Yet another lagging, coincident and leading index for the colombian economy.

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Yet another Lagging, Coincident and Leading Index for the Colombian Economy\textsuperscript{1}

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Abstract
This paper sums up the results of an ongoing research on the construction of indexes for Colombian economic activity and the characteristics of the business cycle. The author uses the statistical framework known as the generalized dynamic factor model (Forni, Lippi, Hallin, Reichlin, 2000) to build a lagging, coincident, and leading quarterly index for Colombian economic activity.

JEL classification: C53, C82, E32.
Keywords: generalized dynamic factor model, coincident indexes, leading indexes.

1) Introduction

Initial interest on coincident and leading indicators began with the methods suggested by Burns and Mitchell (1946). Their method basically consisted in selecting economic time series which showed clear turning points contemporary or in advanced of the “reference cycle”. The series are standardized and averaged to provide a composite cyclic indicator. However, much critique aroused on the lack of statistical criteria used on the definition of the global state of the economy and on the optimality of the weighting scheme used to construct the leading indicators, by Stock and Watson (1989 and 1991) and Emerson and Hendry (1996). From this criticism the use and subsequent publication of coincident and leading indicators for the United States and the U.K.\textsuperscript{2}, by national statistical bureaus, cease in the middle of the nineties. In spite of the criticism there is still somewhat of an academic interest in these measurements of economic activity. The OECD still produces leading

\textsuperscript{1} The opinions expressed here are those of the author and not necessarily those of the Departamento Nacional de Planeación. I express my thanks to Jesus Otero, Gabriel Piraquive and Manuel Ramirez for helpful comments and suggestions. Any remaining errors are my own.
\textsuperscript{2} In light of much criticism, the Office for National Statistics stopped publishing these indicators in 1996; however the publication was taken up by a private agency. At approximately the same time, the United States Bureau of Census stopped publishing these indicators, but they were taken up by the Conference Board.
indicators for most of its members following the traditional method. There has also been an important development of techniques based on econometric and time series analysis.

Stock and Watson (1989 and 1991), (SW henceforth) have used a state space model with observable and predetermined coincident and leading variables. The main idea behind their methodology is to obtain an unobservable process as the coincident index and use the 6-month forecast of this unobserved factor, as the leading index, obtained from a modified vector autoregressive system of this factor and a set of leading variables.

Another approach is the EuroCoin™, which is a coincident indicator of the euro area business cycle. This index is estimated using a set of monthly statistics of the euro area (951 series). This method builds on the previous research on coincident and leading indexes by Forni, Hallin, Lippi and Reichlin (1999, 2000, 2001, and 2003) (FHLR henceforth). The statistical model used is based on the generalization of the dynamic factor model and will be explained in greater detail in section 2.


In this paper the methodology and software developed by FHLR is used to construct a quarterly self-contained system of coincident and leading indicators for the Colombian economy. In section 2 the statistical model and theoretical aspects of it are described; in section 3 an overview of the estimation procedure is presented; in section 4 the data used is described as well as the calibration of the statistical model for the Colombian economy; in section 5 the results obtained from the empirical application to the Colombian economy are presented. Finally the last section presents the conclusions, strengths and weaknesses of the procedure.

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3 Give or take some revisions, modifications and fine tuning of the methods. For more information see www.oecd.org/std/cli.
4 The EuroCoin™ is published monthly by the CEPR (Center for Economic Policy Research).
2) Statistical Model

The essence of the method in FHLR is a factor model\(^5\), where the dynamics (covariance) of a panel of macroeconomic variables can be described by a small number of commonalities in the set. Therefore each variable can be expressed as the sum of a common component (shared accordingly with the other variables in the panel) and an idiosyncratic (orthogonal) component. The SW approach also originates from a factor model, but the classification of the variables as coincident is performed \textit{a-priori}. As stated by FHLR (1999) in their procedure and analogous to the NBER averaging methodology "the first step is to eliminate from each series in the panel, that part of the dynamics which is poorly correlated with the rest of the economy and hence considered as idiosyncratic. Then, in a second step we select coincident and leading indicators by analyzing the phase shifts between these ‘cleaned’ time series. Finally, we aggregate coincident and leading variables into coincident and leading indexes and establish turning points. A major novelty of our methodology is that these steps are not conceptually disjoint operations, but are all consistently nested within a unified theoretical setting"\(^6\). The steps of the procedure will be further explained in section 3.

