Macroeconomic Effects of the Minimum Wage in an Emerging Economy with Labor Informality

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Abstract

We analyze how the minimum wage affects a typical emerging economy with high labor informality. Using an extended New Keynesian small open economy model, we find that an unexpected increase in the minimum wage disproportionately affects low-skilled workers, with limited effects on inflation and the monetary policy rate. A higher minimum wage raises production costs and induces the substitution of formal workers with informal labor and machinery, leading to lower output, employment, and net exports. We also find that the existence of a minimum wage alters the transmission of productivity, demand, and monetary shocks, resulting in a more persistent impact on macroeconomic variables and lower effectiveness of monetary policy in controlling inflation. While the minimum wage mitigates consumption inequality in the short run, it increases employment volatility. The macroeconomic implications of minimum wages are significant, and the mechanisms differ from those highlighted in the literature for advanced economies.

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1 Introduction

What are the macroeconomic effects of the minimum wage in an emerging economy? Recent studies on the aggregate effects of the minimum wage have focused on the United States, an advanced economy typically modeled as closed and without labor informality (Glover, 2019; Šauer, 2018).[1] These studies provide important insights into the macroeconomic effects of minimum wages and their interaction with inflation and monetary policy. They highlight the role of the labor effort response on productivity and prices and the effects of the monetary policy stance on aggregate GDP and inflation. Despite the relevance of these findings, they may not be directly applicable to emerging economies, where the minimum wage plays a larger role in the economic structure, the economy is better characterized as small and open, and the labor market has a higher level of informality.

In this paper, we examine the macroeconomic effects of the minimum wage in emerging economies through the lens of a two-agent New-Keynesian small open economy (TANK-SOE) model with formal and informal labor. We identify important adjustment mechanisms that are largely absent in advanced economies. A key factor distinguishing emerging and advanced economies, and potentially affecting the transmission of minimum wage shocks, is the percentage of workers affected by this wage policy. Using information from the International Labour Organization (ILO), Table 1 reports some labor market indicators that highlight the influence of minimum wages in emerging economies (EMEs) and advanced economies (AEs). On average, the percentage of workers earning the minimum wage is twice as high in EMEs as in AEs, and the share of informal workers is higher in EMEs than in AEs (70% vs. 8%).[2]

High informality may be associated with lower wages for informal workers because, by definition, they are not covered by labor regulations and are vulnerable to being paid below the minimum wage. Labor informality itself may be partly the result of the minimum wage itself, as a higher minimum wage creates a barrier to formality.[3] Finally, the higher importance of the minimum wage in EMEs is confirmed by the Kaitz ratio, which uses both median and mean wages as references.

We calibrate the model to reflect the Colombian economy, a typical small, open EME with a large informal sector (Table 1), and an explicit adjustment rule for the minimum wage that considers past inflation and past labor productivity growth. According to the ILO, informality in Colombia is around 60%, and the minimum wage is relatively high (90% of the median wage). These characteristics make Colombia an appropriate country for studying the macroeconomic effects of the minimum wage.

The analysis is divided in two parts. First, we analyze how an increase in the minimum wage affects key macroeconomic aggregates. Our main result indicates that an increase in the minimum wage leads to a substitution of low-skilled formal labor with machinery and informal labor. The presence of informality creates additional adjustment mechanisms that are more relevant (and possible) in EMEs than in AEs. As the minimum wage increases, firms can substitute low-productivity workers (earning the minimum wage) with cheaper informal workers or machines through automation (Eckardt, 2022; Lordan & Neumark, 2018). Second, we examine how the presence of the minimum wage alters the transmission of standard productivity, demand, and monetary policy shocks. We find that the minimum wage causes the effects of these standard macroeconomic shocks to persist longer and, in addition, makes it more difficult for monetary policy to keep inflation in check.

Our results indicate that while the effect of a minimum wage increase is similar to that of a cost-push shock on broad aggregate variables (output falls, inflation rises, and the central bank responds with a higher nominal interest rate), the transmission channels are more complex. In response to higher minimum wages, firms reduce their demand for low-skilled formal workers and turn to informal labor and automation. This shift affects other factors of production, such as capital in buildings and high-skilled labor, due to increased production costs and

[1] In 2022, the United States had a trade openness of 27%, calculated as the sum of exports and imports of goods and services relative to GDP. By contrast, Latin America and middle-income countries averaged 57% and 52%, respectively (World Bank national accounts data and OECD national accounts data files).

[2] Informality rate is defined as the percentage of employment that is not covered by social security, income taxes, or labor regulations.

[3] For references see Arango and Flórez (2021), Bíró et al. (2022), Katzkowicz et al. (2021), Lemos (2004), and Mora and Muro (2017).

	EMEs	AEs	Colombia
Workers receiving minimum wage	19.8%	9.0%	15.7%
Informality rate	69.5%	7.8%	58.1%
Urban informality rate	59.8%	7.3%	51.0%
Rural informality rate	78.8%	9.7%	84.5%
Average years between minimum wage changes	4	2	1
Minimum wage as a percentage of median wage	67%	55%	90%
Minimum wage as a percentage of mean wage	45%	41%	54%

Notes: The informality rate is defined as the percentage of employment not covered by social security, income taxes, or labor regulations. The average frequency of minimum wage changes for AEs is influenced by European countries, which typically revise their minimum wages at least every two years. In contrast, the United States has a longer adjustment period of approximately six years or more.
Sources: ILO (2020), ILO STAT Database, OECD. Own calculations.

Table 1: Minimum wage, EMEs and AEs.

a weakening of aggregate demand. Our analysis quantifies these effects and shows significant impacts on the labor market and investment, moderate changes in GDP and consumption, and small effects on inflation and monetary policy. We also find that both real and nominal outcomes are amplified when a larger share of labor costs is tied to minimum wage.

Both machinery and informality are important adjustment mechanisms in the model. In a simplified version without capital in machinery, we find that low-skilled consumption increases in both the short and long run after a minimum-wage increase. In this setting, firms substitute low-skilled formal workers with informal labor, resulting in higher income and consumption for low-skilled households, a reduction in inequality, and a smaller contraction of GDP. In an alternative scenario without informality, low-skilled labor is substituted only by machines, leading to a larger decline in low-skilled employment and in consumption. In this scenario, the negative effects of the minimum wage are magnified.

Regarding the interaction of the minimum wage with conventional shocks, our results suggest that the minimum wage increases the persistence of macroeconomic responses and that most adjustments in the labor market are through quantities rather than wages. We also find that monetary policy becomes less effective in controlling inflation in the short run because of rigidities created by the minimum wage. This result is consistent with Glover (2019), who found that, for the US, the presence of a minimum wage mitigates the impact of a policy rate shock on inflation. The author also studies the interaction between the minimum wage and the zero lower bound (ZLB) and finds that away from the ZLB, the macroeconomic effects of a minimum wage increase depend on the monetary policy stance. If the central bank maintains a hawkish stance, the minimum wage increase is contractionary. However, if the stance is dovish, the effect is expansionary. Consistent with the variety of adjustment rules that exist worldwide, we analyze how our results change when considering alternative rules. Our results are qualitatively consistent with this. However, some rules add volatility to the business cycle.

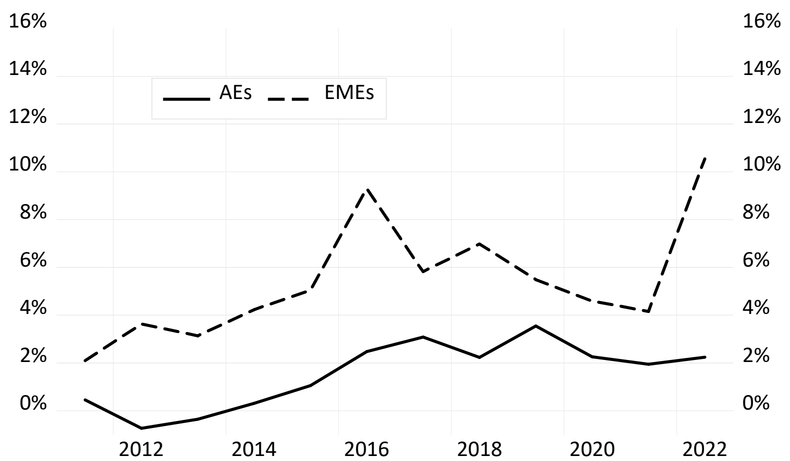
Šauer (2018) examines the macroeconomic impacts of raising the minimum wage in the United States, highlighting a positive effect on income and consumption of low-skilled workers, with minimal effects on inflation and other macroeconomic indicators. The author identifies the "effort channel" as a crucial mechanism for the transmission of minimum wage increases, whereby firms demand greater effort from workers, leading to higher productivity and lower inflation. Our research confirms these patterns in a typical EME, revealing modest aggregate macroeconomic effects and impacts concentrated mainly on low-skilled workers, both formal and informal workers. However, the channels at work are different. We observe an impact on low-skilled consumption that varies over time. Initially, consumption increases as firms struggle to substitute low-skilled formal labor. Over time, firms shift to informal labor and automation, which reduces the income of low-skilled households and leads to a decline in consumption during the transition to the long run. This decline is consistent with the empirical evidence presented by Arango et al. (2022). Importantly, employment may be less affected than in an advanced economy, in part because workers find employment in the informal sector following a minimum wage increase.

Sy and Hosoe (2023) introduce migration as an additional channel for welfare analysis. For the case of the Philippines, the authors find that a higher minimum wage improves welfare through the remittances of workers who migrate after losing their jobs. Albertini and Fairise, 2013 find that wage rigidities in a search and matching environment cause welfare costs. Some empirical studies focus on labor market outcomes and find mixed evidence on employment, as highlighted by Neumark and Munguía-Corella (2021). In addition, Medrano-Adán and Salas-Fumás (2023) find that a 10% increase in the minimum wage in OECD economies reduces output and employment by 0.2% and 1.0%, respectively, while increasing overall income inequality by 0.57%. Similarly, Seok and You (2022) report that in Korea, a 15% increase in the real minimum wage, as in 2018, reduces total employment by 3.5% and gross output by 1.0%, according to a large firm search and matching model. Our results show that a 1% increase in the minimum wage reduces output and total employment of low-skilled workers by 0.1% and 0.3%, respectively.

Policymakers, especially in EMEs, should consider the macroeconomic implications of minimum wages and their interaction with other instruments, especially in periods when minimum wages have been rising globally. As Figure 1 shows, the growth rates of real minimum wages are more volatile in EMEs than in AEs. More importantly, since the COVID pandemic, the real minimum wage in EMEs has been on an upward trend, in contrast to a moderate increase in AEs. Three prominent cases are Turkey, where the real minimum wage has increased by more than 30%; Mexico, where the real minimum wage has experienced double-digit growth for four consecutive years; and Colombia, where the minimum wage has increased by more than three percentage points above the sum of productivity growth and inflation for three consecutive years.

Policymakers have also raised concerns about the effects of minimum wages on monetary policy in the short run. The impact on inflation is often at the center of policy discussions.[4] The model developed in this paper can inform policy discussions by quantifying the macroeconomic and inflationary impacts of changes in the minimum wage and by helping to understand the conditions and parameters under which increases in the minimum wage can stimulate aggregate demand.

Figure 1: Annual real minimum wage growth in selected AEs and EMEs



Sources: OECD (2024) and each country's central bank. Own calculations.
Note: The solid black line represents the average annual real minimum wage growth in AEs (Australia, Canada, France, Germany, Japan, the Netherlands, New Zealand, Portugal, and the United Kingdom). The dashed black line represents the average annual real minimum wage growth in EMEs (Brazil, Bulgaria, Chile, Colombia, Mexico, Romania, and Turkey). We calculate the real minimum wage by deflating each country's nominal minimum wage by the previous year's inflation.

The remainder of this paper is organized as follows. Section 2 provides an overview of the methods used to

[4] For example, in late 2023, Jonathan Heath, Deputy Governor of the Central Bank of Mexico, stated that the increase in the minimum wage and the fiscal deficit are potential inflationary pressures that the central bank will monitor to avoid price increases (Forbes: Minimum wage increase and budget deficit, risks to inflation: Jonathan Heath).

set minimum wages in several countries, including an analysis of the actors involved, frequency of adjustments, and factors considered in minimum wage revisions. Section 3 introduces the structure of our model. Section 4 details the calibration approach and parameter values specific to the Colombian economy. In Section 5, we examine both the direct and indirect effects of minimum wage changes on the labor market and macroeconomic variables by analyzing the dynamics following an unexpected minimum wage increase. In this section, we assess the impact of the minimum wage on the persistence of macroeconomic responses to demand, productivity, and monetary policy shocks. Finally, Section 6 presents a summary of our main findings and their policy implications.

2 Minimum Wage Adjustment Around the World

In 1894, New Zealand introduced a minimum wage policy to protect vulnerable workers.[5] Soon after, Australia and the United Kingdom followed suit, and as of 2023, 187 countries have minimum wage policies in place, as the International Labour Organization (ILO) recommends. Despite its worldwide adoption, there are significant differences in minimum wage institutions across countries. These differences, which include the actors involved in the political economy process of setting the minimum wage, its level relative to other wages, the frequency and rules of adjustment, and the unique characteristics of each economy, result in significant variations in coverage across economic sectors, occupations, educational levels, and regions.

