Economic Watch

Global

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Economic Analysis

Economic Scenarios
Senior Economist
Jaime Martínez-Martín
j.martinez.martin@bbva.com

BBVA Global Activity Index (BBVA- GAIN)

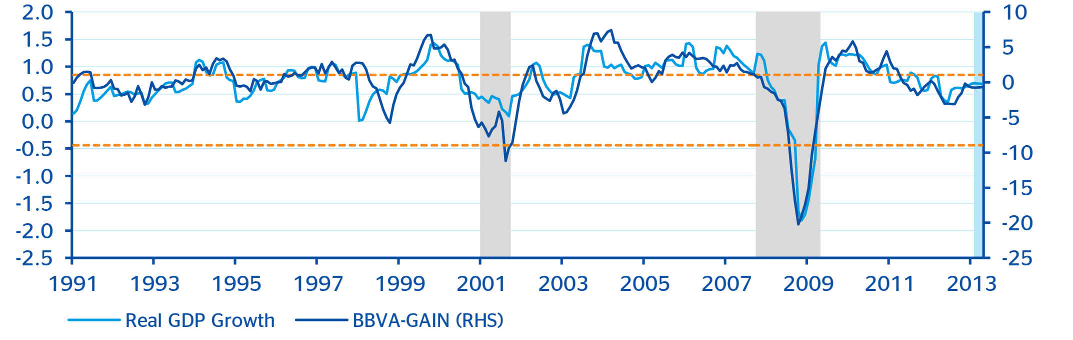
Tracking Indicators for Global Activity in Real Time

- **Broad economic indicator of global business conditions**
  The BBVA Global Activity Index (BBVA-GAIN) is a monthly index designed to gauge overall economic activity. It is based on the notion that co-movements among macroeconomic and financial variables are reflecting an underlying common factor which represents global business cycle dynamics, a non-observed latent variable. As such, BBVA-GAIN has been built upon a single-index dynamic factor model framework to produce **high frequency measurement of the global macroeconomic activity** in a systematic, replicable, and statistically optimal manner from GDP growth, industrial production, Purchasing Managers' Index (PMI), employment, new export orders and a global composite index based on our geographical BBVA Financial Stress Indexes (FSI).

- **Real Time indicator of recession and recoveries. Accurate in capturing historical business cycle turning points**
  Since **BBVA-GAIN** is a summary index, its reliability depends on the accuracy of the data. This assumption has been proved right in the past. We have found that the common factor performs well as a global business cycle indicator since it is extremely consistent with the history of the global business cycle. Accordingly, for an in-depth analysis of the accuracy of the common factor used to compute business cycle inferences, we conduct Markov-Switching regime estimations and provide smoothed probabilities of recession. As a matter of fact, we ascertain that the correlation of global GDP growth with respect to BBVA-GAIN is higher than 0.8, indicating the **high potential of the indicators used in the model to capture global business cycle turning points.** When using this index, trend direction is the most important element – not necessarily the value when the index is above/below a certain figure.

- **It can also be used to predict quarterly GDP growth (backcasts, nowcasts and forecasts)**
  Our extension of Aruoba and Diebold (2010) allows us to examine the information content of additional real activity data, survey indexes and financial indicators to **produce short-term forecasts of global GDP growth.** All in all, we strongly consider that our BBVA-GAIN is a valid tool to be used for short-term analysis.

Chart 1
BBVA- GAIN and world GDP (%, QOQ) on a monthly basis (Updated March 6, 2013). Shading corresponds to recession and blue corresponds to forecasts:



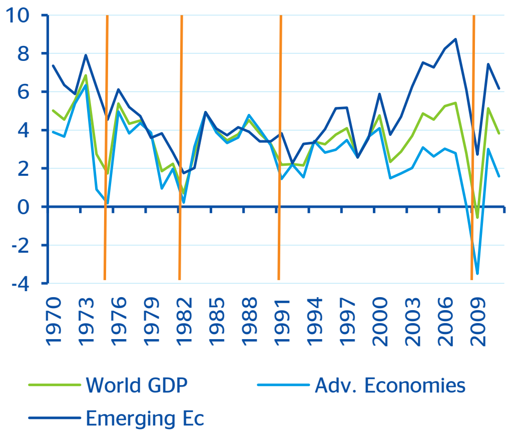
Source: BBVA Research

1. Introduction

The world has seen four global recessions since World War II: 1975, 1982, 1991, and 2009. Each recession led to fears of an economic debacle but each time the global economy managed to recover in a year or two. The global recession of 2009, which followed the financial market crisis triggered by the failure of the investment banking firm Lehman Brothers the year before, was the worst of the four recessions and the most synchronized across countries (see Chart 2). Some worried that the world would relive the Great Depression of the 1930s. Luckily, and as a result of policy actions that were often aggressive and unconventional, that did not come to pass. Since 2010, the global economy has been on the road to recovery – albeit fragile.

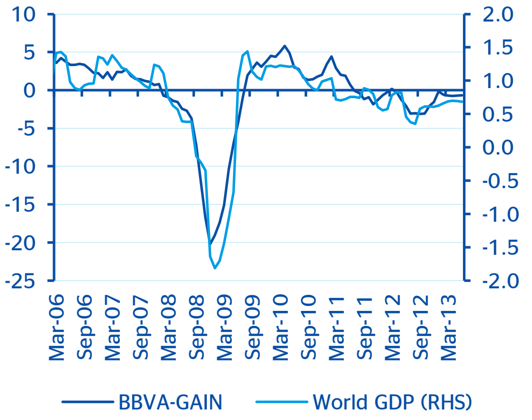
The so-called "Great Recession" of 2009 came as a huge shock to policymakers and economic agents. The sudden and grave downturn in the global economy triggered drastic reactions by policymakers who implemented monetary and fiscal policies to offset the adverse economic situation. As a result, when the economy began to recover, the economic agents seemed to acknowledge the need for new tools to monitor economic developments on a high frequency basis. At times of great uncertainty, having the most up-to-date information on the changes in the economy becomes paramount. Economic data are published with a lag. So, for example, at this point (third month of Q1) our most up-to-date information on GDP is from Q4 2012 while the advanced estimates of major economies for Q1 2013 are expected to be released by mid-May. In addition to such significant lags, the size and volatility of cyclical movements in recent years have once again raised the issue for the need to develop tools that will define the state of the economy in real time.

Chart 2
Breakdown of world GDP (%, YOY)



Source: World Economic Outlook, IMF

Chart 3
BBVA-GAIN and world GDP (%, QOQ) on a monthly basis (Updated March 4, 2013)



Source: BBVA Research

2. Methodology

We use a small-scale single-index dynamic factor model to produce an accurate economic indicator of global business conditions in real time. Each indicator in the model is a priori given equal weighting in the calculations. The procedure then assigns different weights to different variables depending on how important they turn out to be in capturing fluctuations in the entire set of variables. A simple Principal Component Analysis (PCA) which uses the variance-covariance matrix of the data to create new variables[1] (components) would only capture contemporaneous correlations. Therefore, it is important to highlight that our approach is framed under a Dynamic Factor Analysis context, which is able to capture more complicated patterns of lead and lag correlations across the indicators. This procedure is therefore ideal for creating our BBVA-GAIN as it allows us to combine information from different types of economic variables, mixed frequencies and ragged ends.

The dynamic factor model used is therefore based on the idea that economic indicators share a common business cycle component such that they exhibit high statistical correlation with the global GDP growth rate. In addition to the correlation criteria, the economic indicators should use the published data for the quarter before the corresponding GDP figure becomes available, and they must be relevant in the model from both theoretical and empirical points of view. Thus the evolution of each of the indicators i for the period t, z_t^i can be broken down into the sum of two stochastic unobservable components. The first component, x_t, usually called “common factor”, includes the combined dynamics of all the indicators and can be identified with the global economic cycle. The second component, u_t^i, known as the idiosyncratic component, refers to the particular dynamics of indicator i during period t:

$$z_t^i = \beta_i x_t + u_t^i$$

The movement of the common and idiosyncratic components is established by autoregressive models of order p and q:

$$x_t = \rho_1 x_{t-1} + \ldots + \rho_p x_{t-p} + e_t$$

$$u_t^i = d_1^i u_{t-1}^i + \ldots + d_q^i u_{t-q}^i + \varepsilon_t^i$$

In this case, e_t and ε_t^i are non-observable error terms that are assumed to be independent and not serially correlated. Mariano and Murasawa (2003) propose that if we consider the quarterly series as the weighted sum of its monthly expressions, the above model could be represented in state-space form and estimated by maximum likelihood using Kalman filtering.