The following paragraphs will summarize the construction and assumptions of the FHLR model, naturally a more comprehensive treatment of the model can be found in FHLR (1999, 2000, 2001, and 2003).

a. Identifying the common components

Define \(x_i = (x_{i1}, \ldots, x_{in})'\) as the panel of \(n\) macroeconomic series suitably transformed\(^7\). Since the goal is to summarize in a small number of indexes the commonality of the variables in the panel we look for \(q\) processes \(z_{ht} = h=1, \ldots, q\) that satisfy the following conditions:

i. \(z_{ht}\) is a linear combination of the leads and lags of the variables of the panel:

\[
z_{ht} = p_h(L)x_i, \quad h=1, \ldots, q
\]

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\(^5\) See Harman (1967) for an introduction to factor analysis.
\(^6\) FHLR (1999), pg 2.
\(^7\) Guaranteeing stationarity for all the series and standardized so the different units of each series do not overshadow the explained variance
ii. \( z_{ht} \) and \( z_{kt} \) are mutually orthogonal at any lead and lag \( h \neq k \) and the filters \( p_h(L) \) are normalized such that:
\[
p_h(L)p_k(F)' = 0, \quad \text{For } h \neq k
\]
\[
p_h(L)p_h(F)' = 1, \quad 8
\]

iii. the filters \( p_h(L) \) and associated processes \( z_{ht}, h=1,\ldots,q \) are such that the sum of the explained variance is maximized:
\[
\sum_{j=1}^n \text{var}(\gamma_j q)
\]
\( \gamma_j q = (\gamma_1 q, \ldots, \gamma_q q)' \) is the projection of \( x_t \) on the past, present and future of \( z^q_t = (z^1 t, \ldots, z^q t)' \) given the following decomposition of \( x_t \) on the above mentioned aggregates (hence \( \gamma_j q \) for \( i=1,\ldots,n \) is the commonality of each series in the panel).

\[
x_t = \gamma^q_t + \zeta^q_t = C^q(L)z^q_t + \zeta^q_t = K^q(L)x_t + \zeta^q_t \quad (1)
\]

Where the residual vector is \( \zeta^q_t \) and \( C^q(L) \) and \( K^q(L) \) are the following filters:

\[
C^q(L) = (p_1(F)' \ldots p_q(F)')
\]
\[
K^q(L) = C^q(L)C^q(F)' = p_1(F)p_1(L)' + \ldots + p_q(F)p_q(L)' \quad 9
\]

The processes \( z_{ht}, \ldots, z_{kt} \) that satisfy requirements, i), ii) and iii) are called the dynamic principal components of \( x_t \). The dynamic principal components are related to the eigenvalues and eigenvectors of the spectral density matrix of \( x_t \), akin to the static case where they are related to the eigenvalues and eigenvectors of the variance-covariance matrix. The main difference between the dynamic and static case is that the relationship between the principal components (in this case \( z_{ht} \) for \( h=1,\ldots,q \)) and the original series (in

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8 Where \( F = L^{-1} \), \( L \) and \( F \) as usual are the backward and forward shift operators, respectively.