Some common factors are considered when minimum wages are periodically adjusted, with slight variations between countries. Inflation is the most common economic variable used to determine the minimum wage. Unexpected changes in inflation result in arbitrary changes in the purchasing power of the minimum wage. If inflation rises unexpectedly, a fixed nominal minimum wage results in an effective pay cut for the workers. Another common factor is productivity growth, or some measure directly related to it, which economic theory suggests should be reflected in workers remuneration.

For example, in Brazil, wages are adjusted every four years, considering past inflation and economic growth. Similarly, Costa Rica considers expected inflation, economic growth, and deviations from inflation expectations. In Colombia, minimum wage adjustments are made annually through negotiations involving unions, the private sector, and the government, with the combined impact of observed inflation and changes in labor productivity serving as the basis for wage increases.

However, many countries use less common variables to determine periodic changes in the minimum wage. For example, Malaysia uses a comprehensive rule that includes socioeconomic indicators such as poverty line income, median wage, productivity growth, consumer inflation, and unemployment rate. In France, the purchasing power of blue-collar workers is considered along with changes in the consumer price index, while in the Netherlands, adjustments are based on changes in the weighted average of collectively agreed wages.

While approximately half of the countries opted for a single, universally applicable national minimum wage, the other half allows for variations across regions (or sectors) to reflect differences in the cost of goods and services and other economic conditions. In particular, some large countries, such as the United States, Brazil, and Russia, have adopted a hybrid approach that combines a national minimum wage floor with provisions for higher regional levels.

An important element in analyzing the effects of minimum wages on the business cycle is the periodicity of adjustments. On the one hand, inflation erodes the real value of the fixed minimum wage over time. On the other hand, for firms, sudden and large adjustments in the minimum wage can disrupt hiring decisions by increasing and introducing uncertainty about labor costs.

To address these issues, many countries have established mechanisms to periodically adjust the minimum wage in line with ILO recommendations.[6] However, there is considerable variation in the frequency of adjustments across countries. Most countries adjust their minimum wages every one or two years (for example, Colombia, Costa Rica, and Mexico), but others do so more frequently (the Netherlands, twice a year) or less

[5] What is a minimum wage. A short history (ILO).

[6] Article 4 of Convention No. 131.

often (Malaysia, every three years; Brazil, every four years). Other countries may also use a rule that triggers an adjustment when a certain condition is met.[7] The frequency is important because it determines the degree of nominal and/or real rigidities and may induce inflation inertia by indexing current pricing decisions to past inflation, thereby affecting the conduct of monetary policy and altering the transmission and propagation of such shocks.

In summary, the adjustment of the minimum wage in different countries follows periodic, although not necessarily regular, patterns. Some countries have established mechanisms that consider the perspectives of labor market actors, including unions, firms, and government agencies. These adjustments generally consider economic variables such as inflation, economic growth, and productivity, in an attempt to maintain the purchasing power of labor income and a fairer distribution.

The variety of adjustment rules implies that no single model fits all countries. However, the model proposed below is based on the most common adjustment variables and the frequency of changes. In Section 5.5 we allow for different wage-setting rules. In this way, the qualitative results of this study are informative for several countries, and the model can be adapted to other countries by adjusting for other possible minimum wage-setting rules.

3 Model

We develop a general equilibrium model to study the effects of the minimum wage on macroeconomic variables in a small open emerging economy. Our model differs from those in the literature in at least three ways: *i)* we consider two households instead of one, which differ in their labor productivity, access to financial markets, and ownership of firms; *ii)* physical capital is divided into buildings and machinery, allowing for a flexible production structure; *iii)* low-productivity households supply formal and informal labor; the former is paid a minimum wage that evolves according to a predetermined adjustment rule. Other features of the model are standard in the literature: the small open economy produces a homogeneous good that is a substitute for the good produced by the rest of the world, the central bank sets the domestic interest rate according to a Taylor rule, and the model stationarity is imposed with a debt-elastic interest rate. A list of the model variables is reported in Appendix D, and a full description of the model equations, steady state, and calibration is provided in Appendix E.

Our small open economy setup follows the emerging market business cycle literature (Garcia-Cicco et al., 2010; Schmitt-Grohé & Uribe, 2003) by assuming that the domestic final good is substitutable for the good produced by the rest of the world. This property, together with the exogenous foreign interest rate, allows the model to be closed with net exports, eliminating the need for explicit modeling of exports and imports. We also follow Gali and Monacelli (2005), who introduced monetary policy and nominal exchange rate regimes in an SOE. In contrast, we assume that domestic and foreign goods are homogeneous rather than imperfect substitutes, which simplifies the behavior of nominal and real exchange rates. We also depart from the assumption of complete markets and assume that households trade an international bond, as in Schmitt-Grohé and Uribe (2003).

3.1 Households

Households are divided into two groups: high-skilled/high-productivity $\left(N^H\right)$ and low-skilled/low-productivity $\left(N^L\right)$. High-skilled households have several characteristics that distinguish them from low-skilled households. First, they offer a highly productive form of formal labor $\left(h_t^H\right)$. Second, they own firms and receive the profits generated by the firms (Π_t). Third, they own two types of capital: machinery (k_t^m) and buildings $\left(k_t^b\right)$.[8] High-skilled households consume $\left(c_t^H\right)$ and invest in both types of capital $\left(i_t^m \text{ and } i_t^b\right)$. Additionally, high-skilled households have access to both domestic and foreign financial markets, b_t and a_t^f.

[7] For example, in France, the minimum wage increases annually or when the annual inflation rate exceeds 2%.

[8] Subsection 3.2 discusses the importance of considering both forms of capital.

The representative high-skilled household maximizes the present value of its utility

$$\max_{c_t^H, h_t^H, b_{t+1}, a_{t+1}^f, i_t^b, i_t^m, k_{t+1}^b, k_{t+1}^m} \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \exp(Z_t) \left[\frac{\left(c_t^H\right)^{1-\sigma}}{1-\sigma} - \psi_H \frac{\nu_H}{1+\nu_H} \left(h_t^H\right)^{\frac{1+\nu_H}{\nu_H}} \right], \tag{1}$$

where $Z_t = \rho_Z Z_{t-1} + \epsilon_t^Z$ represents a discount factor shock, subject to the intertemporal budget constraint

$$P_t \left(c_t^H + i_t^b + i_t^m\right) + q_t P_t^f a_{t+1}^f + P_t b_{t+1} \leq P_{t-1} b_t R_{t-1}^{pol} + q_t P_{t-1}^f a_t^f \Phi_{t-1} R_{t-1}^f + W_t^H h_t^H + R_t^b k_t^b + R_t^m k_t^m + \frac{\Pi_t}{N^H}, \tag{2}$$

P_t is the price of domestic final goods, P_t^f is the (exogenous) price of foreign goods expressed in foreign currency, q_t is the nominal exchange rate, R_t^{pol} and R_t^f are the returns on domestic and foreign assets, and W_t, R_t^b and R_t^m are the nominal returns to high-skilled labor and capital in buildings and machinery.

Assuming that domestic and foreign goods are homogeneous and that the law of one price holds, we have the following condition:

$$P_t = q_t P_t^f. \tag{3}$$

In other words, the domestic and foreign goods have the same price, once they are expressed in the same currency. Differentiating the law of one price from equation (3), we have:

$$\Delta q_t = \pi_t - \pi_t^*, \tag{4}$$

where π_t^* is the exogenous inflation in the rest of the world, normalized to zero. This equation implies that any movement in domestic inflation is passed into changes in the nominal exchange rate.

The optimization problem is also subject to adjustment cost of investment in buildings and in machinery,

$$k_{t+1}^x \leq i_t^x + (1-\delta_x) k_t^x - \frac{\phi_x}{2} \left(\frac{i_t^x}{i_{t-1}^x} - 1 \right)^2, x \in \{b, m\}. \tag{5}$$

Following Schmitt-Grohé and Uribe (2003), we consider that the risk premium depends on the deviations of the debt to GDP ratio from its long-run value:

$$\Phi_t = \Phi\left(A_t^f\right) = \widetilde{\phi} + \phi_a \left(\frac{q_t P_t^f A_t^f}{P_t Y_t} - \frac{A_{ss}^f}{Y_{ss}} \right), \tag{6}$$

where Y_t and A_t^f denote the output and aggregate foreign assets, respectively. Subscript ss denotes the steady-state value of the variable. The foreign interest rate is given by:

$$R_t^f = R_{ss}^f. \tag{7}$$

After normalizing the the budget constraint by P_t, from the first order conditions (F.O.Cs) we find the marginal rate of substitution between consumption and labor,

$$\psi_H \left(h_t^H\right)^{\frac{1}{\nu_H}} = w_t^H (c_t^H)^{-\sigma}, \tag{8}$$

This equation represents the labor supply of high skilled workers. In the presence of labor market rigidities and non-competitive wages, equation (8) would be irrelevant. Similarly, the Euler equations for domestic and foreign bonds,

$$\left(c_t^H\right)^{-\sigma} = \beta \mathrm{E}_t \left[\exp(Z_{t+1} - Z_t) \left(c_{t+1}^H\right)^{-\sigma} \right] \frac{R_t^{pol}}{1+\pi_{t+1}}, \tag{9}$$

$$\left(c_t^H\right)^{-\sigma} = \beta \mathrm{E}_t \left[\exp(Z_{t+1} - Z_t) \left(c_{t+1}^H\right)^{-\sigma} \right] \frac{R_t^f \Phi_t}{(1+\pi_{t+1}^*)}, \tag{10}$$

These two equations represent the uncovered interest rate parity condition. The Euler equations for capital in machinery and buildings are given by:

$$\mu_t^x = \beta \mathrm{E}_t \Big[\exp(Z_{t+1} - Z_t) \Big(\big(c_{t+1}^H\big)^{-\sigma} r_{t+1}^x + \mu_{t+1}^x (1 - \delta_x) \Big) \Big] \text{ for } x \in \{b, m\}, \tag{11}$$

where μ^q are the Lagrange multipliers. Similarly, the first-order conditions for investment imply that:

$$\left(c_t^H\right)^{-\sigma} = \mu_t^q \left[1 - \phi_q \left(\frac{i_t^q}{i_{t-1}^q} - 1 \right) \frac{1}{i_{t-1}^q} \right] + \beta \mathrm{E}_t \left[\mu_{t+1}^q \exp(Z_{t+1} - Z_t) \phi_q \left(\frac{i_{t+1}^q}{i_t^q} - 1 \right) \frac{i_{t+1}^q}{\left(i_t^q\right)^2} \right] \text{ for } q \in \{b, m\}, \tag{12}$$

where $w_t^H = W_t^H / P_t$, $r_t^b = R_t^b / P_t$, $r_t^m = R_t^m / P_t$, and $\pi_t = P_t / P_{t-1}$.

Low-skilled households face borrowing constraints and lack access to financial markets. As a result, their only source of income is labor. These hand-to-mouth households consume $\left(c_t^L\right)$ and supply both formal labor $\left(h_t^F\right)$—earning the minimum wage $\left(W_t^F\right)$—and informal labor $\left(h_t^I\right)$, for which they earn a market wage below the minimum $\left(W_t^I\right)$. This specification captures the connection between the two types of labor supplied by low-skilled households, reflecting their mobility between the formal and informal sectors. It aligns with the standard two-sector models used to analyze minimum wage effects, as in Gramlich (1976) and Mincer (1976). Moreover, this approach is consistent with the findings of Breza and Kaur (2025), who argue that in developing and low-income countries, low-wage employment is often masked as self-employment. At the same time, there is growing evidence that workers often prefer self-employment to many available wage jobs, particularly low-skill positions in the formal sector. In our model, self-employment is represented by informal labor.

The representative low-skilled household maximizes the present value of its utility,

$$\max_{c_t^L, h_t^I, h_t^F} \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \exp(Z_t) \left[\frac{\left(c_t^L\right)^{1-\sigma}}{1-\sigma} - \psi_I \frac{\nu_I}{1+\nu_I} \left(h_t^I\right)^{\frac{1+\nu_I}{\nu_I}} - \psi_F \frac{\nu_F}{1+\nu_F} \left(h_t^F\right)^{\frac{1+\nu_F}{\nu_F}} \right], \tag{13}$$

subject to its budget constraint,

$$P_t c_t^L \leq W_t^I h_t^I + W_t^F h_t^F + \frac{P_t T_t}{N^L}, \tag{14}$$

where T_t is the transfer from the government.

From the normalized F.O.C., we find the marginal rates of substitution between consumption and labor (both formal and informal). These two equations represent the labor supply of low-skilled households:

$$\psi_I \left(h_t^I\right)^{\frac{1}{\nu_I}} = \left(c_t^L\right)^{-\sigma} w_t^I \text{ and} \tag{15}$$

$$\psi_F \left(h_t^F\right)^{\frac{1}{\nu_F}} = \left(c_t^L\right)^{-\sigma} w_t^F, \tag{16}$$

where $w_t^I = W_t^I / P_t$ and $w_t^F = W_t^F / P_t$. The latter equation is irrelevant in the presence of a binding minimum wage.