The methodology used is in line with the seminal proposal of Stock and Watson (1991), since we use a small-scale single-index dynamic factor model to produce an accurate economic indicator of global business conditions in real time. As in the Stock-Watson proposal, the model benefits from the information provided by several monthly coincident economic indicators. In addition, we use the approach proposed by Aruoba and Diebold (2010) on how to adjust a factor model to handle the different start and finish dates of the indicators, as they are typically available in real-time forecasting due to differing release timeliness. In short, we believe that such an extension is extremely useful for dealing with monthly and quarterly indicators, which allow us to include world real GDP as an additional coincident indicator to the constituent set of indicators[2]. Finally, the mixing frequencies procedure along with the model’s dynamic properties and its state-space representation are exhaustively developed in the appendix.

1: which are uncorrelated linear combinations of the original variables.
2: By implementing the extension of Camacho and Doménech (2012) we obtained better statistical properties, including one-month leading financial indicators, as highlighted in the following section.

3. The model

The BBVA Global Activity Index (BBVA-GAIN) aims to fill this gap and is based on the notion that co-movements among macroeconomic variables reflect an underlying common factor. This monthly factor gauges the global business cycle dynamics, a non-observed latent variable. Our data set (Table 1) covers most of the widely-used global activity indicators as it contains a set of key real variables (hard indicators), confidence variables (soft indicators) and financial indicators. The main constraint in expanding it to include more variables is the limited availability of high-frequency and timely data on the global economy. The methodology used is based on the seminal proposal of Stock and Watson (1991)[3].

Table 1
Variables included in BBVA-GAIN

	Series	Sample	Source	Publication delay	Data transformation
1	World Real Gross Domestic Product (GDP, SAAR, Mil. USD)	1991.1 2012.12	BBVA Research	2 to 3 months	QGR
2	Industrial Production Index (IPI) - Global (SA, 2000=100)	1992.1 2012.12	CPB	2.5 months	MGR
3	JP Morgan Global PMI – (50+=Expansion)	1998.1 2013.2	Markit Economics	0 months	Level
4	Employment Index - Global: Manufacturing (50+=Expansion)	1998.1 2013.2	Markit Economics	0 months	Level
5	New Export Orders Index – Global: Manufacturing (50+=Expansion)	1998.1 2013.2	Markit Economics	0 months	Level
6.1	VIX - Chicago Board Options Exchange Market Volatility Index	1991.1 2013.2	CBOE - Bloomberg	0 months	Level
6.2	Financial Stress Index - Global	1991.1 2013.2	BBVA Research	0 months	Level

Notes: SA means seasonally adjusted. MGR, QGR and L stand for monthly growth rates, quarterly growth rates and levels, respectively. CPB: Netherlands Bureau for Economic Policy Analysis (World Trade Monitor).
Source: BBVA Research

Every six months, the IMF releases its estimates of world GDP on a yearly basis and it sporadically releases its quarterly estimates. In this sense, the benefits of more frequent timely releases of our world GDP estimates are eventually high than those costs related to longer publication delay and less frequent updates. As a result, world real GDP has been selected as a proxy for global activity, based on our own estimates. This global cycle reference combines an appropriate representativeness of global activity which is based on the aggregation of national quarterly growth rates (Quarterly National Accounts) of 69 countries and has a weighting of 92% with respect to world GDP ppp (on average, 1980-2012). It is updated on a quarterly basis. The cross-correlation between both series is over 0.9.

The data set managed in this sample spans the period from January 1991 to February 2013. With respect to the potential set of indicators that could be used in the analysis, we only selected those that verify four properties. Firstly, they must exhibit high statistical correlation with the global GDP growth rate. Secondly, they should refer to the data for the quarter in question that were published before the GDP figure became available in the respective quarter.

3: For further technical details, please refer to the methodological section.

Thirdly, they must be relevant in the model from both theoretical and empirical points of view. Lastly, they must be available in at least one third of the sample.