9 This automatic re-alignment of the variables exploits completely the information of the panel not only the information of the coincident variables, but it also includes the leading and lagging ones in order to identify more thoroughly the common component.
this case the panel \( x_n \) are in terms of all the values of \( z_{ht} \) and \( x_n \), at different times rather than a single \( z_{ht} \) and \( x_n \)

The filters are derived from the eigenvectors \( p_h(e^{-i\theta}) \), corresponding to the \( h \)th eigenvalue \( \lambda_h(\theta) \) in descending order, from the spectral density matrix \( \Sigma(\theta) \), at frequencies \(-\pi < \theta < \pi\). By setting \( \lambda_h(\theta) = \int_{-\pi}^{\pi} \lambda_h(\theta)d\theta \), the maximal explained variance is given by \( \lambda_1 + ... + \lambda_q \), and the percentage of explained variance is given by the ratio \( \frac{\sum_{i=1}^{q} \lambda_i}{\sum_{i=1}^{\infty} \lambda_i} \), as seen in the following subsection and section 3 this ratio provides a useful indicator for the choice of \( q \). The exact estimation of filter \( K^q(L) \), used to derive the common components from \( x_n \), is derived in Appendix A of FHLR (1999).

**b. Establishing a bridge between the principal components and the generalized dynamic factor model**

The use of principal components has introduced a method to extract the commonalities; however there is still a need to define a procedure to choose the relevant number of components. This is where the use of the dynamic factor approach lends a hand. The factor model that FHLR have in mind represents the sum of two unobservable components: the common components (common to all the variables in the panel) and a set of idiosyncratic components uncorrelated with the common components.

Let the panel \( x_{nt} \) be a construction of the first \( n \) elements of an infinite sequence \( x_{jt} \), \( j=1, \ldots, \infty \), then for each \( n \)th-element \( x_{nt} \).
\[
x_{jt} = \chi_{jt} + \xi_{jt} = b_j(L)u_j + \xi_{jt},
\]
where \( \chi_{jt} \) is the common component, \( u_j = (u_{jt}, \ldots, u_{jt}, \ldots) \) is the vector of common shocks, \( b_j(L) \) is a vector of two-sided filters and the idiosyncratic component \( \xi_{jt} \), which is

10 For a quick overview of principal component analysis in the frequency domain see Jolliffe (2002) and for a more comprehensive treatment see Brillinger (1981).
11 Here lies an important departure from the model proposed by SW (1989), where there is one common shock. Since there is one common shock it can only be loaded contemporaneously by all of the variables in the panel. Hence none of the variables in the panel can be leading or lagging and there must be only one source of common variation within the panel (although this also makes their common cycle stronger).
orthogonal to $u_{i-k}$ for any $k$ and $j$. Stacking over $n$ we have the generalized dynamic factor model:

$$x_{nt} = \chi_{nt} + \xi_{nt} = B_n(L)u_t + \xi_{nt} \quad (2)$$

This model has the following properties:

Let $\lambda^{\text{t}}_{hn}(\theta)$, $h=1,..,n$ be the $h$th-eigenvalue of the spectral density matrix of $\chi_{nt}$. Similarly, $\lambda^{\xi}_{hn}(\theta)$, $h=1,..,n$ be the $h$th-eigenvalue of the spectral density matrix of $\xi_{nt}$.

i. $\lambda^{\text{t}}_{hn}(\theta) < \Delta$, as $n \rightarrow \infty$, is bounded in $[-\pi, \pi]$ for $h$ and $n$.

ii. $\lim_{n \rightarrow \infty} \lambda^{\text{t}}_{hn}(\theta) = \infty$, the first $q$ eigenvalues diverge in $[-\pi, \pi]$ for $h \leq q$.

Returning to equation (1) and making explicit its dependence on $n$.

$$x_{nt} = \gamma_{nt} + \xi_{nt} = C_n(L)z_{nt} + \xi_{nt} \quad (3)$$

Now this model has the following properties:

iii. $\lambda_{hn}(\theta) < \Delta$, as $n \rightarrow \infty$, for $h=q+1,..,n$ in $[-\pi, \pi]$, the last $n-q$ eigenvalues of $x_{nt}$ are bounded.

iv. $\lim_{n \rightarrow \infty} \lambda_{hn}(\theta) = \infty$, for $h \leq q$ in $[-\pi, \pi]$, the first $q$ eigenvalues of $x_{nt}$ diverge.

