METHODOLOGY FOR THE HIGH-FREQUENCY FORECASTING MODEL FOR MEXICO

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ABSTRACT

The high-frequency forecasting technique combines the use of high-frequency information, times series equations, and regression analysis. The methodology estimates the quarterly GDP by three independent approaches: production, expenditure, and by principal components. It is based on the same approach used in the preparation of the national accounts, to estimate the production of final goods and services in an open economy. The model constitutes a system of purely econometric relationships with no subjective intervention of the economist in the determination of arbitrary assumptions or initial conditions. This methodology allows us to anticipate the current quarter GDP, in advance of the official release, using monthly economic indicators.

I.- INTRODUCTION

This document focuses on the description and development of the methodology to construct a High-Frequency Forecasting Model. We explain the methodological approach used by the econometric technique of the high-periodicity models, also called "current quarter models".

The extensive use and development of the econometric technique for high-frequency models began at the end of the 80's and beginning of the 90's at the University of Pennsylvania, and under the leadership of Lawrence R. Klein, Nobel Laureate in Economics 1980. This methodology appeared as a technical advance in the field of applied econometrics, and as a response to the market demand for very short-term econometric tools.

*/ This document is part of my Ph.D. dissertation research, supervised by Lawrence R. Klein, 1980 Nobel Laureate in Economics. At present, I am the Director of the Center for Economic Forecasting of Mexico (CKF) in Philadelphia, Pennsylvania, USA.

A high-frequency forecasting model is defined as a purely econometric system with no subjective intervention of the economist in the determination of arbitrary assumptions or initial conditions. The methodology combines high-frequency information, times series equations, and regression analysis. The model was originally designed to anticipate the quarterly GDP for the U.S. economy, in advance of the official release date.

The methodology estimates the GDP by three independent approaches: production, expenditure, and by principal components. It is based on the same approach used in the preparation of the National Accounts, to estimate the final production of goods and services in an open economy.

In order to explain the high-frequency methodology to construct the model for the current quarter GDP, this document presents a brief review of Lawrence Klein's pioneer works on this topic, and some other related studies. Furthermore, we explain the general methodology and our proposal for the specific case of the Mexican economy. At the end, we present some concluding remarks.

II.- BIBLIOGRAPHIC REVIEW

Until the end of the 50's, the information for national and social accounts was available only on an annual frequency in all the countries. This database, in turn, determined the annual periodicity of the econometric models. It was not until the beginning of the 60's when a few industrialized countries began to generate quarterly databases, which would enable econometricians to construct higher-periodicity models, in this case quarterly models.

Nowadays, the flow of economic and financial information is basically continuous or in real time, allowing the construction of models with higher periodicity. In this regard, we can classify the annual econometric models as "low-frequency models", and those of higher periodicity as "high-frequency models".

One of the pioneer works in the field of construction of higher periodicity models was the quarterly model of Wharton Econometrics, headed by Lawrence Klein and constructed at the beginning of the 70's. At that time, the quarterly model was used to generate the initial conditions for the annual model. In other words, the quarterly model generated forecasts for the first two years, and the annual model was given to take those estimates for the short run, and from there the annual model generated its own forecasts for the medium term.

A different approach was presented by Liu and Hwa in 1974[1/]. They used monthly series to interpolate quarterly data from national accounts; and then, they elaborated a system of

[1/] Liu and Hwa (1974), also mentioned in Klein and Park (1993).

monthly accounts. Based on this monthly system, they constructed a monthly macro model for the U.S. economy.

Further developments continued by the end of the 70's and into the 80's on the use of high-frequency information for forecasting purposes. Among these studies we can find the following: a).- the monthly econometric model of the Federal Reserve, used to estimate and to forecast the monthly national product; b).- the development of the VAR and VARMA models, which gives origin to the high-frequency model of the University of Michigan; c).- of course, the model of the University of Pennsylvania, which combines time series equations with regression analysis, and began to work at higher frequency by the end of the 80's.

A more recent procedure was used by Payne[2/] from the U.S. Department of Commerce. Payne's model tries to predict the GDP growth in anticipation of the official release from the Bureau of Economic Analysis. That study is also based on the use of high-periodicity information linked to the quarterly aggregate demand components. The model estimates GDP from the demand side only, although similar procedures could be developed for the income or production sides.

The original idea of the model of the University of Pennsylvania[3/] referred to the combination of high and low frequency information in macroeconometric models. This approach was based on the use of monthly information to estimate quarterly components of the national accounts. In other words, it tried to establish links between short and long-term models. The methodology included two types of variables that were used in two types of equations. The two variables were: monthly indicators and quarterly components from the national accounts. The equations were: ARIMA's associated with the extrapolation of the monthly indicators, and "bridge equations" to link monthly indicators with quarterly components. In this way, this methodology could be used to estimate GDP from both, expenditure and income side, as in the national accounts approach.