Our model is based on the notion that co-movements among the macroeconomic variables have a common element – the common factor that moves in accordance with the global business cycle dynamics (see Chart 3). The derived index provides a single, summary measure of a factor common to selected global economic data and can also be used to predict global quarterly GDP growth in blocks of three quarters, i.e. backcasts, nowcasts and forecasts (see Chart 4).

Thus, it will be interesting to see whether the delay in the publication of some of the selected indicators (GDP, industrial production, global PMI, employment and new export orders) will affect the forecast performance of global economic activity and whether it can be improved upon in real time by including additional early available indicators. For this purpose, the final enlargement of the model is conducted by including two alternative financial indicators [i.e. implied volatility (VIX), BBVA Financial Stress Index (FSI)[4]]. Notably, we find that the correlation, if any, between global GDP growth and both indicators arises when they are assumed to lead from one to two quarters. Based on these results, financial indicators are assumed to lead the business cycle dynamics in h months, with h=1, ..., 12. To select the optimal number of leads, we compute the log likelihood associated with these lead times. As a result, the maximum of the likelihood function is achieved when they lead the common factor by one month. We opt for M3 (including composite BBVA FSI) because of its wider range to capture potential in-sample fluctuations. The estimated loading factors are displayed in Table 2.

Table 2
Loading factors

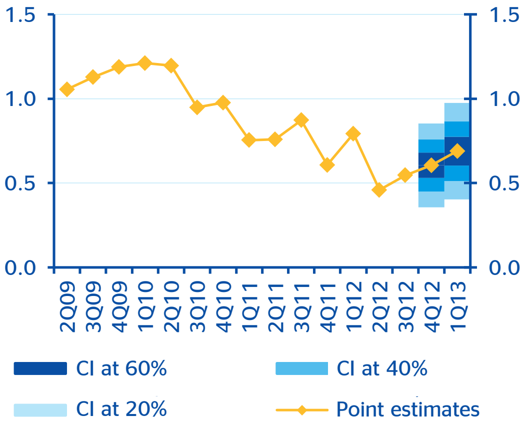
Model	GDP	IPI	PMI	Emp	NExpO	VIX	FSI	Correlation
M1	0.06 (0.01)	0.16 (0.02)	0.23 (0.01)	0.17 (0.01)	0.23 (0.02)	---	---	0.81
M2	0.06 (0.01)	0.14 (0.02)	0.22 (0.01)	0.17 (0.02)	0.22 (0.02)	-0.10 (0.02)	---	0.85
M3	0.05 (0.01)	0.13 (0.02)	0.21 (0.01)	0.16 (0.02)	0.21 (0.02)	---	-0.08 (0.01)	0.83

Notes: The loading factors (standard errors are in brackets) measure the correlation between the common factor and each of the indicators appearing in columns. See Table 1 for a description of these indicators.
Source: BBVA Research based on own estimates

To check empirically whether the business cycle information that can be extracted from the common factor agrees with the global business cycle, world GDP growth along with shaded areas that refer to our estimates of smoothed probabilities of recession are plotted in Chart 5.

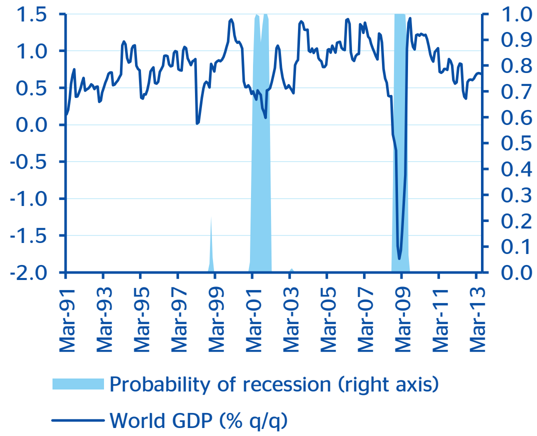
4: The BBVA Research Financial Stress index (FSI) factors in credit risk (5-year sovereign CDS, non-financial CDS and financial CDS), volatility (equity, interest rate and exchange rate) and liquidity tension (interbank rate spread and the 3-month risk-free rate) measures. We have weighted both the US and Eurozone's FSIs to proxy the global financial stress. They cover a wide share of financial markets able enough to capture significant global fluctuations.