Under these assumptions there is a strong similarity between equations (2) and (3). FHLR (1999) show that conditions iii, and iv hold for the eigenvalues of $x_{nt} \Leftrightarrow$ the generalized factor representation exists (2). They also show that for $n$ large $\gamma_{nt}$ is a good approximation of $\chi_{nt}$. In their own words “these results build a firm bridge linking principal components and factor analysis. The basic intuition behind them is that, by taking the principal components, we are taking an average of the x’s. When $n$ is large, we get a kind of Large Number result. The idiosyncratic components, which are poorly correlated, disappear, so that we are essentially left with linear combinations of the (leads and lags of) the common components. Such linear combination spans almost the same dynamic space as the common factors…”

The bridge established above suggests a criterion for the choice of the number of principal components to maintain. Since $\lambda_{hn}(\theta)$ in $[-\pi, \pi]$ is bounded for $h>q$ and diverges for $h \leq q$ as $n \rightarrow \infty$, then for a large $n$ we expect a “jump” (in the own words of the authors)

12 FHLR (1999), pg 6.
between $\lambda_{qn}$ and $\lambda_{q+1n}$. This suggests adding principal components until the increase in the explained (marginal gain) is larger (smaller) than some prespecified value.

c. One-sided estimation and forecasting for the end-of-sample problem caused by two-sided filtering

The use of the two-sided filter $K^i(L)$ creates a problem at the end (or at the beginning) of the sample. Even thought we are interested in the historical performance of the index (central part of the sample) our main practical interest is the performance of the index at the end of the sample. However, we do not wish to loose the automatic realignments introduced by the two-sided filter. With this in mind FHLR (2003) suggest a one-sided filter for the end of the sample, also used in forecasting the common components. The authors use the dynamic principal components method along with the method developed by SW (2002) for generating forecast, in a factor model, using static principal components. Both methods share the same objective of finding a set of aggregates that span approximately the same dynamic space as the factors in a factor model. The hybrid two-step estimator developed by FHLR (2003), first estimates the covariance matrix for the common $(\Gamma_{\chi_0}^{\chi'})$ and idiosyncratic component $(\Gamma_{\xi_0}^{\xi'})$ obtained through the dynamic method; in the second step these matrices are used to obtain contemporaneous averages that minimize the fraction of idiosyncratic variance contained in the aggregates. Later these aggregates can be used for an in-sample or out-of-sample estimation of the common components.

d. An example of advantages of the two-sided filter

To gain a clearer perspective of the advantages of the two-sided filter (automatic realignment) for a more thorough approximation of the common factor space, let’s look at the following simple example\(^{13}\):

Assume that $x_{1t} = \chi_{1t} + \xi_{1t}$ and $x_{2t} = \chi_{2t} + \xi_{2t}$, where $\chi_{1t} = u_t$, $\var(\xi_{1t}) = \var(\xi_{2t}) = 1$, $\chi_{2t} = u_{t-1}$, $\cov(\xi_{1t}, \xi_{2t}) = 0$

\(^{13}\) This example is from FHLR (2003).
This implies that the two variables $x_{1t}$ and $x_{2t}$ share one common shock $u_t$ loaded contemporaneously for the first variable and lagged one period for the second variable. Also the idiosyncratic and common variance ratio is 1 for both variables. Given these set of assumptions we can average these variables to obtain the relevant aggregates:

a. Through a Contemporaneous Average:

$$x_{1t} + x_{2t} = \frac{(u_t + u_{t-1}) + (\xi_{1t} + \xi_{2t})}{2}$$

Since the common shock is serially independent the idiosyncratic component is as large as the common component. No clear advantage in using this kind of average.

b. Through an Aligned Average

$$\frac{x_{1t-1} + x_{2t}}{2} = \frac{(u_{t-1} + u_{t-2}) + (\xi_{1t-1} + \xi_{2t})}{2} = u_{t-1} + \frac{(\xi_{1t-1} + \xi_{2t})}{2}$$

In this case the idiosyncratic variance is only $\frac{1}{2}$ of the common variance. Through this average the fraction of the idiosyncratic variance contained in the aggregate is minimized.