Macroeconomic aggregates can be defined as follows: Consumption is the sum of the consumption of each representative household multiplied by the number of households of each type: $C_t = N^H c_t^H + N^L c_t^L$. Investment in buildings and machinery is given by $I_t^b = N^H i_t^b$ and $I_t^m = N^H i_t^m$, respectively, because low-skilled households do not make investment decisions. Domestic demand is given by $D_t = C_t + I_t^b + I_t^m$. The aggregate labor supply for high-skilled, low-skilled formal, and low-skilled informal workers is defined as the total number of hours worked: $L_t^H = N^H h_t^H$, $L_t^F = N^L h_t^F$, and $L_t^I = N^L h_t^I$.

3.2 Production

The final good sector is perfectly competitive. It combines a continuum of differentiated intermediate goods ($Y_t(j)$ with $j \in [0,1]$) into the final good (Y_t). This firm maximizes its profits according to

$$\max_{Y_t(j)} P_t Y_t - \int_0^1 P_t(j) Y_t(j) dj, \text{ where} \tag{17}$$

$$Y_t = \left(\int_0^1 Y_t(j)^{\frac{\xi-1}{\xi}} dj \right)^{\frac{\xi}{\xi-1}} \tag{18}$$

is the production technology of the final good, $P_t(j)$ and P_t are the prices of the jth intermediate good and the aggregate price, respectively. From the F.O.C., we find that the demand for input j depends on its relative price and the aggregate demand for domestic goods,

$$Y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\xi} Y_t, \tag{19}$$

and that the aggregate price index for domestic goods is the average price of the heterogeneous set of inputs,

$$P_t = \left[\int_0^1 P_t(j)^{1-\xi} dj \right]^{\frac{1}{1-\xi}}. \tag{20}$$

Domestic production of the homogeneous good is allocated to consumption, investment, and net exports $Y_t = C_t + I_t^m + I_t^b + NX_t$. A monopolistically competitive firm produces each intermediate good. The firm faces a Cobb-Douglas production function and makes static and dynamic decisions. Regarding static decisions, each firm j minimizes its costs by choosing its optimal demand for capital in machinery, capital in buildings, and for each type of labor: high-skilled formal, low-skilled formal, and low-skilled informal. The firm's optimization problem is given by:

$$\min_{K_t^b(j), K_t^m(j), L_t^H(j), L_t^I(j), L_t^F(j)} (1+\tau^H) w_t^H L_t^H(j) + w_t^I L_t^I(j) + (1+\tau^F) L_t^F(j) + r_t^b K_t^b(j) + r_t^m K_t^m(j), \tag{21}$$

where τ is a tax levied on the wages of high-skilled and low-skilled formal workers subject to the technology

$$Y_t(j) = A_t \left(K_t^b(j) \right)^{\alpha} (L_t(j))^{1-\alpha}, \tag{22}$$

where total factor productivity follows $A_t = (1-\rho_a) Z^a + \rho_a A_{t-1} + \epsilon_t^A$, where ϵ_t^A is a productivity shock, and $K_t^b(j)$ is the demand for capital in buildings, which complements the other production factors, $L_t(j)$.

The labor demand for each firm j ($L_t(j)$) is a nested CES function that aggregates the three types of labor and machinery. The CES structure provides sufficient flexibility to capture different substitution and complementarity effects among these inputs, allowing us to better capture the dynamics after a minimum wage shock. This structure is defined as:

$$L_t^L(j) = \left[\theta_L \left(L_t^I(j) \right)^{\frac{\eta_L - 1}{\eta_L}} + (1-\theta_L) \left(L_t^F(j) \right)^{\frac{\eta_L - 1}{\eta_L}} \right]^{\frac{\eta_L}{\eta_L - 1}}, \tag{23}$$

$$L_t^m(j) = \left[(1-\theta_m) \left(L_t^L(j) \right)^{\frac{\eta_m - 1}{\eta_m}} + \theta_m \left(K_t^m(j) \right)^{\frac{\eta_m - 1}{\eta_m}} \right]^{\frac{\eta_m}{\eta_m - 1}}, \text{ and} \tag{24}$$

$$L_t(j) = \left[\theta \left(L_t^m(j) \right)^{\frac{\eta - 1}{\eta}} + (1-\theta) (L_t^H(j))^{\frac{\eta - 1}{\eta}} \right]^{\frac{\eta}{\eta - 1}}. \tag{25}$$

This aggregation structure requires further examination. At the lowest level, the demand for low-skilled labor, $L_t^L(j)$, combines both low-skilled informal and formal labor. These two types of labor are substitutes, giving firms the option of employing informal labor in response to minimum wage increases (Eq. (23)). At the intermediate level, the aggregation technology, $L_t^m(j)$, combines low-skilled labor with capital in machinery. These two inputs are also substitutes, allowing firms to choose automation in response to the higher cost of low-skilled labor (Eq. (24)). At the highest level, the production function $L_t(j)$ combines $L_t^m(j)$ and high-skilled labor. Unlike the other levels of aggregation, these two inputs are complementary (Eq. (25)). Note that the factor $L_t(j)$ is not equal to the total employment. Instead, $L_t(j)$ combines the different types of labor and machinery in a non-linear way.

From the normalized F.O.C., we find the relative demand of factors as a function for their relative prices,

$$\frac{w_t^m}{(1+\tau^H)w_t^H} = \frac{\theta}{1-\theta}\left(\frac{L_t^H}{L_t^m}\right)^{\frac{1}{\eta}}, \tag{26}$$

$$\frac{w_t^I}{(1+\tau^F)w_t^F} = \frac{\theta_L}{1-\theta_L}\left(\frac{L_t^F}{L_t^I}\right)^{\frac{1}{\eta_L}}, \tag{27}$$

$$\frac{r_t^m}{w_t^L} = \frac{\theta_m}{1-\theta_m}\left(\frac{L_t^L}{K_t^m}\right)^{\frac{1}{\eta_m}} \text{ and,} \tag{28}$$

$$\frac{L_t}{K_t^b} = \frac{(1-\alpha)}{\alpha}\frac{r_t^b}{w_t}. \tag{29}$$

and the aggregate factor prices,

$$w_t = \left(\theta^{\eta}\left(w_t^m\right)^{1-\eta} + (1-\theta)^{\eta}\left((1+\tau^H)w_t^H\right)^{1-\eta}\right)^{\frac{1}{1-\eta}}, \tag{30}$$

$$w_t^m = \left((1-\theta_m)^{\eta_m}\left(w_t^L\right)^{1-\eta_m} + \theta_m^{\eta_m}\left(r_t^m\right)^{1-\eta_m}\right)^{\frac{1}{1-\eta_m}}, \tag{31}$$

$$w_t^L = \left(\theta_L^{\eta_L}\left(w_t^I\right)^{1-\eta_L} + (1-\theta_L)^{\eta_L}\left((1+\tau^F)w_t^F\right)^{1-\eta_L}\right)^{\frac{1}{1-\eta_L}} \tag{32}$$

and the real marginal cost

$$mc_t = \frac{1}{A_t}\left(\frac{r_t^b}{\alpha}\right)^{\alpha}\left(\frac{w_t}{1-\alpha}\right)^{1-\alpha}. \tag{33}$$

The dynamic optimization of intermediate firms is related to their pricing decision. We adopt the framework proposed by Calvo (1983), in which intermediate firms set their prices to maximize the present value of profits, given the expected demand for their products. In each period, each firm has an exogenous probability, $1-\phi$, of being able to change its price. The remaining ϕ firms do not optimally change their prices but adjust them according to past inflation (indexation). The optimal decision for a firm that can change its price in period t is given by:

$$\max_{P_t(j)} \mathrm{E}_t \sum_{k=0}^{\infty} (\beta\phi)^k \frac{U_{c,t+k}}{U_{c,t}}\left[\left(\frac{\chi_{tk}P_t(j)}{P_{t+k}}\right)^{1-\xi} Y_{t+k} - mc_{t+k}\left(\frac{\chi_{tk}P_t(j)}{P_{t+k}}\right)^{-\xi} Y_{t+k}\right], \tag{34}$$

where χ_{tk} is the cumulative inflation up to the period $t+k$. From the F.O.C

$$P_t(j) = \frac{\xi}{\xi-1}\mathrm{E}_t\left[\frac{\sum_{k=0}^{\infty}(\beta\phi)^k U_{c,t+k}mc_{t+k}(\chi_{tk}P_{t+k})^{\xi}Y_{t+k}}{\sum_{k=0}^{\infty}(\beta\phi)^k U_{c,t+k}(\chi_{tk}P_{t+k})^{\xi-1}Y_{t+k}}\right]. \tag{35}$$

This equation implies that the optimal price of a firm that can change prices is given by

$$P_t^{\#} = \frac{\xi}{\xi - 1} \frac{X_{1,t}}{X_{2,t}}, \text{ where} \tag{36}$$

$$X_{1,t} = U_{c,t} mc_t P_t^{\xi} Y_t + \beta \phi \mathrm{E}_t \left[\left(\frac{\chi_{tk+1}}{\chi_{tk}} \right)^{\xi} X_{1,t+1} \right], \text{ and} \tag{37}$$

$$X_{2,t} = U_{c,t} P_t^{\xi - 1} + \beta \phi \mathrm{E}_t \left[\left(\frac{\chi_{tk+1}}{\chi_{tk}} \right)^{\xi - 1} X_{2,t+1} \right]. \tag{38}$$

By applying the law of large numbers to the continuum of firms, it can be demonstrated that aggregate prices can be expressed as a weighted average of the optimal and lagged prices resulting from the decisions of individual firms,

$$P_t^{1-\xi} = (1 - \phi) \left(P_t^{\#} \right)^{1-\xi} + \phi (\pi_{t-1} P_{t-1})^{1-\xi}. \tag{39}$$

After normalization we find the inflation rate,

$$\pi_t^{1-\xi} = (1 - \phi) \left(\pi_t^{\#} \right)^{1-\xi} + \phi \pi_{t-1}^{1-\xi}, \text{ where} \tag{40}$$

$$\pi_t^{\#} = \frac{\xi}{\xi - 1} \frac{x_{1,t}}{x_{2,t}} \pi_t, \tag{41}$$

$$x_{1,t} = C_t^{-\sigma} mc_t Y_t + \beta \phi \mathrm{E}_t \left[x_{1,t+1} \left(\frac{\pi_{t+1}}{\pi_t} \right)^{\xi} \right] \text{ and,} \tag{42}$$

$$x_{2,t} = C_t^{-\sigma} Y_t + \beta \phi \mathrm{E}_t \left[x_{2,t+1} \left(\frac{\pi_{t+1}}{\pi_t} \right)^{\xi - 1} \right]. \tag{43}$$

Finally, due to price rigidities, the total output in the economy is given by:

$$Y_t = \frac{A_t \left(K_t^b \right)^{\alpha} L_t^{1-\alpha}}{v_t^p}, \tag{44}$$

where v_t^p is the price dispersion:

$$v_t^p = \int_0^1 \left(\frac{P_t(j)}{P_t} \right)^{-\xi} dj = (1 - \phi) \left(\frac{\pi_t}{\pi_t^{\#}} \right)^{\xi} + \phi \left(\frac{\pi_t}{\pi_{t-1}} \right)^{\xi} v_{t-1}^p. \tag{45}$$

3.3 Minimum wage

As noted above, the model considers three types of workers. The wage and employment of high-skilled formal workers and low-skilled informal workers are determined by the equilibrium between the supply and demand for their respective labor. In contrast, low-skilled formal workers are paid the minimum wage; therefore, their employment level is determined by the demand for labor from firms.

The government adjusts the nominal minimum wage $\left(\Delta W_t^F \right)$ according to a rule that considers inflation and productivity dynamics ($\Delta MP_{L,t-1}$), with some room for unexpected changes $\left(\epsilon_t^F \right)$. These changes are modeled as shocks that can be permanent or transitory in nature,

$$\Delta W_t^F = \frac{W_t^F}{W_{t-1}^F} = \pi_{t-1} \Delta MP_{L,t-1} \left(1 + \epsilon_t^F \right), \text{ where} \tag{46}$$

$$\Delta MP_{L,t} = \frac{(Y_t / Y_{t-1})}{(EMP_t / EMP_{t-1})} \tag{47}$$

and EMP is the total employment. The rule in equation (46), which is commonly used in EMEs and particularly in Colombia, implies that changes in the nominal minimum wage are fully reflected in the real minimum wage.[9] Given this setup, the real minimum wage $\left(w_t^F\right)$ follows

$$w_t^F = w_{ss}^F + \Delta w_t^F, \tag{48}$$

where $\Delta w_t^F = \Delta W_t^F - \pi_t$. For wage setting to be relevant, we assume that in the steady state, the real wage of formal low-skilled workers, w_{ss}^F, is higher than the real wage determined by market clearing.

Consistent with empirical evidence on the lighthouse/beacon effect of the minimum wage in EMEs, including Colombia (Bell, 1997; Maloney & Mendez, 2004; Neumark et al., 2004; Pérez, 2020), we assume that there is a short-run transmission of minimum wage shocks to high-skilled workers' wages. We also assume that high-skilled wages are persistent in the short run. These two assumptions distort the competitive equilibrium of high-skilled wages in the short run but ultimately ensure that the long-run equilibrium remains competitive. We consider that:

$$w_t^H = \left(w_{t-1}^H\right)^{\rho_H} \left(w_t^{H,market}\right)^{1-\rho_H} \left(\frac{w_t^F}{w_{t-1}^F}\right)^{\rho_F}, \tag{49}$$

where $w^{H,market}$ is the competitive equilibrium wage for high-skilled workers.