Chart 4
Global: observed GDP growth and forecasts based on BBVA-GAIN (%, Q/Q) March 4, 2013



Source: BBVA Research based on Haver Analytics

Chart 5
World GDP (QOQ, %) and probability of global recession



Source: BBVA Research based on own estimates

The figure shows that the coincident indicator performs well as a business cycle indicator since it is extremely consistent with the history of the global business cycle. During periods that are classified as expansions, the values of the coincident indicator are usually positive. At around the beginning of the commonly-dated recessions, the common factor falls drastically and remains low until around the dates when BBVA world growth pinpoints the end of the recessions.

To formally test whether our BBVA-GAIN is an accurate real time indicator of recession and recoveries, let us assume that there is a regime switch in the index itself[5]. For this purpose, we assume that the switching mechanism of the common factor at time t, x_t, is controlled by an unobservable state variable, s_t, which is allowed to follow a first-order Markov chain. Following Hamilton (1989), a simple switching model may be specified as:

$$x_t = c_{s_t} + \sum_{j-1}^{p} \alpha_j x_{t-j} + \varepsilon_t$$

where $\varepsilon_t \sim iidN(0,\sigma)$ [6]. The nonlinear behavior of the time series is governed by c_{s_t}, which is allowed to change within each of the two distinct regimes, $s_t = 0$ and $s_t = 1$. The Markov-Switching assumption implies that the transition probabilities are independent of the information set at $t-1$, X_{t-1} and of the business cycle states prior to $t-1$. Accordingly, the probabilities of staying in each state are

$$p(s_t = i/s_{t-1} = j, s_{t-2} = h, \ldots, X_{t-1}) = p(s_t = i/s_{t-1} = j) = p_{ij}$$

Taking the maximum likelihood estimates of parameters, reported in Table 3, in the regime represented by $s_t = 0$, the intercept is positive and statistically significant while in the regime represented by $s_t = 1$, it is negative and statistically significant. Therefore, we can associate the first regime with expansions and the second regime with recessions. Based on the related literature, expansions are more persistent than downturns (estimated p_{00} and p_{11} of about 0.99

5: Camacho, Pérez-Quirós and Poncela (2012) show that although the fully Markov-Switching dynamic factor model is generally preferred to the shortcut of computing inferences from the common factor obtained from a linear factor model, its marginal gains rapidly diminish as the quality of the indicators used in the analysis increases. This is precisely our case.
6: Based on related literature, we did not include any lags in the factor. We checked that the resulting model is dynamically complete in the sense that the errors are white noise.

and 0.90, respectively). These estimates are in line with the well-known fact that expansions are, on average, longer than contractions.

Table 3
Markov-switching estimates

c0	c1	σ^2	p00	p11
0.85 (0.17)	-8.95 (0.64)	7.09 (0.61)	0.99 (0.00)	0.90 (0.06)

Notes. The estimated model is , where x_t is the common factor, s_t is an unobservable state variable that governs the business cycle dynamics, εt-$iidN(0,\sigma)$, and $p\ (s_t = i/s_{t-1} = j\ ) = p_{ij}$.
Source: BBVA Research based on own estimates

That said, Figure 5 illustrates the great ability of the model to capture the global business cycle and validates the interpretation of state $s_t = 1$ as a recession and the probabilities plotted in this chart as probabilities of being in recession.

All in all, our main empirical results are summarized as follows. Firstly, we have found that the coincident indicator (BBVA-GAIN) performs well as a global business cycle indicator since it is extremely consistent with the history of the global business cycle[7]. Secondly, the estimated factor loadings, which measure the correlation between the non-financial indicators and the common factor (see Table 2) are all positive, indicating that such economic indicators are pro-cyclical. As one might expect, financial indicators such as implied volatility (VIX), which shows global risk aversion, and our BBVA Financial Stress Index (FSI) become countercyclical. In all cases, the factor loadings are statistically significant. Thirdly, we ascertain that the correlation of global GDP growth with respect to the BBVA-GAIN is higher than 0.8, indicating the high potential of the indicators used in the model to explain global growth.