3) The Procedure

Following the theoretical background established in section 2 we now look at the procedure used in the construction of coincident and leading indexes for the Colombian economy.

a. Organizing and choosing the variables

The first step is to transform the variables in order to guarantee stationarity and standardize the variables. The next step is to define a-priori the group of core variables (which, a-priori, show an important commonality between them and with GDP) that must be in the panel and a group of candidate variables (non-core).
b. Core analysis

Using the variables defined in the core (Table 1), we set a predetermined number of factors $q$ which we will later validate according to the criterion defined in section 2b and set a data dependent rule $[M = \text{round}(\sqrt{T}/4)]$ for the estimate of the sample covariance matrix. Then we use the discrete Fourier transform to estimate the spectral density matrix $\Sigma(\theta)$ of the panel $x_{nt}$. In the frequency domain a filter is constructed out of the first $q$ eigenvectors from the estimated spectral density matrix (the dynamic principal components). Finally using the inverse discrete Fourier transform we obtain an estimate of filter $K^q(L)$; this filter is used to acquire the common component for each of the variables in the core. The idiosyncratic components are obtained as a residual (since they are orthogonal). We also get a scalar estimate of the idiosyncratic component as an average of the idiosyncratic components in the core; let’s call this the “overall idiosyncratic component (OYC henceforth)” for this panel. For the moment only the core variables are included in this panel –the core panel-.

c. Non-core analysis

In the non-core analysis the procedure used in obtaining the common components is the same as the one mentioned for the core variables. However since the non-core variables are candidate\textsuperscript{14} variables, the core panel is augmented by each of the non-core variables (one at a time). For each of these augmented panels the OYC is estimated and compare to the OYC of the core panel. If the OYC for the augmented panel is smaller than the OYC for the core panel then the candidate variable is included in the final panel. This final panel, naturally, includes the core variables and the non-core variables that reduce the OYC. This is equivalent to maximizing the overall commonality between the variables, which is our main objective.

\textsuperscript{14} Remember that we do not want to include variables in our final panel that have a small commonality with the other variables and a large idiosyncratic component.
d. Validation of the number of factors

After determining the final panel we must test if the \( q \) chosen \textit{a-priori} is optimal. Now following the criterion established in section 2b we know that the procedure must estimate the dynamic eigenvalues \((\lambda_1(\theta), \ldots, \lambda_q(\theta))\) in descending order, obtain their values in \([-\pi, \pi]\), and report the percentage of explained variance\(^{15}\), given by the ratio \[ \frac{\sum_{i=1}^{k} \lambda_i}{\sum_{i=1}^{n} \lambda_i} \] for \( k \leq n \). In sum the criterion tell us to include factors until the marginal contribution of an additional factor to the total explained variance is below a constant \(\alpha\), when this happens \( q \) is optimal.

e. Phase analysis and classification of the variables (leading, coincident or lagging)

Once the common components are estimated for each of the series of the final panel we must classify each of them as being “in phase” or in “phase opposition” with respect to the common component of the GDP, which is a reference point to classify the variables as leading, coincident or lagging. With this in mind, we proceed as follows: first we use the estimate of \( \Sigma^x(\theta) \)\(^{16}\) to compute the cross-spectral density of each common component with respect to the common component of GDP. Second we compute the argument of these densities, which is the phase angle delay (Appendix A) with respect to GDP, at frequency zero. Let \( \phi_j(\theta) \) in \([-\pi, \pi]\) be the phase angle shift for the common component \( \chi_j \). At frequency zero lets define the new series as:

\[ \omega_j = \begin{cases} \chi_j & \text{if } \phi_j(0) = 0, \text{ in phase} \\ -\chi_j & \text{if } \phi_j(0) = \pi, \text{ phase opposition} \end{cases} \]

Using the series \( \omega_j \) we compute the phase angle shift, \( \psi_j(\theta^*) \), with respect to the GDP at a typical business cycle for the Colombian economy (the calibration of \( \theta^* \) will be explained)

\[ \sum_{i=1}^{n} \lambda_i = 1 \]

---

\(^{15}\) Since the data is standardized.