3.4 Labor Market Equilibrium

In our setup, there are three types of labor with different equilibrium conditions in the short run. Informal low-skilled labor operates under perfect competition; therefore, wages w_t^I and employment h_t^I are determined by the interaction between demand and supply. In contrast, neither type of formal employment reaches competitive equilibrium in the short run. The binding minimum wage ensures that the level of formal employment is entirely determined by the demand side, that is, $L_t^{F,d}(w_t^F)$. At this wage, workers would like to supply more labor, but they are not hired. The difference between aggregate supply and demand generates unemployment:

$$u_t^F = N^L h_t^{F,s}(w_t^F) - L_t^{F,d}(w_t^F). \tag{50}$$

Regarding formal skilled workers, the wage stickiness described in equation 49 causes a temporary distortion following an increase in the minimum wage. This increase leads to higher wages and creates an excess supply for this production factor, resulting in unemployment:

$$u_t^H = N^H h_t^{H,s}(w_t^H) - L_t^{H,d}(w_t^H) \tag{51}$$

Total employment reflects the aggregate number of hours worked in the economy by low-skilled formal and informal workers and formal high-skilled workers:

$$EMP_t = L_t^{F,d}(w_t^F) + L_t^I + L_t^{H,d}(w_t^H). \tag{52}$$

3.5 Policy institutions

On the policy side, the model considers two institutions: the central bank and the government. Regarding monetary policy, we define a standard Taylor rule that adjusts the (nominal) policy interest rate according to the gaps on inflation and output,

$$\log\left(\frac{R_t^{pol}}{R^{pol}}\right) = \rho_r \log\left(\frac{R_{t-1}^{pol}}{R^{pol}}\right) + r_\pi \log\left(\frac{\mathrm{E}_t \pi_{t+1}}{\pi}\right) + r_y \log\left(\frac{4Y_t}{\sum_{s=1}^4 Y_{t-s}}\right) + \epsilon_r, \tag{53}$$

[9] In Subsection 5.5 we explore the effects of alternative rules.

where $\sum_{s=1}^{4} Y_{t-s}$ is annual GDP. This output gap specification accounts for changes in the steady state that do not result in permanent gaps in the economy. This is particularly useful when analyzing the impact of permanent changes on the real minimum wage. The real interest rate on bonds is given by:

$$R_t = R_t^{pol} - \mathrm{E}_t \pi_{t+1} \tag{54}$$

On the fiscal side, we assume that the government maintains a balanced budget in each period, with tax revenues from the wages of high-skilled and formal low-skilled workers equal to the lump-sum transfers provided to low-skilled households,

$$\frac{T_t}{P_t} = \tau^F w_t^F L_t^F + \tau^H w_t^H L_t^H. \tag{55}$$

3.6 Trade Balance

Finally, from the aggregate equilibrium conditions, we find that the nominal trade balance is equal to the change in net foreign assets:

$$NX_t = q_t P_t^f \left(A_{t+1}^f - A_t^f \Phi_{t-1} R_{t-1}^f \right). \tag{56}$$

Combining equations (56) and (3), we obtain the real trade balance as:

$$NX_t^{real} = \left(A_{t+1}^f - A_t^f \Phi_{t-1} R_{t-1}^f \right). \tag{57}$$

4 Parameters, Calibration, and Adjustment to the Colombian Business Cycle

We set the parameter values using a combination of literature for Colombia (González et al., 2011), international evidence (Behar, 2025; Chen, 2020; Krusell et al., 2000; Whalen & Reichling, 2017), and moment matching. Table 2 shows the parameter values and their sources. To calibrate the model, we solve a system of equations that includes the steady state (Appendix E), normalization conditions, and the targeted moments. This results in a final set of 15 equations that cannot be solved analytically because of the dimensionality of the model. Eight of these equations represent the core variables of the model, whereas seven are associated with the targets.[10] Table 3 reports the targets from the data and the associated calibrated parameters.

Before matching the model to the data, we categorized Colombian workers according to their labor income relative to the minimum wage using data from the Colombian Household Survey (GEIH) from 2010 to 2019.[11] In particular, we define high-skilled formal workers as those with earnings above 1.1 times the minimum hourly wage, low-skilled formal workers as those with earnings between 0.9 and 1.1 times the minimum hourly wage, and the remainder as low-skilled informal workers. According to these computations the mass of high-skilled households $\left(N^H\right)$ corresponds to 52%.[12]

It is important to note that in Colombia, as in other Latin American countries, employment with earnings below the minimum wage is not fully penalized. In fact, the fraction of workers earning less than the minimum wage varies from 8% in Uruguay to about 70% in Peru. This situation creates a duality in the labor market: on the one hand, some jobs are performed in sectors such as agriculture, construction, and retail trade, where the value added is relatively low, there are many small and unregistered firms (with no law enforcement), and self-employment is abundant. For this segment of the economy, the minimum wage and other constraints

[10] We use MATLAB's *fsolve* function to obtain the solution numerically. Notably, this calibration process ensures precise alignment to all specified targets.

[11] The National Administrative Department of Statistics (DANE) conducts the GEIH, a continuous household survey that examines employment, income, hours worked, and other labor market-related variables. The survey started in July 2006 and replaced the Continuous Household Survey (ECH), which ran from 2001 to June 2006.

[12] We define minimum wage earners using a range because workers surveyed in the GEIH may report the wage they receive instead of the wage stated in their contract. This discrepancy may be explained by social security deductions and subsidies.

are obstacles for firms to hire formal workers. On the other hand, there are higher-productivity firms that are registered, formal, comply with legal requirements, pay their workers at least the minimum wage, and contribute to social security. The labor market in these countries is segmented, as formal jobs protected by regulations coexist with informal, low-productivity jobs. Our calibration for Colombia is consistent with this empirical fact.

Given the wage thresholds, we calibrate the relative productivity between low-skilled and high-skilled workers (θ) to yield a wage ratio of 2.7, and the relative productivity between formal and informal low-skilled workers (θ_L) to yield a wage ratio of 2.24. We set the disutility of low-skilled labor (ψ_I) to match a labor income share (of total labor income) of 17% for low-skilled households.

To define the initial level of the minimum wage (w_{min}), we target a level of low-skilled formal employment that is 10% below that of the competitive market. The remaining parameters in the production function are the share of capital in buildings (α) and the relative productivity of machinery (θ_m). These values are chosen to match an investment over GDP of 30% and a share of investment in machinery with respect to the total investment of 30%. It is important to note that our calibration algorithm perfectly matches the long-run ratios. For the long-run equilibrium, we assume that domestic and external inflation rates are zero, that is, $\pi = \pi^f = 1$, total factor productivity is set to generate a GDP equal to one (normalization), and net foreign debt is 50% of GDP ($A^f_{ss} = 50\%$). The risk premium and the labor tax rate are consistent with the average values observed in Colombia: $\Phi_{ss} = 1.0037$, and $\tau^H = \tau^F = 20\%$, respectively.

Parameter	Definition	Value	Source
σ	Intertemporal elast. subs	2.0	Glover (2019)
β	Discount factor	0.9878	González et al. (2011)
δ_m	Depreciation of K_m	0.0125	Krusell et al. (2000)
δ_b	Depreciation of K_b	0.03125	Krusell et al. (2000)
ν_H	High-skilled Labor elasticity	1.0	Glover (2019)
$\nu_F = \nu_I$	Low-skilled labor elasticity	2.0	Behar (2025)
ψ_H	Disutility of high-skilled labor	1.0	Glover (2019)
η	Elast. subs. L_m vs L_H	0.7	Krusell et al. (2000)
η_m	Elast. subs. L_L vs K_m	1.25	Chen, 2020
η_L	Elast. subs. L_I vs L_F	1.50	Behar (2025) and Krusell et al. (2000)
ϕ	Price rigidity	0.75	González et al. (2011)
ξ	Elast. subs. intermediates	12	González et al. (2011)
ρ_r	Persistence R	0.70	González et al. (2011)
r_π	Taylor π	1.50	González et al. (2011)
r_y	Taylor y	0.25	González et al. (2011)
π	Long run inflation	1.0	Normalization
π^f_{ss}	LR foreign inflation	1.0	Normalization
A^f_{ss}	Net foreign assets LR	-0.50	Data
Φ_{ss}	LR risk premium	1.0037	Data
τ_{ss}	Labor taxes	1.2	Data
ϕ_b	Capital adjustment cost k_b	0.005	Calibrated*
ϕ_m	Capital adjustment cost k_m	0.0025	Calibrated*
ϕ_a	Risk premium elast. to debt	0.50	Calibrated*

*Note: * These parameters are adjusted to replicate business cycle moments. They do not affect the long run equilibrium.*

Table 2: Parameters. Description of parameters, values and sources.

Finally, the adjustment costs of capital (ϕ_b and ϕ_m), elasticity of the risk premium (ϕ_a), and persistence and volatility of shocks are calibrated to replicate specific moments in the Colombian economy's business cycle (Panel A of Table 4), such as the relative volatility of consumption, investment, and net exports, as well as their

Target	Value	Parameter	Definition	Value
GDP	1.0	Z^a	Productivity	1.05
I/GDP	0.18	α	Capital share	0.25
I^b/I	0.65	θ_m	Productivity L_m vs K_m	0.34
w_H/w_F	2.7	θ	Productivity L_m vs L_H	0.30
w_F/w_I	2.24	θ_L	Productivity L_F vs L_I	0.16
Low skill labor income share	0.17	$\psi_I = \psi_F$	Disutility of low-skilled labor	3.73
$h^F/h^{F,comp}$	0.9	w_{min}	Minimum wage	0.39

Table 3: Targeted moments and calibrated parameters. $h^{F,comp}$ is the level of formal low-skilled employment in the competitive equilibrium without minimum wage.

correlations with GDP.

To analyze the business cycle properties of the model, we compare the standard stylized macroeconomic facts of the Colombian economy with those generated by the simulated model incorporating productivity, demand, and monetary policy shocks. Using quarterly data for Colombia from 2000 to 2019, we subtract the cyclical component of the log of GDP, consumption, investment, and trade balance over GDP using a Hodrick-Prescott filter. With the cyclical components, we calculate the relative volatility of each variable with respect to GDP and its correlation with GDP. To compare the results of the model with the data, we simulate the model using Dynare (Adjemian et al., 2024) and then apply the same logarithmic transformation and detrending procedure that we used for the data (last column of 4).

Our results, presented in Panel B of Table 4, show that the model reproduces the procyclicality of consumption and investment and the countercyclicality of the trade balance. Furthermore, the volatility of investment in the model is close to that observed in data. However, consumption and the trade balance are less volatile in the model than in the data.[13] The simulated results in the model are consistent if we take the model in levels or after filtering the data.

Panel A. Parameter Values for Exogenous Processes

Shock	Persistence	Volatility
Total Factor Productivity (TFP)	0.925	0.0024
Discount factor	0.75	0.001
Monetary Policy	0.9	0.0025

Table 4: Exogenous Processes and Model vs Data

5 Results

We now explore the macroeconomic effects of the minimum wage through the lens of the calibrated DSGE model. We first analyze the effects of an unexpected and permanent increase in the nominal minimum wage, which, according to the Colombian adjustment rule, generates a permanent increase in real minimum wage. We then analyze how the presence of the minimum wage and its adjustment rule affect the transmission of conventional shocks such as productivity, discount factor, and monetary policy. Finally, we examine how our results change when we consider alternative specifications of the model and different adjustment rules for the minimum wage, similar to those used in other countries, as mentioned in Section 2.

[13] The real business cycle literature has emphasized the lower relative volatility of consumption in general equilibrium models (Garcia-Cicco et al., 2010; Plotnikov, 2017; Rebelo, 2005).