7: Represented by world real GDP quarterly growth estimates (BBVA Research)

4. Conclusions

The so-called "Great Recession" of 2009 came as a huge shock to policymakers and economic agents. The sudden and grave downturn in the global economy triggered drastic reactions by policymakers who implemented monetary and fiscal policies to offset the adverse economic situation. When the economy began to recover, the economic agents seemed to acknowledge the need for new tools to monitor economic developments on a high frequency basis. At times of great uncertainty, having the most up-to-date information on the changes in the economy becomes paramount.

The BBVA Global Activity Index (BBVA-GAIN) is a monthly index designed to gauge overall economic activity. It has been built upon a dynamic factor model framework to produce high frequency measurement of the global macroeconomic activity in a systematic, replicable, and statistically optimal manner from world GDP, industrial production, Purchasing Managers' Index (PMI), employment data, new export orders and a global composite indicator based in our geographical BBVA Financial Stress Indexes (FSI). Our extension of Aruoba and Diebold (2010) allows us to examine the information content of additional real activity data, survey indexes and financial indicators to produce accurate short-term forecasts of global GDP growth.

Accordingly, for an in-depth analysis of the accuracy of the common factor used to compute business cycle inferences, we conduct Markov-Switching regime estimations and provide smoothed probabilities of recession. We have found that the coincident indicator performs well as a global business cycle indicator since it is extremely consistent with the history of the global business cycle. In addition, we ascertain that the correlation of global GDP growth with respect to BBVA-GAIN is higher than 0.8, indicating the high potential of the indicators used to capture global business cycle turning points. Therefore, we strongly consider that our BBVA-GAIN is a valid tool to be used for short-term analysis.

References

Aruoba, B., and Diebold, F. 2010. Real-time macroeconomic monitoring: Real activity, inflation, and interactions. *American Economic Review: Papers and Proceedings* 100: 20-24.

Camacho, M. and Doménech, R. 2012. MICA-BBVA. A Factor Model of Economic and Financial Indicators for Short-term GDP Forecasting. *SERIEs: Journal of the Spanish Economic Association,* forthcoming.

Camacho, M., Pérez-Quirós, G. and Poncela, P. 2012. Markov-switching dynamic factor models in real time. CEPR *Discussion Papers* 8866.

Gianone, D., Reichlin, L. and Small, D. 2008. Nowcasting: The real-time informational content of macroeconomic data. *Journal of Monetary Economics* 55:665-676.

Hamilton, J., 1989. A new approach to the economic analysis of nonstationary time series and the business cycles. *Econometrica* 57: 357-384.

Mariano, R., and Murasawa, Y. 2003. A new coincident index of business cycles based on monthly and quarterly series. *Journal of Applied Econometrics* 18: 427-443.

Stock, J., and Watson, M. 1991. A probability model of the coincident economic indicators. In Kajal Lahiri and Geoffrey Moore editors, *Leading economic indicators, new approaches and forecasting records. Cambridge University Press,* Cambridge.

Wheelock D., and Wohar, M. 2009. Can the term spread predict output growth and recessions? A survey of the literature. *Federal Reserve Bank of St. Louis Review* 91: 419-440.

Technical Appendix

A.1. Mixing frequencies

Let us assume that the level of quarterly GDP, Y_t^*, can be decomposed as the sum of three unobservable monthly values Y_t , Y_{t-1} , Y_{t-2} . For instance, the GDP for the third quarter of a given year is the sum of the GDP corresponding to the three months of the third quarter

(1) $Y^*_{III} = Y_{09} + Y_{08} + Y_{07}$

or equivalently

(2) $$Y^*_{III} = 3\left(\frac{Y_{09} + Y_{08} + Y_{07}}{3}\right)$$

Among others, Mariano and Murasawa (2003) have shown that if the sample mean of equation (2) can be well approximated by the geometric mean

(3) $Y^*_{III} = 3(Y_{09}Y_{08}Y_{07})^{1/3}$

then the quarterly growth rates can be decomposed as weighted averages of monthly growth rates. Taking logs of expression (3) leads to

(4) $$lnY^*_{III} = ln3 + \frac{1}{3}(lnY_{09} + lnY_{08} + lnY_{07})$$

which allows us to compute the quarterly growth rate for the third quarter as

(5) $$lnY^*_{III} - lnY^*_{II} = \frac{1}{3}(lnY_{09} + lnY_{08} + lnY_{07}) - \frac{1}{3}(lnY_{06} + lnY_{05} + lnY_{04}) =$$
$$= \frac{1}{3}[(lnY_{09} - lnY_{06}) + (lnY_{08} - lnY_{05}) + (lnY_{07} - lnY_{04})]$$

and by redefining these terms as $y^*_{III} = lnY^*_{III} - lnY^*_{II}$, and $y_j = lnY_j - lnY_{j-1}$, one can define