This original idea developed by L. Klein at the end of the 80's, constitutes an essential part of the high-frequency forecasting model for the U.S. economy, also known as "current quarter model" from the University of Pennsylvania. This model has been working since the beginning of the 90's and generates weekly updates for the current quarter GDP estimates of the U.S. economy.

Klein's model at present, Current Quarter Model (CQM)[4/], estimates the quarterly GDP through three different approaches: incomes, expenditures, and principal components of monthly indicators. The first two approaches follow the national accounts methodology, using monthly indicators to estimate the quarterly sub aggregates of GDP. The third approach is based on the statistical technique of the principal components extracted from a set of monthly

[2/] Payne (2000).
[3/] Klein and Sojo (1989).
[4/] Klein and Park (1993), Klein and Park (1995).

variables highly correlated with GDP. The model combines high-frequency information, time series equations and regression analysis. These three approaches generate three different estimates for the quarterly GDP, which are averaged to obtain a final estimate.

The details of each approach are explained in the following methodological section. Although for the case of Mexico we will use the production approach (value added) instead of the income side (due to the absence of information for quarterly income components), the general methodology remains the same.

III.- METHODOLOGICAL APPROACH

A.- The Macroeconomic Frame

The total production of final goods and services in an economy is called Gross Domestic Product (GDP). This measurement of total production is expressed by the fundamental macroeconomic identity[5/] :

$$GDP = Cp + Cg + I + \Delta S + X - M$$

where Cp stands for private consumption, Cg represents government consumption, I stands for gross fixed investment, ΔS is the change in inventory, and $X - M$ represents net exports.

The macroeconomic identity indicates that the total production in the economy is equal to the total absorption. But also, the identity can be expressed in terms of the payments received by production factors. In other words, the total production in an economy is exhausted by the payments to production factors, the latter constituting the income side.

In macroeconomic terms, we can say that the fundamental identity gives origin to three different approaches to compute the total production of the economy: production or value added, income, and expenditure. This macroeconomic methodology generates the National Income and Product Accounts (NIPA).

a).- Production or Value Added approach

This methodology computes the GDP through the value added in each productive sector or in each production process. It says, the supply of sectoral production of final goods and services.

[5/] Dornbusch and Fisher (1990), Rivera-Batiz (1994), Krugman and Obstfeld (1994).

In computing the value added, the national accounts use the value of gross production and subtract intermediate inputs, in order to avoid double counting in the final product.

$$\underset{\text{(Value Added)}}{\text{GDP}} = \underset{\text{Production}}{\text{Gross}} - \underset{\text{Inputs}}{\text{Intermediate}}$$

b).- Income approach

This method estimates the value of the total production of goods and services as the sum of all payments to production factors. It says, the value of total production is distributed as the income paid to all the factors that intervene in the production process.

Roughly speaking, we can say that the original factors intervening in the production process are: labor, capital, and land. In this way, the national accounts compute the GDP through the payment to workers (W), income paid to capital owners (P), rent paid to landowners (R), and interest payments (In), plus indirect taxes net of subsidies (Tx).

$$GDP = W + P + R + In + Tx$$

c).- Expenditure approach

This approach estimates the total output through the sum of all final expenses in the economy. In other words, it is equal to the sum of all the purchases of the national production by national residents and foreigners. The sum of all these expenses is also known as the total absorption of the economy.

The economy's total expenditure or absorption is equal to the sum of the private expenses of final goods and services (Cp), the expenses of the public sector (Cg), the gross investment of government and private sector (I), the change in inventory (ΔS), the value of exports of goods and services (X), less the value of imports of goods and services (M).

$$GDP = Cp + Cg + I + \Delta S + X - M$$

B.- The Model's Frame

The methodology used by the high-frequency forecasting model, to estimate the quarterly GDP, is based on three different approaches as well. The first two approaches come from the national accounts frame: production and expenditure side[6/]. The third approach comes from the statistical method of the principal components. With these three approaches, we obtain three different estimates of GDP, which are averaged to get the final estimate.

Both approaches, production and expenditure, follow the same methodology of the national accounts to compute the GDP. We do try to use the same monthly indicators that the statisticians of the national accounts use to estimate each component of the quarterly GDP. In this way, the high-frequency forecasting model tries to replicate the national accounts methodology (in two of its three approaches), to anticipate the quarterly GDP using high-periodicity information (monthly indicators).

The production and expenditure methods use two sets of variables that are used in two different types of equations. The first set of variables is the monthly indicators (I_{it}), which are the same or similar indicators to the ones used by the national accounts to estimate the quarterly components of GDP. The second set of variables is the quarterly components of GDP (N_{it}).