Panel B. Data vs Model

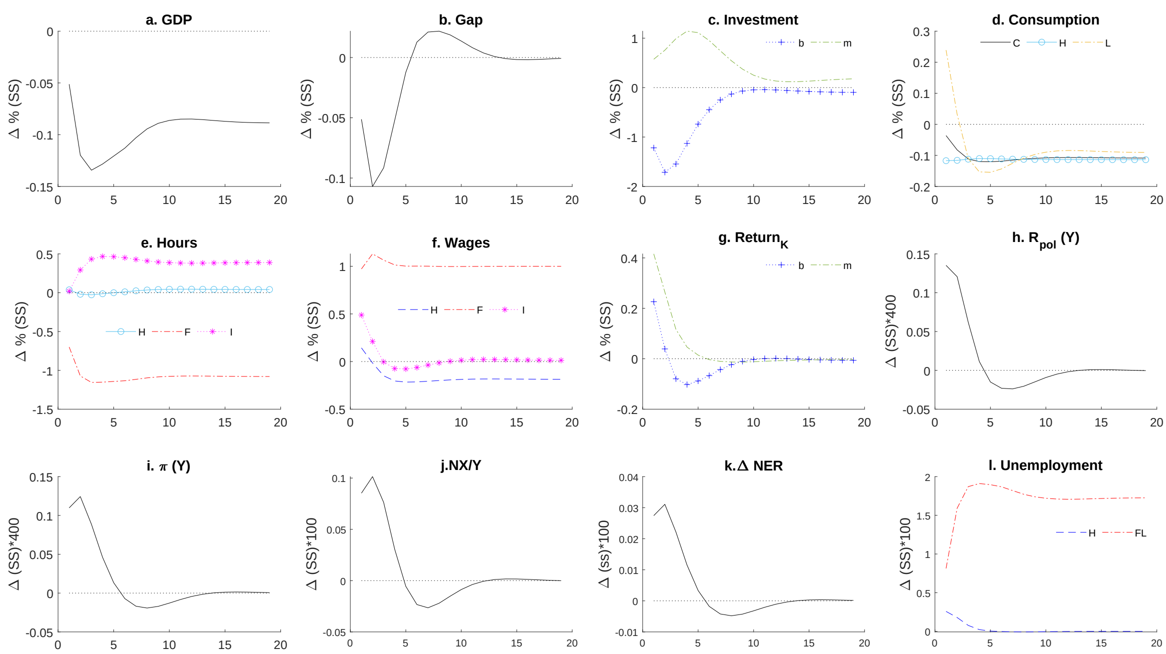
Statistic	Data	Model	Model (HP)
Standard deviations			
σ_y	0.01	0.01	0.01
σ_c/σ_y	0.93	0.58	0.56
σ_i/σ_y	5.43	5.22	5.67
$\sigma_{NX/y}/\sigma_y$	0.84	0.47	0.59
Correlations with (y)			
GDP (y)	1.0	1.0	1.0
Consumption (c)	0.68	0.86	0.88
Investment (i)	0.64	0.80	0.76
Net exports/GDP (nx/y)	-0.51	-0.37	-0.32

Note: Panel A reports the calibrated parameters for the exogenous processes. Panel B compares the simulated model with the data.

5.1 Unexpected and Permanent Increase in the Minimum Wage

In this subsection, we examine the macroeconomic response to an unanticipated increase in the nominal minimum wage of 100 basis points (1%). Due to past inflation indexation, in the Colombian adjustment rule, this change in the nominal wage induces a permanent change in real wages, pushing the economy to a new steady state.[14] Figure 2 shows the responses of the GDP, output gap, investment, consumption, labor market outcomes, inflation, monetary policy, and foreign variables. At first glance, the minimum wage shock resembles a cost-push shock: inflation rises (Panel i), output falls (Panel a), a negative output gap opens (Panel b), and the central bank responds by raising its nominal interest rate (Panel h). However, the transmission mechanisms are different.

Figure 2: Impulse response of main macroeconomic aggregates to a 100 bp increase in the minimum wage



Note: The vertical axis shows the percentage difference with respect to the initial steady state except for the interest rate, R, and inflation, π (annualized absolute difference). H stands for high-skilled, F for formal low-skilled, I for informal, and L for low-skilled.

[14] We solve for the transition path using the *perfect foresight* option in Dynare.

Looking more closely at the behavior of production factors, we find that in response to higher minimum wages, firms demand less low-skilled formal labor (Panel e) and substitute it with informal labor (Panel e) and machinery (Panel c). Quantitatively, we find that the magnitude of the response of low-skilled formal labor is smaller in the short run, consistent with the findings of Hurst et al. (2022). Capital accumulation and adjustment costs explain the slow adjustment of low-skilled formal labor in the short term. Immediately after the shock, it is costly to invest in new machinery, which limits the substitution between low-skilled formal labor and machinery. Over time, adjustment costs fall, and firms substitute the right amount of labor for machinery. As a result, the short-run elasticity of labor demand is less than one, while in the long run, it is closer to one.

These figures are similar in magnitude to the empirical evidence reported by Arango et al. (2019) and Cardenas and Bernal (2003) for industrial employment in Colombia, who found that the elasticity of the labor wage ranges from 0.7 to 1.4. However, it is important to recognize that while these elasticities are similar, they may vary because of the unique economic structure of emerging markets. With respect to unemployment, Panel l shows that a higher minimum wage increases the gap between the supply and demand for low-skilled labor, leading to a higher unemployment rate for these workers.

Regarding informal labor, we observe some temporal differences in the response of real wages (Panel f), reflecting the interaction between supply and demand at different time horizons. For instance, in the short run, as firms substitute formal low-skilled workers with informal labor, the demand for the latter increases, and wages rise by approximately 0.49%. During the transition, as low-skilled households see their income and consumption fall, they increase the supply of informal labor and drive down wages; this phenomenon is known as the additional worker effect.[15]

The remaining factors of production, capital in buildings, and high-skilled labor are affected by higher production costs and general equilibrium effects that alter the decisions of high-skilled labor households. Panel c shows how investment in buildings falls after the shock, as firms reduce their demand for other factors that are more complementary to low-skilled labor and machinery. High-skilled households also reduce their investment in buildings and allocate more resources to capital in machinery (Panel c). For high-skilled labor, hours barely change (Panel e), but wages increase on impact due to the transmission of the minimum wage shock, and the unemployment rate rises temporarily for this group (Panel l). When the transmission disappears, the lower demand for this type of labor pushes wages down, and the unemployment rate returns to zero.

Minimum wage shock has an important effect on consumption inequality (Panel d). From the perspective of high-skilled households, they smooth their consumption by permanently reducing it after the shock (-0.12%). Alternatively, hand-to-mouth consumers experience a more volatile path because of income fluctuations. Nevertheless, on impact, the increase in the minimum wage has a positive effect on the consumption of low-skilled workers (0.24%) and reduces consumption inequality. In the short run, firms do not fully substitute formal low-skilled labor, and the aggregate income of low-skilled households increases as a result. As firms find other ways to produce using cheaper informal labor and machinery, low-skilled households experience declines in income and consumption. During this transition, low-skilled consumption falls and converges in the long run to a level lower than the initial equilibrium (-0.09%). Households partially compensate for the decline in formal income by supplying more informal labor (Panel e). This short-run effect of a minimum wage increase on inequality is consistent with the empirical results of Sotomayor (2021) for Brazil, who observe a decrease in inequality in the months around the minimum wage increase.

To understand the aggregate effects on inflation, output, and the monetary policy response, we first calculate the change in unit labor costs, defined as the wage bill divided by the total number of hours worked. This indicator provides a sense of the change in the marginal cost of production, which is the main driver of inflation in New Keynesian models. On impact, we see that a 1% increase in the minimum wage translates into a 0.4% increase in labor costs. In the long run, the effect is approximately 0.1%. These relatively small magnitudes, together with the substitution of more expensive low-skilled formal labor with cheaper informal workers and

[15] Evidence of the additional worker effect in Colombia is presented in Cardona-Sosa and Morales (2015), who showed that in the first six months after the primary breadwinner's job loss, spouses increase their labor force participation by between 9% and 20%. Additionally, Arango et al. (2015) showed that participation increases six times more in recessions than in expansions, showing that the additional worker effect is higher than the discouraged worker effect over the business cycle.

machinery, explain the small response of annual inflation (Panel i), output gap (Panel b), and monetary policy rate (Panel h). Quantitatively, GDP falls by 0.13% on impact and in the long run (0.09%), generating a temporarily negative output gap. The monetary policy response is limited for two reasons. On the one hand, the inflationary shock is small; on the other hand, because of the rule of adjustment, the nominal shock has real and permanent effects, which reduces the adjustment margin of the monetary policy.

In terms of external variables, a higher minimum wage triggers domestic inflation and depreciates the nominal exchange rate (Panel k). Currency depreciation and weakening domestic demand lead to an increase in the trade balance (Panel j). In the long run, net exports return to their initial level, constrained by the debt-to-GDP ratio. As reported in Appendix C, the response of net exports and investment depend on the sensitivity of the risk premium to changes in the debt-to-GDP ratio. If the sensitivity is low, households find it easier to borrow abroad, allowing them to finance additional investment in machinery. Consequently, net exports increase less in response to the shock. As a robustness check, in sections 5.2 and 5.3 we analyze how our results change when we consider different model specifications closer to the standard literature and alternative values for the elasticities of substitution in production.

Following the literature on advanced economies (Glover, 2019; Šauer, 2018), in Appendix A we analyze the macroeconomic effects of a transitory shock to the minimum wage. The results are qualitatively consistent with those the of benchmark case. However, the initial responses of all variables are different. For example, investment in machinery increases less (1% vs. 2%), while inflation and the monetary policy interest rate increase more. In this scenario, firms know that the shock is transitory and that the minimum wage will eventually return to its initial level. Therefore, they do not have the same incentives to invest in machinery; consequently, they do not substitute a large fraction of their formally employed low-skilled labor. As a result, the impact on formal low-skilled labor is less than 1%. Less substitution affects short-run inflation, which rises more than in the benchmark case and causes the policy rate to react more. This comparison highlights how the presence of a minimum wage, with its associated rigidity, affects the responsiveness of the real interest rate to monetary policy shocks.

Finally, in Appendix B, we explore the impact of the incidence of the minimum wage. We compare our benchmark results to a counterfactual economy in which the share of labor compensation earned by minimum wage workers is 35% instead of 16%, as in the benchmark economy. The results are qualitatively the same, but the real and nominal effects are magnified in the counterfactual economy.

5.2 Sensitivity to Model Assumptions

In this section, we explore how our main results change when we modify some of the model assumptions to be more consistent with the standard models of real business cycles. The alternative models are more consistent with the standard models of real business cycles. In particular, we consider three scenarios: *i)* no machinery (only one type of capital–buildings), *ii)* no informal labor (low-skilled households offer only formal labor), and *iii)* only one type of household with three types of labor. In all cases, we re-calibrate the model to target the same moments. Table 5 reports the calibrated parameters for each alternative version of the model.

Parameter	Benchmark	NoK_x	No Infor.	One HH
$\psi_I = \psi_F$	3.73	4.30	3.44	0.69
α	0.25	0.39	0.25	0.25
θ	0.30	0.14	0.29	0.29
θ_L	0.16	0.16	N/A	0.25
θ_m	0.34	N/A	0.33	0.40
w_{min}	0.39	0.39	0.39	0.19
A	1.05	0.67	1.08	0.63

Table 5: Calibrated Parameters. Alternative Models.

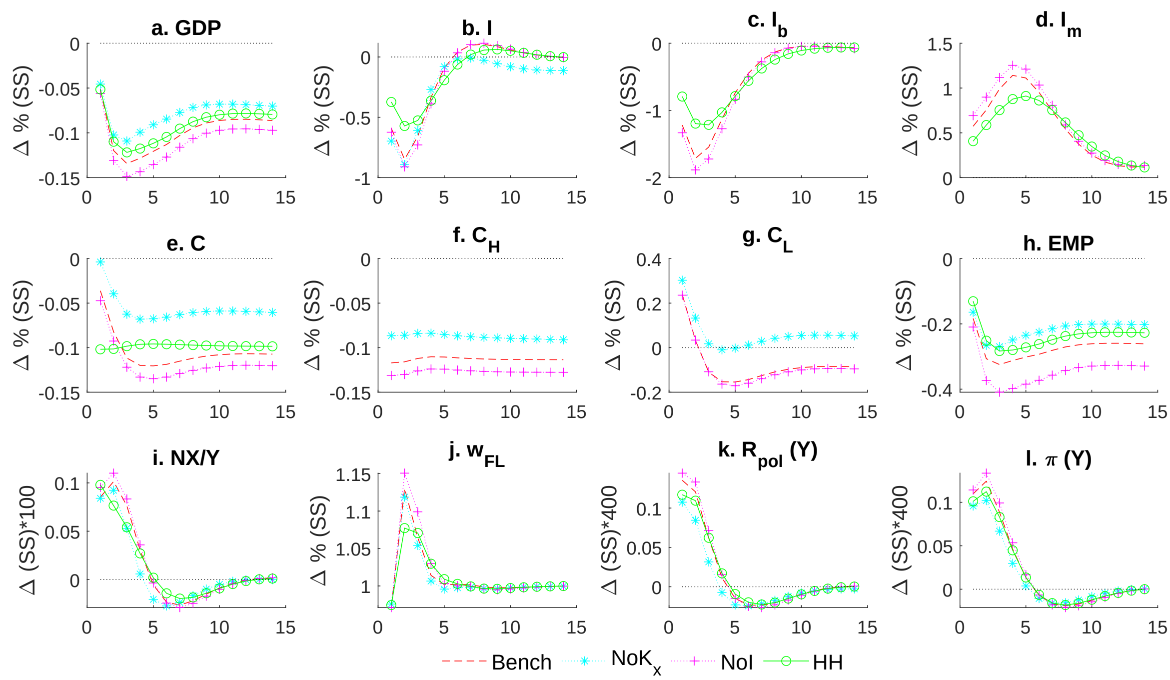
Figure 3 shows the results for the main macroeconomic variables for the benchmark model and alternative scenarios. As we can see, all specifications are qualitatively consistent for the main macroeconomic aggregates (GDP, consumption, employment, policy rate, and inflation), but the magnitudes differ across scenarios. One version that attracts our attention is the model with only one type of capital. In this scenario, a higher minimum wage induces firms to hire more informal workers because they are the only available substitution option. Therefore, low-skilled households do not experience a fall in income, and their consumption increases, which is consistent with the results presented by Šauer (2018). As a result, aggregate consumption falls less (than in the other scenarios), and the contractionary effects on output and employment are smaller. We also observe a reduction in consumption inequality in this scenario.

