbitrarily set at 100, since Eviews treats missing values as an error and warning messages appear as the program runs.<sup>10</sup>

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<sup>10</sup> The only error message that should appear is of the type “FP Exception - possible illegal operation on NA - Missing data generated in...”. Any other type of error message indicates real problems with the program.

**Figure 1.3 EViews “Run” command window**



When the errors option has been set, press “OK” and the Leading Indicator is calculated and plotted.

The variable *cliamp* contains the CLI, while *iipcyc2* contains the reference series. Both variables are generated in the file MEXCYCLES.WK1.

**Step 5 (optional).** In order to add (or subtract) any series to the CLI the program must be modified. Go to the ‘Aggregation of the series’ section at the end of the program, where the averaging commands are included:

```

smpl @first @last-4
gener agr1 = ((emptrendnorm+prodnorm+stockinvnorm+usrateinvnorm
+cppinvnorm+reernorm+empmanufnorm)/7)/100
smpl @last-3 @last
gener agr1 = ((emptrendnorm+prodnorm+stockinvnorm+usrateinvnorm
+cppinvnorm+reernorm)/6)/100

```

The command *smpl* denotes the sampling period over which a variable is being averaged. In other words, the averaging process is split into periods because of the missing values in the series, particularly in the beginnings/endings. The term *@first* is used to identify the first observation, *@first+1* is used for the second observation, and so on. The command *genr* creates the variable *agr1*, the average of the normalized components of the composite index. To add (or subtract) one variable to the CLI, the programmer has to write (or delete) the name of the variable followed by the termination *...norm*. If the number of series has changed, then the denominator of the ratio has to be modified in accordance to the number of averaged elements, e.g., have 5 as a denominator if the sum contains 5 summands. Here the programmer must be careful to include the new variable only in those periods in which it presents non-missing values.

The following example illustrates the adding of a new hypothetical variable named *newvar*, which has non-missing values from March 1985 to date. The program should be modified in the following way:<sup>11</sup>

```
smpl @first @first+1
genr agr1 =
((emptrendnorm+prodnorm+stockinvnorm+usrateinvnorm+cppinvnorm+reernorm
+empmanufnorm)/7)/100
smpl @first+2 @last-4
genr agr1 =
((emptrendnorm+prodnorm+stockinvnorm+usrateinvnorm+cppinvnorm+reernorm
+empmanufnorm+newvar)/8)/100
smpl @last-3 @last
genr agr1 =
((emptrendnorm+prodnorm+stockinvnorm+usrateinvnorm+cppinvnorm+reernorm
+newvar)/7)/100
```

Please note that the variable appears only for the sampling period for March 1985 to date (*@first+2 @last*). Also note that the denominator has changed in the relevant command because of the adding of a new variable.

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<sup>11</sup> The following modifications will work only after the required procedures are applied to the series, e.g. seasonal adjusting, detrending, smoothing, normalizing, etc.

## ANNEXES

### 1) Moving Average smoothing techniques

#### *Introduction to MA decomposition of time series*

Time series (Y) can be thought of as the combination of several components: a trend (T), a cyclical component (C), a seasonal component (I), and a random component (E). These components may be assumed to build the series in a multiplicative (1) or an additive (2) way.

$$Y_t = I_t T_t C_t E_t \quad (1)$$

$$Y_t = I_t + T_t + C_t + E_t \quad (2)$$

The decomposition of the series in its components is one of the objectives of time series analysis. One simple approach to this problem is the use of moving averages on the series.

A moving average (MA) is a formula that approximates the original series by averaging individual observations as follows

$$M(Y, n) = \frac{(Y_1 + Y_2 + \dots + Y_n)}{n} \quad (3)$$

What equation (3) states is that individual values in M are the result of averaging  $n$  observations of  $Y$ . As we move to other observation of M, different values of  $Y$  will be averaged. In other words, it is a polynomial applied at different phases of the series. MA procedures can be used to eliminate one or several components of the series, depending on the length,  $n$ , of the process. If the MA process is used to eliminate randomness from a series, then the larger the randomness, the greater  $n$  must be. As  $n$  becomes larger, other components (seasonal, cyclical, etc.) will be eliminated.

#### *Weighted MA techniques*

Of course one MA process can be estimated on another moving average,

$$M'(Y, n) = \frac{(M_1 + M_2 + \dots + M_n)}{n} \quad (3.1)$$

These series are called nxn moving averages and they have the peculiarity of weighting observations such that central observations have a larger weight than distant ones. Another way of conceptualizing these averages is using the previously described polynomial with coefficients different than 1. Two particular cases of this type of MA's are the Spencer and the Henderson moving averages processes, their weighting is useful to eliminate the irregular and the seasonal components of series.

### *MCD Moving Average Estimation*

The Months of Cyclical Dominance MA estimate is one type of MA that determines the length of the MA process, depending on the variability of the series to be smoothed.