The monthly indicators I_{it}, give rise to the first set of equations, the ARIMA's that are used to obtain the future values of those monthly variables.

$$I_{i,t} = \alpha_{i1} \; I_{i,t-1} + \alpha_{i2} \; I_{i,t-2} + \ldots + \alpha_{ik} \; I_{i,t-k} + \beta_{i1} \; e_{i,t-1} + \ldots + \beta_{ik} \; e_{i,t-k}$$

In order to link the monthly estimates to the quarterly components of GDP, we form the 3-month average of the monthly indicators.

The second set of variables, which are the quarterly components, generates the second type of equations: "bridge equations". The bridge equations are used to establish the links between the monthly indicators and the corresponding quarterly aggregates of the national accounts.

$$N_{i,T} = \alpha_i + \beta_i \; I_{i,T} + \varepsilon_{i,T}$$

where I_{iT} represents the 3-month average of the monthly indicator, which is used in the equation of the quarterly component of GDP ($N_{i,T}$).

In this way, we establish the corresponding links between the monthly indicators and the quarterly aggregates of GDP, as the statisticians of the national accounts do.

If we use the bridge equation in percentage change, and if the monthly indicator is exactly the same as the one used by the statisticians of the national accounts, then we can

[6/] Because of the absence of quarterly information for the Income side of GDP, in the case of Mexico we use the production side instead of the income approach, which is a difference with the U.S. model.

expect that $\alpha_i = 0$ and $\beta_i = 1$. It says, the percentage change in I_{iT} should explain the percentage change in $N_{i,T}$.

Certainly, in the application of these two macroeconomic approaches (production and expenditure), we need to choose the same indicators used by the national accounts, or similar indicators at least. From here, we obtain two different estimates of GDP given by these two methods.

The third approach uses the statistical method of the principal components. This method is based on the idea of having a set of strategic variables, highly correlated with GDP, we can extract the main independent sources of variation, which are called the principal components. In other words, given a set of original indicators, we can construct a set of mutually non-correlated linear combination of variables that explains the total variation of the original set. We then use this set of principal components as the explanatory variables in the regression of GDP.

Now, in the application of the principal components method, we use two types of equations. The first is a set of equations given by the vector of principal components extracted from the original set of strategic indicators. The second is the regression of GDP as a function of the principal components.

Regarding the first set of equations, the principal components, suppose that we have an original set of explanatory variables (X_1, X_2, …., X_k) highly correlated with GDP, and from which we want to find its main independent sources of variation or principal components. The methodology of the principal components defines a vector of linear functions (Z_i) from the original variables (X_k) that captures the most of its variation[7/].

$$Z_i = a_{i1} X_1 + a_{i2} X_2 + \dots + a_{ik} X_k$$

Where the a's are chosen such that the variance of the Z's are maximized. Putting it in another way, the principal components method finds the vector of Z's, which are linear combinations, mutually non-correlated or independent, and with the maximum variance. Thus, Z_1 is the first principal component with the highest variance, Z_2 is the second principal component with the second highest variance (but not correlated with Z_1), and so on.

The second type of equation in the model of principal components, establishes the relationship between the quarterly GDP and the quarterly principal components extracted from the original variables (PC_i).

$$GDP_t = f\,(PC_i)$$

[7/] Maddala (1992), Dhrymes (1970), Greene (1997).

It is important to notice that the original set of variables is monthly, which determines that the principal components are also monthly. Therefore, we need to get the 3-month average of the principal components in order to be linked to the quarterly GDP equation.

With this third equation for GDP, we obtain the third quarterly estimate. This new estimate is averaged with the other two estimates, obtained from the production and expenditure side, in order to get the final estimate of the quarterly GDP.

Note that in here we use monthly data, estimate monthly principal components, and average the components, for use in quarterly regression. We could, alternatively, average the indicators into quarterly values and then find the principal components, and from this point proceed as in the other case.

IV.- GENERAL REMARKS

The methodology of the high-frequency forecasting model allows us to estimate the quarterly GDP through three different approaches: production, expenditure, and principal components. The three different approaches generate three independent estimates, which are averaged to obtain the final estimate of the quarterly GDP.

The high-frequency forecasting technique combines the use of high-periodicity information, time series equations, and regression analysis. This methodology allows us to anticipate the quarterly GDP in advance of the official release, and with certain degree of accuracy.

Given that the methodology generates a mechanical system of econometric relationships, the high-frequency forecasting model avoids the subjective intervention of the economist in the determination of arbitrary assumptions or initial conditions.

This methodology is based on the macroeconomic frame of the national accounts, which makes it feasible to be adapted to any other country with at least a system of quarterly national accounts and monthly information on economic and financial activity.

Finally, whenever new data become available (every month), the database can be immediately enlarged with all data revisions for prior periods and then generate new projections, with a Current Quarter Model , we can inch-along quarter-by-quarter.

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