When low-skilled workers can offer only one type of labor, an increase in the minimum wage pushes firms to substitute formal low-skilled workers with machinery, which sharply increases investment. Unable to increase their labor supply, low-skilled households see their employment and income decrease. Consequently, the contractionary effects of raising the minimum wage are magnified in this scenario. We also observe that the limited possibility of substitution leads to additional increases in wages, inflation, and the policy rate. If we allow low-skilled households to offer informal labor, their drop in income forces them to increase the supply of informal labor, which pushes down informal wages and dampens the inflationary effects of the policy.

On the other hand, if we consider only one type of capital, the contractionary effects of the minimum wage increase are reduced. In this scenario, higher formal wages for low-skilled workers force firms to hire more informal workers, and low-skilled households do not experience a decrease in income after the shock. Consequently, low-skilled consumption increases, and the decline in aggregate consumption is smaller (than in the other scenarios). This relatively higher demand causes output and employment to fall less.

For the remaining scenario, we consider only one type of household offering three different types of labor: formal high-skilled, formal low-skilled, and informal low skilled. In this case, the representative household can perfectly smooth consumption and adjust its labor supply decisions. Compared to the benchmark scenario, consumption and employment fall less, leading to a smaller reduction in the GDP.

Figure 3: Impulse Response of Main Macroeconomic Aggregates to a 100 bp increase in the minimum wage.



Note: The vertical axis shows the percentage difference with respect to the initial steady state except for the interest rate, R, and inflation, π (absolute difference - annualized). Bench stands for the benchmark model, NoK_x for a model without machines, NoI for a model without informality, and HH for a model with only one household.

5.3 Sensitivity to Elasticities of Substitution in the Production Function

We now explore how the benchmark results change under alternative values of the elasticities of substitution in the production function. In particular, we consider three cases:

1. Higher elasticity of substitution between high-skilled labor and the bundle of machines and low-skilled labor, $\eta = 0.9$. In other words, these two factors are now less complementary.

2. Higher elasticity of substitution between machines and low-skilled labor, $\eta_m = 2.0$.

3. Higher elasticity of substitution between low-skilled formal and informal labor, $\eta_L = 2.0$.

In all cases, the model is re-calibrated to match the same targets as in the benchmark economy. The calibrated parameters for the alternative scenarios are listed in Table 6, and the simulations for the permanent change in the minimum wage are presented in Figure 4.

Parameter	Benchmark	$\eta = 0.9$	$\eta_L = 2.0$	$\eta_m = 2.0$
θ	0.30	0.28	0.30	0.21
θ_L	0.16	0.16	0.20	0.16
ψ_I	3.73	3.74	3.74	3.25
α	0.25	0.25	0.25	0.25
A	1.05	1.05	1.07	1.12
w_{min}	0.39	0.39	0.39	0.40

Table 6: Calibrated Parameters. Sensitivity.

Figure 4 shows the impulse response functions following a permanent increase in the minimum wage for the benchmark scenario and alternative cases. As shown in the figure, most of the results are qualitatively consistent: higher labor costs for hiring formal low-skilled workers reduce the demand for this type of labor, leading to a substitution with informal labor and machinery. Higher production costs lead to a reduction in aggregate output, employment, and consumption.

A notable finding is the elasticity of substitution between machines and low-skilled labor. When production technology allows greater substitution between these factors, firms more aggressively replace formal low-skilled labor with machinery. As a result, investment in machinery increases notably compared to other scenarios, leading to a surge in aggregate investment at the time of impact and mitigating the negative effects on the GDP. However, to finance this additional investment, high-skilled households reduce their consumption more significantly.

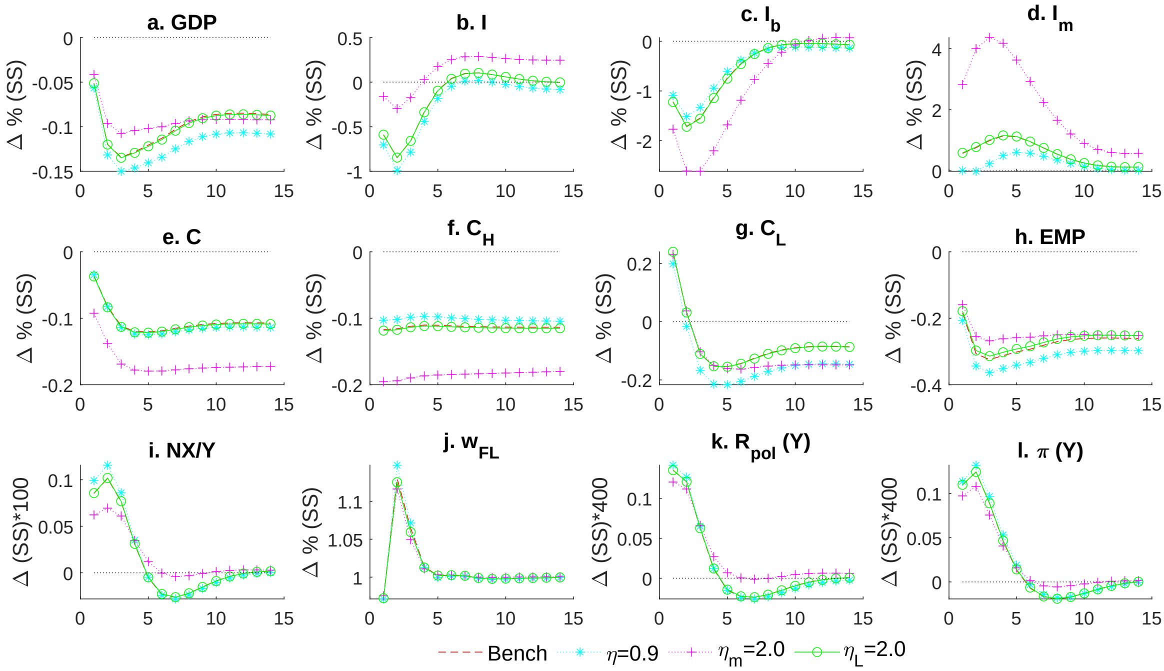
5.4 Minimum Wage as a Propagation Mechanism of Conventional Shocks

In this section, we examine how the minimum wage and its adjustment rule affect the transmission of four conventional shocks: total factor productivity (TFP), the discount factor, and monetary policy. Each shock is set to 1%, with a persistence of 75% for the TFP and discount factor shocks, while the persistence of the monetary policy shock remains unchanged relative to the benchmark model. To facilitate comparison, we also simulate an alternative model without labor market frictions, i.e., without a minimum wage and without transmission effects on high-skilled wages.[16]

Figure 5 illustrates the macroeconomic and labor market responses to a 1% productivity shock in the two versions of the model. In both cases, we observe an expansion of economic activity and a decline in inflation, indicative of a positive supply shock that reduces production costs and stimulates economic output. The central bank prioritizes inflation control over output gap fluctuations and lowers the policy rate. Comparing

[16]Impulse response functions are computed using the *stoch-simul* option of Dynare.

Figure 4: Impulse Response of Main Macroeconomic Aggregates to a 100 bp transitory increase in the minimum wage. Benchmark model and alternative parameters.



Note: The vertical axis shows the percentage difference with respect to the initial steady state except for the interest rate, R, and inflation, π (annualized absolute difference). H stands for High-skilled, F for formal low-skilled, I for informal, and L for low-skilled. Bench stands for the benchmark model; $\eta = 0.9$ for the model with higher elasticity of substitution between high-skilled labor and the bundle of machines and low-skilled labor, $\eta_m = 2.0$ for the model with higher elasticity of substitution between machines and low-skilled labor; and η_L for the model with higher elasticity of substitution between low-skilled formal and informal labor.

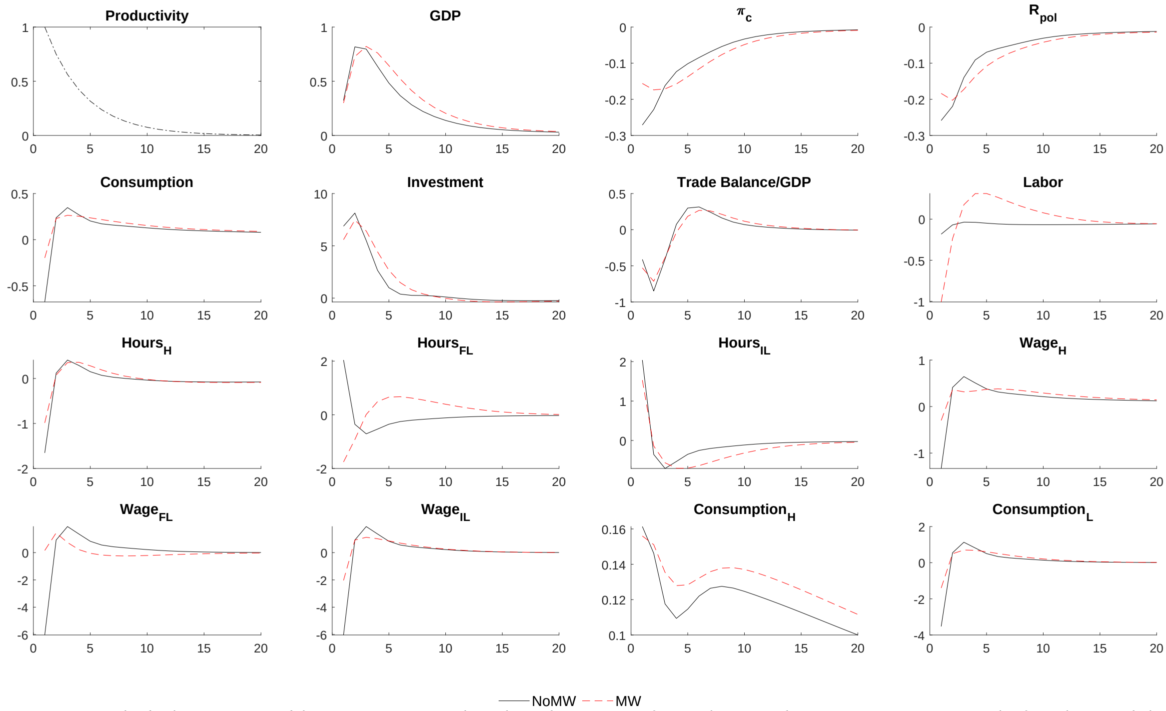
the macroeconomic effects between the two models, we find that the minimum wage affects both the initial response and persistence of key variables. In particular, the initial decline in inflation is less pronounced in the presence of a minimum wage due to wage rigidity, although it is more persistent. This trend extends to aggregate consumption, investment, output, and the policy rate. Regarding labor market dynamics, we find that the minimum wage environment induces adjustments primarily through quantities rather than prices, consistent with the modeled rigidities. Ospina, 2023 finds dimilar results for labor market outcomes.

The behaviors of household hours, wages, and consumption are quantitatively consistent in both models. However, there is a notable difference in the response of formal low-skilled workers with and without the minimum wage. In the absence of labor market rigidities, a productivity shock initially reduces employment, while in the presence of labor market rigidities, it leads to an increase in employment. In the absence of labor market rigidities, a productivity shock reduces all wages at the time of its impact, resulting in a decrease in the income of low-skilled workers. This induces them to increase their formal and informal labor supply. Conversely, the existence of an adjustment rule that considers labor productivity leads to an increase in the minimum wage. This, in turn, increases the cost of labor and reduces the demand for low-skilled labor in the short run.

Despite these differences, both scenarios return to the initial steady state as productivity shocks dissipate. Additionally, we observe a positive effect on consumption for both high- and low-skilled households due to the minimum wage and its transmission to high-skilled wages. Our results are consistent with the existing evidence presented by Fiess et al. (2010) and Leyva and Urrutia (2020), suggesting that informality is countercyclical.

We now analyze the effects of a positive shock to the discount factor that increases the willingness of high-skilled households to consume in the short run. By construction, this shock increases the consumption of high-skilled workers and reduces the resources allocated to investment in buildings and machinery (Panel A of Figure 6). In the case of low-skilled households, the shock does not directly affect them because of their

Figure 5: Impulse response functions to a 1% total factor productivity (TFP) shock



Note: Except trade balance, variables are expressed in log deviations from the steady state. NoMW stands for the model without minimum wage, and MW for the model with minimum wage.

financial constraints. The higher demand for final goods also raises inflation in the short run, forcing the central bank to raise interest rate. The fall in investment and the higher interest rate lead to a contraction in output. As in the previous case, we observe that the presence of a minimum wage and its adjustment rule increase the persistence of macroeconomic aggregates such as GDP, inflation, investment, and the nominal interest rate. In this regard, while inflation increases less upon impact, it takes more time to return to the initial level because of labor costs.

Next, we introduce a 1% monetary policy shock that raises both nominal and real interest rates. Panel B of Figure 6 illustrates how the presence of a minimum wage affects the monetary policy transmission. Notably, we observe that the efficacy of the policy rate in curbing inflation is reduced due to labor cost rigidities, and an increase in the real interest rate has a smaller impact on inflation than expected. Consistent with previous scenarios, macroeconomic aggregates exhibit longer adjustment periods before returning to their initial levels, consistent with the findings of Angel-Urdinola (2004). Additionally, other macroeconomic variables react as expected to a monetary policy shock: GDP, consumption, and investment all decline.

