

Box 2

Inclusion of the labor market in the 4GM model

Sara Naranjo-Saldarriaga
 José D. Pulido-Pescador
 Mario A. Ramos-Veloza*

Introduction

Banco de la República, the Central Bank of Colombia, continuously reviews and updates the tools used for macroeconomic forecasting and monetary policy analysis. These tools include macroeconomic models, which enable the collective analysis of inflation and economic growth dynamics in the medium term and serve as a quantitative framework for formulating monetary policy. One such model is the neo-Keynesian semi-structural model developed by González et al. (2020), which is known as 4GM. This methodology, based on the general structure of the International Monetary Fund's (IMF) Global Projection Model adapted to a small, open economy, is similar to that used by several central banks.

This Box presents an extension of the 4GM model, called 4GM-LM (4GM with labor market), which the Bank's technical staff began to use in this *Report*. This version expands the base model by integrating wage and unemployment dynamics. This addition enables a more rigorous analysis of the influence of labor market behavior on inflation, economic growth, and potential output, thereby making it possible to explicitly incorporate their implications for monetary policy decisions. A detailed description of the model is provided in Ramos-Veloza, Naranjo-Saldarriaga, and Pulido (2026).

1. Main changes from the original 4GM model

The original 4GM model consists of four main components: one for aggregate demand (IS curve), another for inflation (four Phillips curves covering goods, services, food, and regulated goods), a third for monetary policy (Taylor rule), and a final component for the exchange rate (open interest rate parity). The updated model adds two more components that represent the behavior of wages and the unemployment rate, as well as their connection to economic activity and prices, both in the short and long term.

The first additional block breaks down the unemployment rate into cyclical and trend components. The cyclical component of unemployment is explained by Okun's law, which links the cyclical nature of economic activity (the output gap) to that of unemployment. The trend component follows an autoregressive process with a long-term attractor, which allows persistent output gaps (as measured in a centered three-year moving window) to have some effect on the unemployment trend, a phenomenon known as hysteresis.

The second block models wage behavior in the economy.¹ Nominal wages are converted into real wages by deflating them with inflation expectations. Real wages are separated into

* The authors are members of the Macroeconomic Modelling Department. The opinions herein expressed are solely their responsibility and do not compromise the Bank or its Board of Directors

¹ The wage measure in the model corresponds to a dynamic factor that explains the common behavior among a set of five wage series. The series presents the median incomes of employed persons and workers with social security, both from DANE's Integrated Household Survey (GEIH, for its Spanish acronym, as well as the nominal wage indices from the sectoral surveys of industry, commerce, and construction published monthly by DANE.

cyclical and trend components. The cyclical component of real wages reflects the labor component of firms' marginal costs and, through this channel, affects the Phillips curves for the four price baskets. Thus, an increase in the real wage gap implies greater labor-market inflationary pressures, which affect prices. Meanwhile, the trends in real wages play a role similar to that of labor productivity, affecting potential output. Nominal wages are described by a new Phillips curve in which the unemployment rate gap serves as an indicator of labor market demand pressures. Thus, a tight (loose) labor market, where the unemployment gap is negative (positive), exerts upward (downward) pressure on nominal wages, which, in turn, raises (lowers) real wages.

Finally, in the new model, the aggregate demand and the potential output equations are modified to account for labor market effects. In particular, the Investment-Savings (IS) equation recognizes that changes in households' purchasing power, derived from labor-market conditions, influence their consumption, the main component of aggregate demand. Thus, both the unemployment and the real wage gaps directly affect the output gap. In addition, the economy's growth capacity (i.e., potential output) is affected by structural changes in the labor market, as reflected in movements in the trend components of the unemployment rate and real wages. In summary, there are four new mechanisms that connect the goods and services market with the labor market:

Okun's law establishes an inverse relationship between unemployment and output gaps. When the economy grows above its potential, unemployment tends to fall; conversely, when the economy contracts below its potential, unemployment tends to increase.

Effect of the labor market on aggregate demand: recognizes that the purchasing power of households directly influences consumption; therefore, the cyclical components of real wages and the unemployment rate affect aggregate demand.

Effects of structural changes in the labor market on potential output: shifts in the trend components of real wages and unemployment affect the economy's productive capacity and, consequently, potential output.

Finally, in addition to these changes, given the decline in oil's share in Colombia's exports in recent years, the new version of the model replaces oil prices with the terms of trade, an indicator that encompasses a broader set of prices for Colombia's export supply. Accordingly, the new version of the model includes three additional observable variables relative to the original: the unemployment rate, a wage indicator, and the terms-of-trade index. The model parameters are estimated using data from 2003 to 2025, Bayesian techniques for large-scale models, and an estimation algorithm that isolates pandemic-induced atypical fluctuations in the main macroeconomic variables, following Ferroni, Fisher, and Melosi (2024).