(6) $$y^*_{III} = \frac{1}{3}y_{09} + \frac{2}{3}y_{08} + y_{07} + \frac{2}{3}y_{06} + \frac{1}{3}y_{05}$$

This expression can directly be generalized as

(7) $$y^*_t = \frac{1}{3}y_t + \frac{2}{3}y_{t-1} + y_{t-2} + \frac{2}{3}y_{t-3} + \frac{1}{3}y_{t-4}$$

This aggregation rule represents the quarterly growth rate as the weighted sum of five monthly growth rates.

A.2. Dynamic properties

The model follows the lines proposed by Aruoba and Diebold (2010), which are extensions of the dynamic factor model suggested by Stock and Watson (1991). Let us assume that the indicators included in the model admit a dynamic factor representation. In this case, the variables can be written as the sum of two stochastic components: a common component, x_t, which represents the overall business cycle conditions, and an idiosyncratic component, which refers to the particular dynamics of the series. The underlying business cycle conditions are assumed to evolve with *AR(p1)* dynamics:

(8) $x_t = \rho_1 x_{t-1} + \ldots + \rho_{p1} x_{t-p1} + e_t$

where $e_t \sim iN(0, \sigma_e^2)$.

Apart from constructing an index of the business cycle conditions, we are interested in computing accurate short-term forecasts of GDP growth rates. To compute these forecasts, we start by assuming that the evolution of the monthly growth rates depends linearly on x_t and on their idiosyncratic dynamics, u_t^y, which evolve as an AR(p2):

(9) $y_t = \beta_y x_t + u_t^y$

(10) $u_t^y = d_1^y u_{t-1}^y + \ldots + d_{p2} u_{t-p2}^y + \varepsilon_t^y$

where $\varepsilon_t^y \sim iN(0, \sigma_y^2)$. In addition, the idiosyncratic dynamics of the k monthly indicators can be expressed in terms of autoregressive processes of $p3$ orders:

(11) $z_t^i = \beta_i x_t + u_t^i$

(12) $u_t^i = d_1^i u_{t-1}^i + \ldots + d_{p3} u_{t-p3}^i + \varepsilon_t^i$

where $\varepsilon_t^i \sim iN(0, \sigma_y^2)$. Finally, we assume that all the shocks e_t, ε_t^y, and ε_t^i, are mutually uncorrelated in cross-section and time-series dimensions.

A.3. State space representation

Let us first assume that all the variables included in the model were observed at monthly frequencies for all periods. Since GDP is used in quarterly growth rates, y_t^*, according to expressions (7)-(9) it enters into the model as:

(13) $$y_t^* = \beta_y\left(\frac{1}{3}x_t + \frac{2}{3}x_{t-1} + x_{t-2} + \frac{2}{3}x_{t-3} + \frac{1}{3}x_{t-4}\right) + \left(\frac{1}{3}u_t^y + \frac{2}{3}u_{t-1}^y + u_{t-2}^y + \frac{2}{3}u_{t-3}^y + \frac{1}{3}u_{t-4}^y\right)$$

The unit roots of hard indicators are accounted for by using the time series in their monthly growth rates. Soft indicators, such as Purchasing Managers' Index, are used in levels. Calling Z_t^* the monthly growth rates of hard or the level of soft variables, the dynamics of these variables are captured by:

(14) $Z_{it}^* = \beta_i x_{t-j} + u_t^i$

with $i = 1, 2, \ldots, k1$.