5.5 Macroeconomic Effects Under Alternative Rules of Adjustment

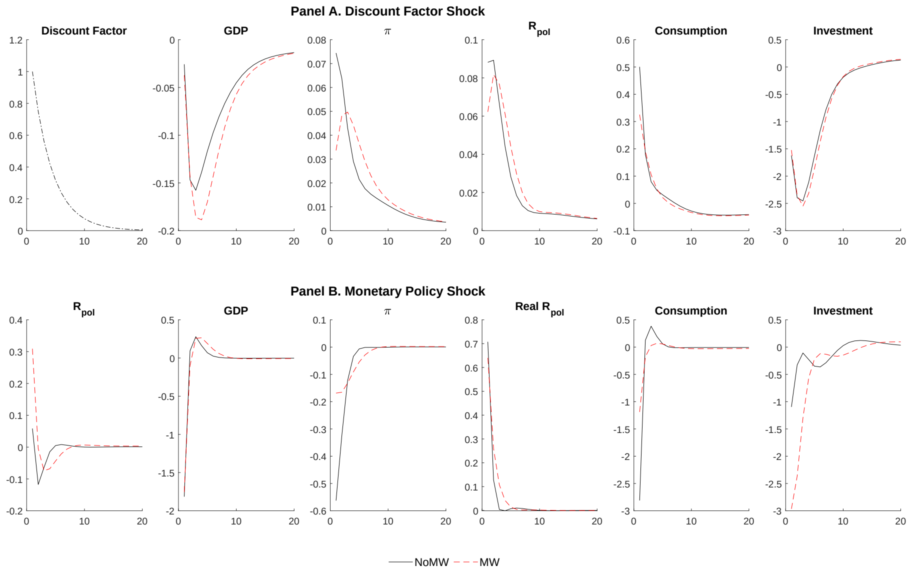
In this section, we explore how alternative adjustment rules affect the transmission of productivity, discount factor, and monetary policy shocks. As discussed in Section 2, the adjustment of the minimum wage may depend on several factors, including inflation, economic growth, productivity, and wage inflation. Based on this evidence, we introduce four adjustment rules that respond to these factors:

i) past inflation combined with the change in the marginal product of labor (Eq. (46), our benchmark, as discussed in Section 5),

ii) past inflation,

$$\Delta W_t^F = \frac{W_t^F}{W_{t-1}^F} = \pi_{t-1}\left(1 + \epsilon_t^F\right), \tag{58}$$

Figure 6: Impulse response functions for main macroeconomic aggregates



Note: Except trade balance, variables are expressed in log deviations from the steady state. NoMW stands for the model without minimum wage, and MW for the model with minimum wage.

iii) past inflation combined with past economic growth,

$$\Delta W_t^F = \frac{W_t^F}{W_{t-1}^F} = \pi_{t-1} \Delta Y_{L,t-1} \left(1 + \epsilon_t^F\right), \text{ and} \tag{59}$$

iv) past inflation combined with the average growth rate of real wages

$$\Delta W_t^F = \frac{W_t^F}{W_{t-1}^F} = \pi_{t-1} \Delta w_{t-1} \left(1 + \epsilon_t^F\right). \tag{60}$$

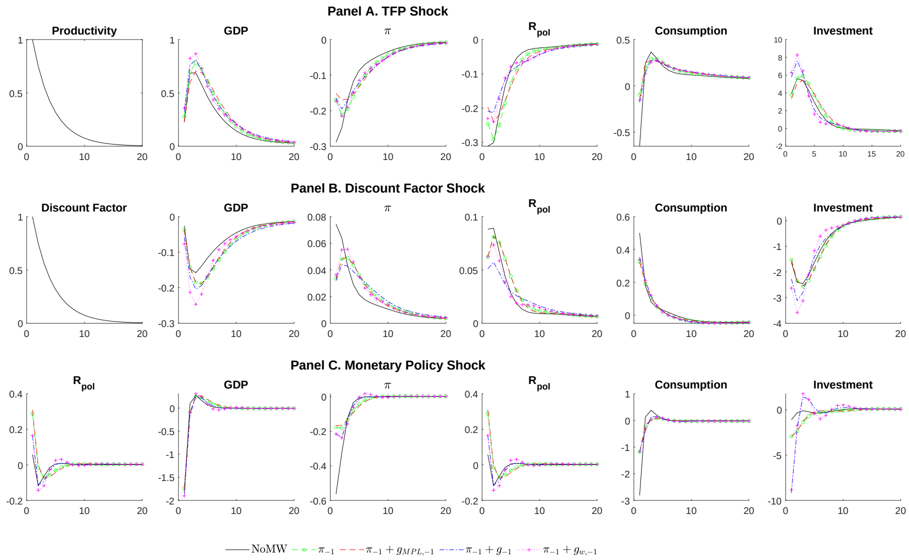
These adjustment rules have different objectives but all have the implicit purpose of preserving the purchasing power of low-skilled workers. In addition to preserving purchasing power, the rule in equation (59) seeks to redistribute the gains from economic growth, whereas the rule in equation (46) compensates for changes in the marginal product of labor. Finally, the rule in equation (60) ensures that changes in the minimum wage reflect the dynamics of other wages in the economy.

With this set of rules, we compare the behavior of transitory shocks to total factor productivity, the discount factor, and monetary policy (Figure 7). In general, we find that the results are qualitatively similar across the rules. However, the magnitudes and persistence of these shocks differ. For example, after a productivity shock (panel A of Figure 7), GDP, investment, inflation, and the policy rate are more responsive in the early quarters under the rules that only adjust for past inflation and nominal wage growth. For these two rules, the minimum wage adjustment has a smaller impact and does not dampen the positive effects of the TFP shock. Note that when the minimum wage is adjusted according to past wage growth, labor and investment become more volatile. Finally, for the monetary policy shock, we observe similar effects for all rules, with minimal differences in magnitude (panel C of Figure 7).

Our results suggest that the choice of minimum wage adjustment rule is not critical to the effects of monetary policy shocks. Macroeconomic variables react similarly, both quantitatively and qualitatively. This result partly stems from the fact that all rules consider past inflation in their adjustment mechanisms, and the monetary shock does not significantly affect the idiosyncratic components of the alternative rules. As in the benchmark case, the efficacy of the monetary policy rate in containing inflation is reduced relative to the model without a minimum wage.

Our simulations reveal that the response of the economy remains qualitatively consistent under different rules. However, the nature of the shock plays a crucial role in determining the quantitative response. Specifically, shocks to productivity or minimum wage induce greater volatility under a rule that allows wage inflation. However, the responses to monetary policy shocks show no discernible difference.

Figure 7: Impulse Response Functions for alternative minimum wage rules



Note: Variables are expressed in log deviations from the steady state. Panel A shows the effects of a 1% TFP shock. Panel B shows the response to a 1% discount factor shock. Panel C shows the response to a 1% monetary policy shock. NoMW stands for the model without minimum wage. The models with different rules of adjustment are: π_{-1} only past inflation, $\pi_{-1} + g_{MPL,-1}$ past inflation and past labor productivity growth, $\pi_{-1} + g_{-1}$ past inflation and past economic growth, $\pi_{-1} + g_{w,-1}$ past inflation and past real wages growth.

6 Conclusions

This paper studies the macroeconomic effects of the minimum wage in a typical small, open, emerging economy, filling a gap in the literature, which has mostly focused on advanced economies. Several characteristics of EMEs make the minimum wage more relevant for economic adjustment than in AEs. These include higher levels of informality, lower labor productivity, and minimum wages closer to the median wage.

We examine the response to an unexpected increase in the minimum wage through the lens of a two-agent New Keynesian SOE model. This has had a substantial impact on the labor market for low-skilled workers. A higher minimum wage leads to the substitution of formal low-skilled workers with informal labor and machinery. These substitutions mitigate the negative impact on economic activity, resulting in a slight reduction in output, modest increase in inflation, and mild monetary policy response. In the short run, investment in machinery is financed by foreign debt, which worsens the trade balance. Interestingly, the consumption response of low-skilled households depends on the time horizon. Initially, these households increase their consumption due to rigidities that prevent firms from substituting low-skilled workers with machines. However, in the transition to the long run, as these frictions disappear, low-skilled workers are replaced, and income and consumption decline. The automation channel is key to the dynamic response of low-skilled consumption. In a simplified model in which capital does not substitute for labor, low-skilled consumption increases in both the short and long run.

We also explore how the minimum wage affects the transmission of standard shocks, such as productivity, discount factor, and monetary policy. Our results indicate that the minimum wage lengthens the duration of the macroeconomic responses. Moreover, labor market adjustments are mainly driven by quantities rather than wages. In all exercises, the relatively muted response of monetary policy is partly the result of the minimum wage being a real rigidity; therefore, its changes constitute a real adjustment that the monetary policy must allow to take place. This real rigidity reduces the short-run effectiveness of monetary policy in controlling inflation.

Finally, we examine whether different adjustment rules affect the transmission of economic shocks and find that the qualitative results are consistent across alternative rules. However, quantitative responses depend on the shock.

Our findings have important implications for policymakers in emerging economies who are considering minimum wage increases, changes in their adjustment rules, or appropriate policy responses to changes in the minimum wage. We find that the effects of the minimum wage on key macroeconomic variables, as well as the channels through which it operates in emerging economies, differ from those documented in studies focusing on advanced countries.

References

Adjemian, S., Juillard, M., Karamé, F., Mutschler, W., Pfeifer, J., Ratto, M., Rion, N., & Villemot, S. (2024, February). *Dynare: Reference Manual, Version 6* (Dynare Working Papers No. 80). CEPREMAP. https://ideas.repec.org/p/cpm/dynare/080.html

Albertini, J., & Fairise, X. (2013). Search frictions, real wage rigidities and the optimal design of unemployment insurance. *Journal of Economic Dynamics and Control*, *37*(9), 1796–1813.

Angel-Urdinola, D. (2004). *A Minimum Wage Increase Can Have an Adverse Distributional Impact: The Case of Colombia* (Archivos de Economía No. No. 247). Departamento Nacional de Planeación. https://doi.org/http://dx.doi.org/10.2139/ssrn.579201

Arango, L., Ávila, O., Bonilla-Mejía, L., Flórez, L. A., Gómez-Pineda, J. G., Grajales-Olarte, A., Guarin, A., Franz Hamann, D. H., Julio-Román, J. M., Lasso-Valderrama, F., Méndez-Vizcaíno, J. C., et al. (2022). Efectos Macroeconómicos Del Salario Mínimo en Colombia. *Revista ESPE-Ensayos sobre Política Económica*, (103), 1–117.

Arango, L., Castellani, F., & Obando, N. (2019). Heterogeneous Labour Demand in the Colombian Manufacturing Sector. *Journal for Labour Market Research*, *53*(1), 1–19.

Arango, L., & Flórez, L. (2021). Regional Labour Informality in Colombia and a Proposal for a Differential Minimum Wage. *The Journal of Development Studies*, *57*(6), 1016–1037.

Arango, L., Parra, F. F., & Pinzón, Á. J. (2015). *El Ciclo Económico Y El Mercado de Trabajo en Colombia: 1984 - 2014* (Borradores de Economía No. 911). Banco de la República de Colombia.

Behar, A. (2025). The elasticity of substitution between skilled and unskilled labor in developing countries: A directed technical change perspective. *Journal of Development Economics*, *174*, 103411.

Bell, L. A. (1997). The Impact of Minimum Wages in Mexico and Colombia. *Journal of Labor Economics*, *15*(3), 102–135. https://doi.org/https://doi.org/10.1086/209878

Bíró, A., Prinz, D., & Sándor, L. (2022). The minimum wage, informal pay, and tax enforcement. *Journal of Public Economics*, *215*, 104728.

Breza, E., & Kaur, S. (2025). Labor markets in developing countries. *Annual Review of Economics*, *17*.

Calvo, G. (1983). Staggered Prices in a Utility-Maximizing Framework. *Journal of Monetary Economics*, *12*(1978), 383–398. http://www.sciencedirect.com/science/article/pii/0304393283900600

Cardenas, M., & Bernal, R. (2003). Determinants of Labor Demand in Colombia: 1976-1996. *Law and Employment: Lessons from Latin American and the Caribbean, Chapter 4*.

Cardona-Sosa, L., & Morales, L. (2015). *Efectos Laborales de Los Servicios de Cuidado Infantil: Evidencia Del Programa Buen Comienzo* (Borradores de Economía No. 882). Banco de la República de Colombia. https://ideas.repec.org/p/bdr/borrec/882.html

Chen, C. (2020). Capital-skill complementarity, sectoral labor productivity, and structural transformation. *Journal of Economic Dynamics and Control*, *116*, 103902.

Eckardt, M. S. (2022). Minimum Wages in an Automating Economy. *Journal of Public Economic Theory*, *24*(1), 58–91.

Fiess, N. M., Fugazza, M., & Maloney, W. F. (2010). Informal Self-Employment and Macroeconomic Fluctuations. *Journal of Development Economics*, *91*(2), 211–226.