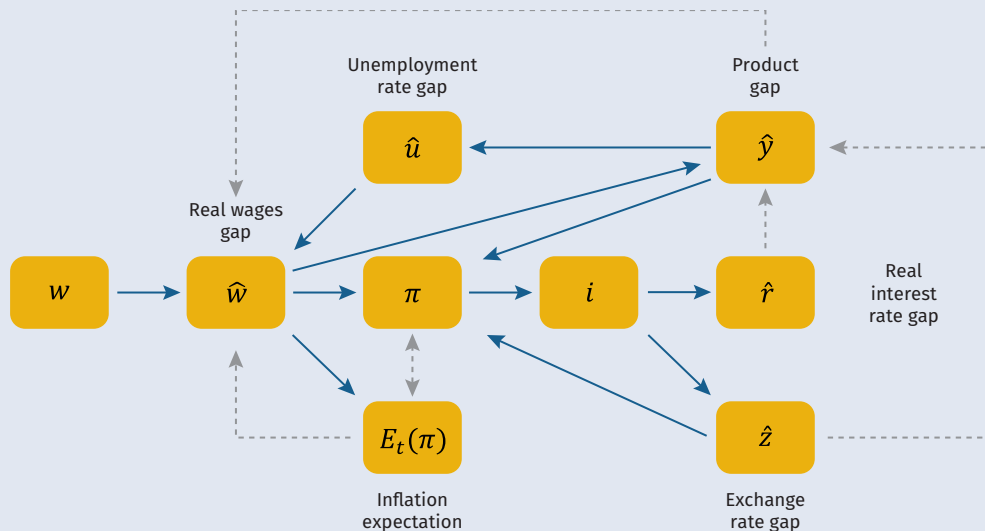
2. Advantages of the new model

The 4GM-LM model offers three advantages for understanding the Colombian economy compared to the previous version. First, it offers a richer economic structure. The new structure introduces labor-market shocks into the model, enabling a more comprehensive understanding of the economy's behavior. Accordingly, it is possible to distinguish whether a spike in inflation was caused by a demand shock, wage increase, trend increase in the unemployment rate, or external factors such as the price of exported goods (terms of trade).

Second, the new model provides a better understanding of the interactions among the goods and services markets and the labor market, as well as the stabilizing role of monetary policy. This is achieved by integrating causal relationships among the variables of both markets within a single analytical framework, which are activated when the economy faces shocks in either market. For example, an unexpected increase in nominal wages raises the cyclical component of real wages given price rigidities. This, in turn, increases production costs and initially raises aggregate demand, thereby raising inflation and inflation expectations, prompting the central bank to raise the policy interest rate to stabilize the economy (Graph B2.1).

Third, the model provides forecasts for the incorporated labor market variables that are internally consistent with those for economic activity and prices published in the *Monetary Policy Report*. Finally, the new version of the model remains compatible with other modules developed for the original 4GM (e.g., endogenous credibility).

Diagram B2.1
Nominal Wage Shock



Source: created by the authors.

Finally, the new version of the model remains compatible with other modules developed for the original 4GM (e.g., endogenous credibility of monetary policy; see Grajales et al., 2025) and with the technology for incorporating the balance of risks in the forecast (i.e., predictive densities; see Méndez-Vizcaíno et al., 2021).

3. Conclusion and utility for monetary policy

The new version of the 4GM model represents an improvement in monetary policy analysis in Colombia. It extends the framework for analyzing inflationary pressures by helping to discern whether these pressures stem from shocks in the goods and services market or the labor market. In addition, it offers a more complete view of deviations in economic behavior from levels compatible with the economy growing at an inflation rate equal to the long-term target (3%), considering not only the output gap but also the unemployment gap.

As with the original version, the semi-structural nature of this new model facilitates both adapting it to the data and communicating its results. In addition, it allows technical staff to explicitly incorporate their judgments regarding the behavior of economic activity, prices, and the labor market into forecasting exercises. The model’s main findings regarding the historical decomposition of shocks, its fit for forecasting, and its ability to simulate data properties are presented in Ramos-Veloza, Naranjo-Saldarriaga, and Pulido (2026).

References

- Ferroni, F.; Fisher, J. D.; Melosi, L. 2024. "Unusual Shocks in Our Usual Models", *Journal of Monetary Economics*, 147:103598. Elsevier.
- González, A.; Guarín, A.; Rodríguez-Guzmán, D.; Vargas-Herrera, H. 2020. "4GM: A New Model for the Monetary Policy Analysis in Colombia", *Borradores de Economía*, 1106. Banco de la República.
- Grajales-Olarte, A.; Hamann, F.; Naranjo-Saldarriaga, S.; Pulido, J. (2025). "Policy Implications of Losing Credibility: Lessons from Colombia's Post-pandemic Inflationary Surge", *Borradores de Economía* (núm. 1304), Banco de la República de Colombia.
- Méndez-Vizcaíno, J. C.; Guarín, A.; Anzola-Bravo, C.; Grajales-Olarte, A. (2021). "Characterizing and Communicating the Balance of Risks of Macroeconomic Forecasts: A Predictive Density Approach for Colombia", *Borradores de Economía*, 1178, Banco de la República.
- Ramos-Veloza, M.; Naranjo-Saldarriaga, S.; Pulido, J. 2026. "Wage Dynamics, Unemployment, and Inflation: Enhancing 4GM Semi-Structural Model", *Borradores de Economía*, 1341, Banco de la República.