Finally, following the suggestions of Wheelock and Wohar (2009), financial indicators are treated as leading indicators of the current business conditions[8]. Accordingly, following the lines suggested by Camacho and Domenech (2012), we establish the relationship between the level of the financial indicator, Z_{ft}^{*} , and the *h*-period future values of the common factor, as follows:

(15) $Z_{ft}{}^{*} = \beta_f x_{t+h} + u_t^f$

As shown in the methodology's section, this model can be easily formulated in state-space representation and estimated by using the Kalman filter. However, we assumed that the time series do not contain missing data which becomes clearly an unrealistic assumption since our data exhibits ragged ends and mixing frequency problems. Fortunately, Mariano and Murasawa (2003) show that the Kalman filter can be used to estimate the model's parameters and infer unobserved components and missing observations. These authors propose replacing the missing observations with random draws ∂_t , whose distribution cannot depend on the parameter space that characterizes the Kalman filter[9]. Hence, while this procedure leaves the matrices used in the Kalman filter conformable, the rows containing missing observations will be skipped from the updating in the recursions and the missing data are replaced by estimates. In this way, forecasting is very simple since forecasts can be viewed as missing data located at the end of the model's indicators. Without loss of generalization, we assume that our model contains only GDP, one non-financial monthly indicator and one financial monthly indicator, which are collected in the vector $Y_t = (y_t{}^{*}, Z^{*}_{it}, Z_{{*}ft})$. For simplicity sake, we also assume that p1 = p2 = p3 = 1, and that the lead for the financial indicator is h = 1. In this case, the observation equation, $Y_t = Z\alpha_t$, is.

$$\begin{pmatrix} y_t^{*} \\ Z_{it}^{*} \\ Z_{ft}^{*} \end{pmatrix} = \begin{pmatrix} 0 & \frac{\beta_y}{3} & \frac{2\beta_y}{3} & \beta_y & & \frac{2\beta_y}{3} & \frac{\beta_y}{3} & \frac{1}{3} & \frac{2}{3} & 1 & \frac{2}{3} & \frac{1}{3} & 0 & 0 \\ 0 & \beta_i & 0 & & \dots & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ \beta_f & \beta_f & & & & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x_{t+1} \\ x_t \\ \vdots \\ x_{t-4} \\ u_t^y \\ \vdots \\ u^y{}_{t-4} \\ u_t^i \\ u_t^f \end{pmatrix}$$

It is worth noting that the model assumes contemporaneous correlation between non-financial indicators and the state of the economy, whereas for financial variables, the correlation is imposed between current values of the indicators and future values of the common factor. The transition equation, $\alpha_t = T\alpha_{t-1} + \eta_t$, is

8: To facilitate the analysis, following Giannone, Reichlin and Small (2008) financial data enter into the model as monthly averages since the bulk of information compiled from the indicators is monthly.
9: We assume that $\partial_t \sim N(0, \sigma_\partial^2)$ for convenience but replacements by constants would also be valid.

$$
\begin{pmatrix} x_{t+1} \\ x_t \\ \vdots \\ x_{t-4} \\ u_t^y \\ \vdots \\ u_{t-4}^y \\ u_t^i \\ u_t^f \end{pmatrix}
=
\begin{pmatrix}
\rho_1 & \dots & 0 & 0 & 0 & \dots & & & 0 \\
1 & & & 0 & & \dots & & & 0 \\
\vdots & \ddots & & \vdots & & \dots & & & \vdots \\
0 & \dots & 1 & 0 & & \dots & & & 0 \\
0 & \dots & & 0 & d_1^y & 0 & 0 & & 0 \\
\vdots & \dots & & \dots & \ddots & & & & \vdots \\
0 & \dots & & & & 1 & 0 & & 0 \\
0 & \dots & & & & 0 & 0 & d_1^i & 0 \\
0 & \dots & & & & 0 & 0 & 0 & d_1^f
\end{pmatrix}
\begin{pmatrix} x_t \\ x_{t-1} \\ \vdots \\ x_{t-5} \\ u_{t-1}^y \\ \vdots \\ u_{t-5}^y \\ u_{t-1}^i \\ u_{t-1}^f \end{pmatrix}
\begin{pmatrix} e_{t+1} \\ e_t \\ \vdots \\ e_{t-4} \\ \varepsilon_t^y \\ \vdots \\ \varepsilon_{t-4}^y \\ \varepsilon_t^i \\ \varepsilon_t^f \end{pmatrix}
$$

where $\eta_t \sim iN(0,Q)$ and $Q = diag\,(\sigma_e^2, 0, \dots, 0, \sigma_y^2, 0, \dots, 0, \sigma_i^2, \sigma_f^2)$

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