\(^{16}\) The spectral density matrix of the common components.
in section 4). We also need to define a maximum phase angle lead, \( \tau \), according to which the classification of the variables will be defined as follows:

\[
\begin{align*}
|\psi_i(\theta^*)| < \tau, & \quad \text{Coincident} \\
\psi_i(\theta^*) > \tau, & \quad \text{Leading} \\
\psi_i(\theta^*) < -\tau, & \quad \text{Lagging}
\end{align*}
\]

f. Construction of the indexes and the end-of-sample correction

From the classification given above the indexes are constructed as the averages of the coincident and leading common components. The level indexes are constructed as the cumulated sums of the original indexes. Since the estimated common components come from a two-sided filter \( K^q(L) \), these estimates at the beginning and at the end of the sample are not adequate. To overcome this FH LR (2003) use contemporaneous averages of the original variables or the one-sided filter mentioned in section 2c for the beginning and last three observations in the sample.

4) Data and calibration for the Colombian economy

The panel constructed from the Colombian data is a set of 70 economic time series, 5 core and 65 non-core variables in the quarterly sample period 1984:01 – 2003:01 (Table 1). Each variable was analyzed to determine the order of integration using unit root test (Dickey-Fuller, Phillips-Perron and KPSS) and the HEGY\textsuperscript{17} test for seasonal unit roots in quarterly series. Following the results of these tests the variables were transformed to guarantee stationarity (by first difference) and to remove seasonality (deterministic or stochastic). Most of the variables showed relevant deterministic seasonality (seasonally adjusted through the use of seasonal dummies) or no seasonality (Table 2). The variables that showed stochastic seasonal patterns were adjusted with the relevant filter identified.

with the HEGY test). Also all of the seasonally adjusted and not seasonally adjusted series show some evidence of a unit root except for 18 series\textsuperscript{18} (Table 3).

The estimation procedure described in section 3 was calibrated for Colombia following Maurer and Uribe (1996) and Maurer, Uribe and Birchenall (1996) for the choice of the length of the business cycle for the Colombian economy. According to these authors the length of the business cycle, in Colombia, is 4 to 5 years. For the empirical application the length of the cycle chosen is 4 years (the results are not sensitive to choosing 5 years). As it was explained in section 3 the length of the cycle is fundamental in the phase analysis to determine the relevant frequencies associated to the cycle and to calibrate the timelead (phase angle lead in the frequency domain) between the series, given a particular cycle. The maximum phase lead is set to one month (expressed in quarters $\tau = 0.33$).

In choosing the optimal number of factors $q$ following the criterion, established in section 2b and explained in detail in section 3d, we must set a floor for the marginal contribution of an additional factor to the total explained variance. For the empirical application $\alpha$ was fixed to 5%, given this calibration $q=2$ (two common factors).

\textsuperscript{18} SIT, AMA, EPT, VOP, ER3, ES6, OVN, PRC, VCC, TSO, PCA, IPU, AM1, CCP, EXC, CDT, LCO and PMA.
5) *Results from an empirical application to the Colombian economy*

The lagging, coincident and leading indexes are derived after calibrating the model. From the first step we obtain the final panel which includes the variables in the core and only two candidate variables SIT (Current economic conditions) and OVN (Car Sales). These are the only variables outside the core that reduce the OYC. These results indicate that the evolution of the real cycle is poorly correlated with the evolution of prices and wages, monetary and financial cycle, trade cycles, fiscal cycles, the evolution of asset prices and the construction cycle. This seems a bit harsh; however this might be the result of using indexes with in the core and non core (such as SIT and IPR) which could sum-up indirectly the dynamic of some of these cycles.