MCD is defined as the number of months needed for the average change in the irregular component to become smaller than the average change in the trend component. The first step involved in the estimation of the MCD is the decomposition of the series into its trend-cyclical and irregular components. To accomplish this task, a Henderson thirteen months moving average is estimated (eq. 4.1):

$$H(Y, n) = \sum_{t=-6}^6 a_{t+6} Y_t \quad (4.1)$$

The series (H) arising from the Henderson MA is an estimate of the trend-cycle component of the Y. Therefore, obtaining the ratio of the seasonal adjusted series to the Henderson MA gives an estimate of the error component of the series.

$$\frac{Y_t}{H_t} = \frac{T_t C_t E_t}{T_t C_t} = E_t \quad (4.2)$$

From the tend-cycle and random components we obtain the percentage change for 1 to 5 months and their overall averages:

$$\sum_{t=2}^n \frac{(X_t - X_{t-j})}{X_{t-1}} \Big/ (n-j) \quad \text{for } j = 1 \dots 5 \quad (4.3)$$

Changes in the irregular component dominate those in the trend-cycle during the first months. However, as the time span increases, changes in the trend cycle become larger and dominate those in the irregular component.

Once the MCD scalar has been obtained for each series, it is used as the length of a moving average process applied to the series.<sup>12</sup> This moving average removes the irregular component of the series.

## 2) Detrending the Series: Hodrick-Prescott Filter

The Hodrick-Prescott Filter (after the paper from Hodrick & Prescott, 1997) is a smoothing technique that decomposes time series in two components: the trend ( $g_t$ ) and the cycle ( $c_t$ )

$$y_t = g_t + c_t \quad \text{for } t = 1, \dots, T \quad (4)$$

There is no seasonal component on the series because it has been previously removed with the X-11 seasonal adjustment method. The smoothed series are obtained by minimizing the variance of secondly adjusted raw series  $y_t$  around its trend component. The programming problem is

$$\text{Min}_{\{g_t\}_{t=1}^T} \left\{ \sum_{t=1}^T c_t^2 + \lambda \sum_{t=1}^T [(g_t - g_{t-1}) - (g_{t-1} - g_{t-2})]^2 \right\} \quad (5)$$

where the Lagrange multiplier  $\lambda$  controls the variability<sup>13</sup> of the trend component, e.g., the smoothness of  $g_t$ .<sup>14</sup>

The HP filter is a good alternative for the Phase Average Trend (PAT) method, originally used in this forecasting exercise. Both techniques provide similar estimates of the trend component, and the recent widespread use of the HP Filter makes it an attractive alternative due to its simple estimation. It also avoids some of the problems intrinsic to PAT procedures like the dependency on the peak-trough estimation, which can lead to biases depending on the nature of the real trend of the series and the MA process used to separate it.

<sup>12</sup> For practical reasons the length of this MA is limited to 1- 6 periods.

<sup>13</sup> Measured as the second difference of the series.

<sup>14</sup> Typically  $\lambda=14,400$  is chosen for monthly data.

### 3) Normalization and Aggregation of the series

Given the wide variability in amplitudes across series, forming the CLI with a simple average of non-standardized variables may generate distortions in the construction of the final index. To avoid this problem a normalization technique is applied to the cyclical component of the MCD-smoothed series that form the CLI. The steps include obtaining the difference between the series and its mean, calculating the mean absolute value of this difference, and using this scalar as a standardizing factor, dividing each variable. By adding 100 to the series they are expressed as an index number.

### 4) Turning Points, The Bry-Boschan technique

The Bry-Boschan technique for selecting turning points consists of:

- 1) Determining trend and cycle elements by weighted moving averages. Exclude local critical points by postulating minimum cycle duration.
- 2) Establishing the immediate neighborhood of potential turns on a slightly smoothed trend by means of a short term moving average.
- 3) Choosing preliminary turning points from the un-smoothed data, testing below noted constraints.

Some useful suggestions for identifying turning points:

- Cycles (from peak to peak or from trough to trough) must have duration greater than 15 months and shorter than 12 years.
- Amplitude of a *doubtful* expansion (or contraction) must not be materially smaller than that of the smallest *clearly recognized* cycle in the series.
- Select highest and lowest points
- Peaks & troughs alternate
- On equal values we generally choose with the last one
- With “Double Turns” we usually pick the last high month before the downward trend, however if the period between the two peaks contains mainly downward movements and only one or two steep rises, then we chose the first high.
- Recognition of ridges and valleys

- We should not take as a turning point a value that is near the beginning (end) of the series<sup>15</sup>

### **Description of the Files**

#### *Mexdata1.xls*

Contains the raw data needed to construct the CLI. The data goes from January 1985 to date for the variables described below. This file must be updated when new monthly data is available.

#### *Mexcycles.wk1*

EViews file containing the procedures generated in the estimation of the CLI. This file has the two final variables compared, IIP (iipcyc) and the CLI (cliamp).

### **Description of the variables**

- Index of Industrial Production seasonally adjusted (iipsa). Source: INEGI
- Changes in Manufacturing Employment (empmanuf). Source: INEGI.
- Stocks of finished goods. Tendency<sup>16</sup> (stock). Source: Business survey, Bank of Mexico.
- Real Effective Exchange Rate (reer). IMF Statistics (W:/IBO drive at the World Bank net, contact the Bank for this data).
- US long term interest rate<sup>15</sup> (usrate). Source: Federal Reserve.
- Employment. Tendency (emptrend). Source: Business survey, Bank of Mexico.
- Cost to banks of managing deposits in national currency. CPP rate.<sup>15</sup> (cpp). Source: Bank of Mexico.
- Production. Tendency (prod). Source: Bank of Mexico, Business Survey.

All these series can be directly downloaded from the OLISnet service provided by the OECD.

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<sup>15</sup> See Bry and Boschan (1971).

<sup>16</sup> Use the reciprocal.

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