The final panel only includes 7 variables, which poses an important issue since the methodology is base on a large $n$. The next step after defining the final panel and validating the number of factors ($q=2$) is the analysis of the time phase lead (or delay) of each variable with respect to the GDP. In sum the criteria for variable classification, explained in section 3b and calibrated according to section 4, is that a variable is *lagging* if its time phase delay is larger than a month (0.33 quarters), its *leading* if the time phase lead is larger than a month (0.33 quarters), and all other variables in between these definitions are considered as *coincident*. Using these rules the classification of the variables in the final panel is as follows:

<table>
<thead>
<tr>
<th>Code of the variable</th>
<th>Time lead *</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIB</td>
<td>0</td>
<td>Coincident</td>
</tr>
<tr>
<td>CUT</td>
<td>0.7240</td>
<td>Leading</td>
</tr>
<tr>
<td>TSD</td>
<td>0.0662</td>
<td>Coincident</td>
</tr>
<tr>
<td>ENE</td>
<td>-0.0249</td>
<td>Coincident</td>
</tr>
<tr>
<td>IPR</td>
<td>0.3361</td>
<td>Leading</td>
</tr>
<tr>
<td>SIT</td>
<td>-0.2745</td>
<td>Coincident</td>
</tr>
<tr>
<td>OVN</td>
<td>-0.5824</td>
<td>Lagging</td>
</tr>
</tbody>
</table>

*Time leads are expressed in quarters.
a. Turning Points

From the coincident index we can determine the turning points as the dates $t^*$ in which the index reaches a local maxima (peak) or minima (trough). To avoid the inconvenience of having two local maxima (or minima) too close together and following Maurer et al. (1996) procedure for identifying turning points a condition is established such that no cycle can be shorter than 4 quarters.

![Coincident index graph showing turning points]

Turning Points for the coincident index

<table>
<thead>
<tr>
<th>Episode</th>
<th>Trough</th>
<th>Peak</th>
<th>Lenght in Months</th>
<th>Years</th>
<th>Cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Expansion</td>
<td>Contraction</td>
<td>Cycle</td>
</tr>
<tr>
<td>0</td>
<td>Sep-99</td>
<td>Jun-00</td>
<td>10</td>
<td>22</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>Mar-97</td>
<td>Sep-97</td>
<td>7</td>
<td>25</td>
<td>32</td>
</tr>
<tr>
<td>1</td>
<td>Dic-94</td>
<td>Mar-95</td>
<td>3</td>
<td>25</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Jun-92</td>
<td>Mar-93</td>
<td>10</td>
<td>22</td>
<td>32</td>
</tr>
<tr>
<td>2</td>
<td>Dic-90</td>
<td>Mar-92</td>
<td>16</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Dic-88</td>
<td>Jun-90</td>
<td>19</td>
<td>7</td>
<td>26</td>
</tr>
<tr>
<td>3</td>
<td>Dic-86</td>
<td>Jun-88</td>
<td>19</td>
<td>7</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Sep-85</td>
<td>Sep-86</td>
<td>13</td>
<td>4</td>
<td>17</td>
</tr>
</tbody>
</table>
Following the criterion we can identify eight complete cycles and an incomplete cycle (beginning in March of 2002) for the period 1985:01 to 2003:01. However, since we calibrated the model for a business cycle length of 4 years we have aggregated these shorter cycles in order to have 4 episodes. Episodes 2 and 3 are within the range of the ones identified by Maurer et al. (1996) for the same period and the predominant expansion characterized by episodes 3 and 4 are consistent with Ocampo and Villar (1993) historical account of the period\(^{19}\). The comparison of the first and second episode with the third and the fourth reveal a lengthening of the cycle in the nineties.

The turning points for the common component of GDP are similar in structure give or take a few changes in the dates of 2 peaks and 3 troughs (Appendix B).

\textit{b. Lagging-Coincident-Leading Indexes}

The leading variables are the Capacity Utilization Rate and the Industrial Production index, this is no surprise and it is also found on the empirical application of FHLR (1999) for the EURO area. However, it is surprising that a variable such as unemployment is coincident, because labor market variables are considered anti-cyclical and in most cases lagging\(^{20}\).

With these results we can construct the lagging, coincident and leading indexes for the Colombian economy.

\(^{19}\) As described in Maurer et al. (1996) pg 9.

\(^{20}\) Maurer et al.(1996) also classify unemployment within their coincident index.
The first observation of the indexes is that there is only a clear lead or lag with respect to the coincident index in some of the turning points, especially in the lagging index. Even though we cannot identify a clear lead for the last recession (1999) there is a strong lag (of a quarter) in the peak (September-97) and trough (September-99) of that episode. For a clearer look at the leading and coincident relations, let’s take a look at the leading index and the common component of the log of GDP.
The leading index shows a stronger leading relation with the common component of the GDP, however, not all of the leads identified (in arrows) coincide with the peaks and troughs identified for the common component of GDP. The leading index manages to anticipate by a quarter the slowdown of economic activity at the end of 1995, the short turn around of economic activity in 1997, the beginning of the recession in 1998 and the lowest point of the recession in 1999. The latest turning point in March 2002 is not anticipated.
6) Conclusions

This paper sums up the results of an ongoing research on the construction of coincident and leading indexes for the Colombian economic activity and the characteristics of the business cycle. The statistical model (and software\textsuperscript{21}) has a different approximation in the construction of such indexes then the ones applied with Colombian data before. The greatest strength of the methodology developed by FHLR is that it is a self contained system where no \textit{a-priori} assumption on the coincident or leading characteristics of the series is needed. However, since the asymptotics (a large final panel, \( n \)) guarantees the consistency of the estimates the use of a considerable small number of series (70) in the Colombian case relative to the multi-country applications for the EURO area (246), brings forth consistency issues.

There are still a few issues to be addressed in future research (both theoretically and empirically for the Colombian case), such as: small sample performance of the two-sided and one-sided filter, small sample diagnostics, forecasting the coincident index, and the construction of a monthly index for the Colombian economy using the generalized dynamic factor model.

\textsuperscript{21} The software has been supplied by the authors (www.dynfactors.org).
References

Appendix A

Definitions: A few relevant concepts you ought to know about time series analysis in the frequency domain

- **FOURIER SERIES**: Fourier series are expansions of periodic functions $f(x)$ in terms of an infinite sum of sines and cosines of the form:

  $$f(x) = \sum_{n=0}^{\infty} a_n \cos(nx) + \sum_{n=0}^{\infty} b_n \sin(nx)$$

  Fourier series make use of the orthogonality relationships of the sine and cosine functions, which can be used to calculate the coefficients $a_n$ and $b_n$ in the sum. The computation and study of Fourier series is known as harmonic analysis.\(^1\)

- **PHASE**: Angular position of a quantity. In our case we are interested in the phase difference between the frequency components of a set of processes. The phase can be expressed in units of time or in degrees.

  1. Phase Lead (Delay): as a small time lead (delay) between two waveforms at a given frequency.

\(^1\) Taken from [http://mathworld.wolfram.com/FourierSeries.html](http://mathworld.wolfram.com/FourierSeries.html)
2. Phase Angle: as a percentage of the entire wave period in degrees.
# APPENDIX B

Turning Points for the common component of GDP

<table>
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<td>Yet another lagging, coincident and leading index for The Colombian economy.</td>
<td>Carlos Alberto Castro I.</td>
<td>Septiembre 2003</td>
<td></td>
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