Gali, J., & Monacelli, T. (2005). Monetary policy and exchange rate volatility in a small open economy. *The Review of Economic Studies*, *72*(3), 707–734.

Garcia-Cicco, J., Pancrazi, R., & Uribe, M. (2010). Real Business Cycles in Emerging Countries? *American Economic Review*, *100*(5), 2510–2531.

Glover, A. (2019). Aggregate Effects of Minimum Wage Regulation at the Zero Lower Bound. *Journal of Monetary Economics*, *107*, 114–128. https://doi.org/https://doi.org/10.1016/j.jmoneco.2018.11.001

González, A., Mahadeva, L., Prada, J. D., & Rodríguez, D. (2011). Policy Analysis Tool Applied to Colombian Needs: PATACON Model Description. *Ensayos sobre Política Económica*, *29*(66), 222–245. https://doi.org/https://doi.org/10.32468/Espe.6606

Gramlich, E. M. (1976). Impact of Minimum Wages on Other Wages, Employment, and Family Incomes. *Brookings Papers on Economic Activity*, *7*(2), 409–462. https://ideas.repec.org/a/bin/bpeajo/v7y1976i1976-2p409-462.html

Hurst, E., Kehoe, P. J., Pastorino, E., & Winberry, T. (2022). *The Distributional Impact of the Minimum Wage in the Short and Long Run* (tech. rep.). National Bureau of Economic Research.

ILO. (2020). *Global Wage Report 2020-21: Wages and Minimum Wages in the Time of COVID-19*. International Labour Office.

Katzkowicz, S., Pedetti, G., Querejeta, M., & Bergolo, M. (2021). Low-Skilled Workers and the Effects of Minimum Wage in a Developing Country: Evidence Based on a Density-Discontinuity Approach. *World Development*, *139*, 105279. https://doi.org/https://doi.org/10.1016/j.worlddev.2020.105279

Krusell, P., Ohanian, L. E., RÌos-Rull, J.-V., & Violante, G. L. (2000). Capital-Skill Complementarity and Inequality: A Macroeconomic Analysis. *Econometrica*, *68*(5), 1029–1054. https://doi.org/https://doi.org/10.1111/1468-0262.00150

Lemos, S. (2004). The Effects of the Minimum Wage in the Formal and Informal Sectors in Brazil. *Available at SSRN 526023*.

Leyva, G., & Urrutia, C. (2020). Informality, Labor Regulation, and the Business Cycle. *Journal of International Economics*, *126*, 103340.

Lordan, G., & Neumark, D. (2018). People Versus Machines: The Impact of Minimum Wages on Automatable Jobs. *Labour Economics*, *52*, 40–53.

Maloney, W., & Mendez, J. (2004). Measuring the Impact of Minimum Wages. Evidence From Latin America. In *Law and Employment: Lessons from Latin America and the Caribbean* (pp. 109–130). National Bureau of Economic Research, Inc.

Medrano-Adán, L., & Salas-Fumás, V. (2023). Do Minimum Wages Deliver What They Promise? Effects of Minimum Wage on Employment, Output, and Income Inequality From Occupational Choice Theory. *Economic Analysis and Policy*, *80*, 366–383.

Mincer, J. (1976). Unemployment Effects of Minimum Wages. *Journal of Political Economy*, *84*(4, Part 2), S87–S104. https://doi.org/10.1086/260534

Mora, J. J., & Muro, J. (2017). Dynamic Effects of the Minimum Wage on Informality in Colombia. *Labour*, *31*(1), 59–72.

Neumark, D., & Munguía-Corella, L. F. (2021). Do Minimum Wages Reduce Employment in Developing Countries? A Survey and Exploration of Conflicting Evidence. *World Development*, *137*, 105165. https://doi.org/https://doi.org/10.1016/j.worlddev.2020.105165

Neumark, D., Schweitzer, D., & Wascher, D. (2004). Minimum Wage Effects Throughout the Wage Distribution. *Journal of Human Resources*, *39*(2). https://doi.org/https://doi.org/10.2307/3559021

OECD. (2024). *OECD Data Explorer*. Retrieved May 2, 2024, from https://data-explorer.oecd.org/

Ospina, M. A. G. (2023). Optimal monetary policy in developing countries: The role of informality. *Journal of Economic Dynamics and Control*, *155*, 104724.

Pérez, J. P. (2020). The Minimum Wage in Formal and Informal Sectors: Evidence From an Inflation Shock. *World Development*, *133*, 104999.

Plotnikov, D. (2017). *What Prevents a Real Business Cycle Model From Matching the US Data? Decomposing the Labor Wedge*. International Monetary Fund.

Rebelo, S. (2005). Real Business Cycle Models: Past, Present and Future. *The Scandinavian Journal of Economics*, *107*(2), 217–238. Retrieved October 31, 2023, from http://www.jstor.org/stable/3441103

Šauer, R. (2018). The Macroeconomics of the Minimum Wage. *Journal of Macroeconomics*, *56*(100), 89–112. https://doi.org/https://doi.org/10.1016/j.jmacro.2018.01.

Schmitt-Grohé, S., & Uribe, M. (2003). Closing Small Open Economy Models. *Journal of international Economics*, *61*(1), 163–185.

Seok, B. H., & You, H. M. (2022). Macroeconomic Impacts of Increasing the Minimum Wage: The Case of Korea. *Economic Modelling*, *113*, 105880.

Sotomayor, O. J. (2021). Can the Minimum Wage Reduce Poverty and Inequality in the Developing World? Evidence From Brazil. *World Development*, *138*, 105182. https://doi.org/https://doi.org/10.1016/j.worlddev.2020.105182

Sy, D. K., & Hosoe, N. (2023). Consequences of a Minimum Wage Increase in a Migrant-Sending Country. *Economic Analysis and Policy*, *80*, 1057–1066.

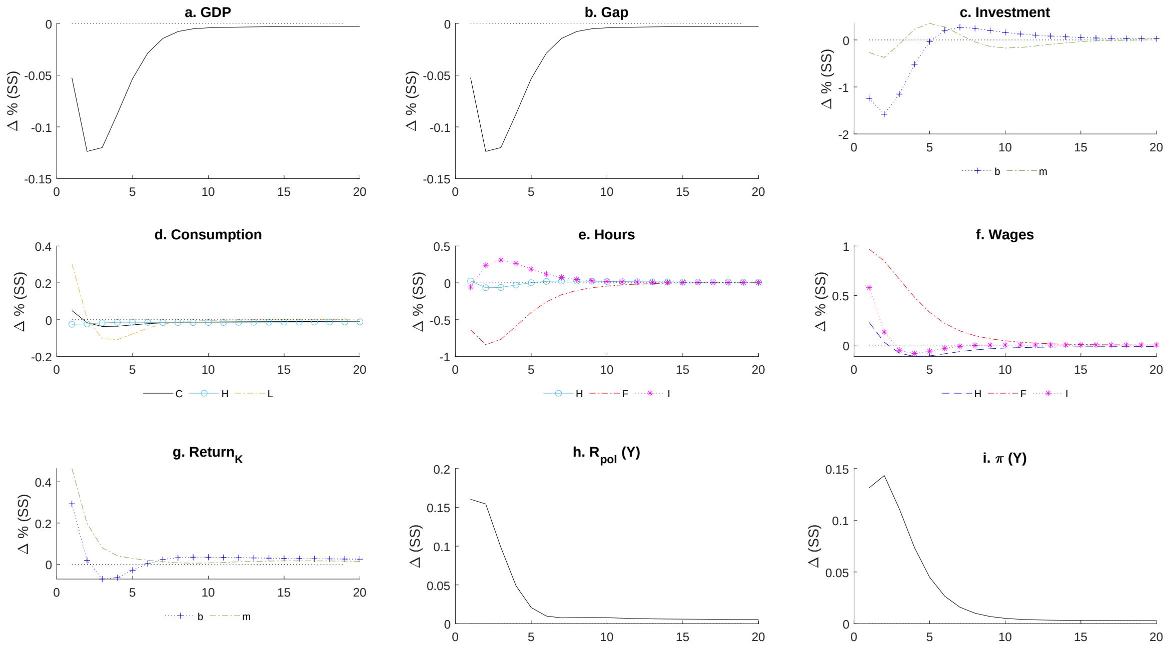
Whalen, C., & Reichling, F. (2017). Estimates of the Frisch Elasticity of Labor Supply: A Review. *Eastern Economic Journal*, *43*(1), 37–42. https://doi.org/https://doi.org/10.1057/eej.2015.23

A Appendix: Transitory Shock to the Minimum Wage

Following the literature on advanced economies (Glover, 2019; Šauer, 2018), in this section, we analyze the macroeconomic effects of a transitory shock to the minimum wage. To do so, we assume that the real minimum wage does not adjust according to past inflation and labor productivity and is only affected by a transitory shock that follows an AR(1) process. The rest of the model structure remained unchanged.

As shown in Figure A.1, the results are qualitatively consistent with those of the benchmark case. However, the initial responses of some variables were different. For example, investment in machinery does not increase on impact, while inflation and the policy rate increase more. In this scenario, firms know that the shock is transitory and that the minimum wage will eventually return to the same initial level. Therefore, they do not have the same incentives to invest in machinery and substitute a large fraction of their formal low-skilled labor. As a result, the impact on formal low-skilled labor is less than 1%. Less substitution has an impact on short-run inflation, which increases more than in the benchmark case and causes the MP interest rate to react more.

Figure A.1: Impulse Response of Main Macroeconomic Aggregates to a 100 bp transitory increase in the minimum wage.



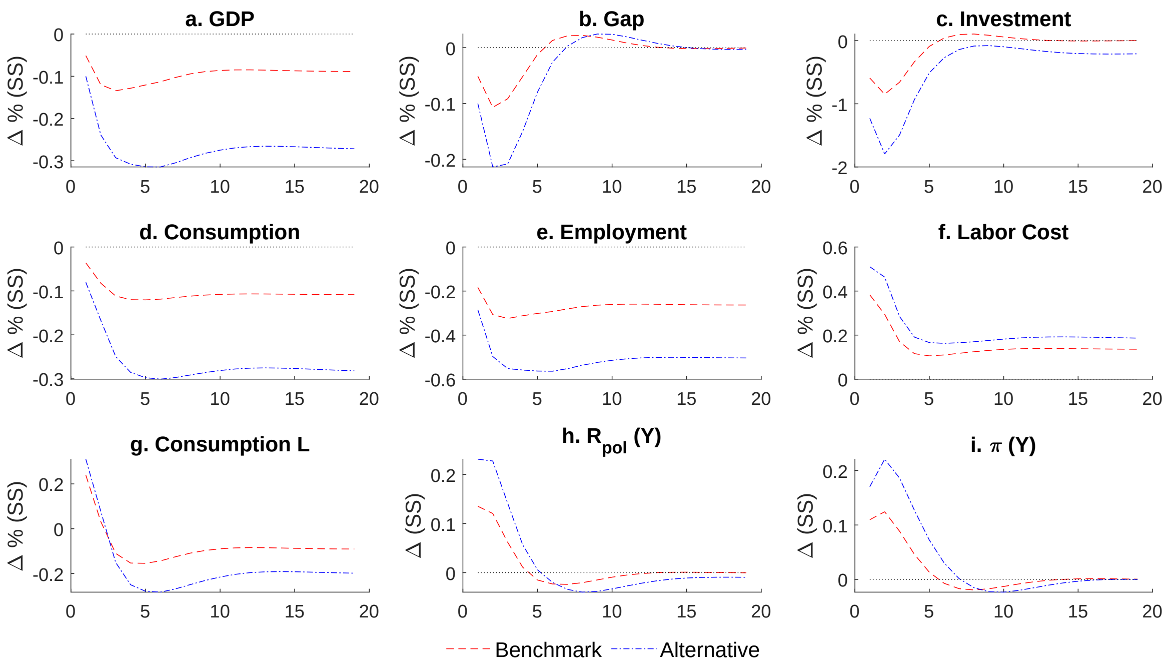
Note: The vertical axis shows the percentage difference with respect to the initial steady state except for the interest rate, R, and inflation, π (annualized absolute difference). H stands for high-skilled, F for formal low-skilled, I for informal, and L for low-skilled.

B Appendix: Minimum Wage Incidence - Counterfactual Economy

To analyze the effects of the incidence of the minimum wage, in this appendix, we explore an alternative calibration of the model. We target a mass of high-skilled households of 40% (vs. 52% in the benchmark model) and a mass of high-skilled labor compensation of 60% (vs. 83% in the benchmark). The remaining targets are the same as those in the benchmark model, and the structure is changed. Consequently, the share of formal low-skilled labor in total compensation is 36%, which is higher than in the benchmark case (15%).

We simulate the model for a 1% increase in the real minimum wage and compare the results with those of the benchmark calibration. As shown in Figure (B.1), the qualitative results are consistent with our benchmark scenario, but the results are magnified when the minimum wage has a greater incidence in the economy. As shown in Panel f, labor costs increase more, leading to larger declines in employment, output, investment, and consumption. As a result, inflation doubles relative to our benchmark, and the monetary policy responds more strongly. As for the consumption of low-skilled households, it rises in the early periods but falls more during the transition and in the long run.

Figure B.1: Impulse Response of Main Macroeconomic Aggregates to a 100 bp transitory increase in the minimum wage. Benchmark model and alternative calibration.

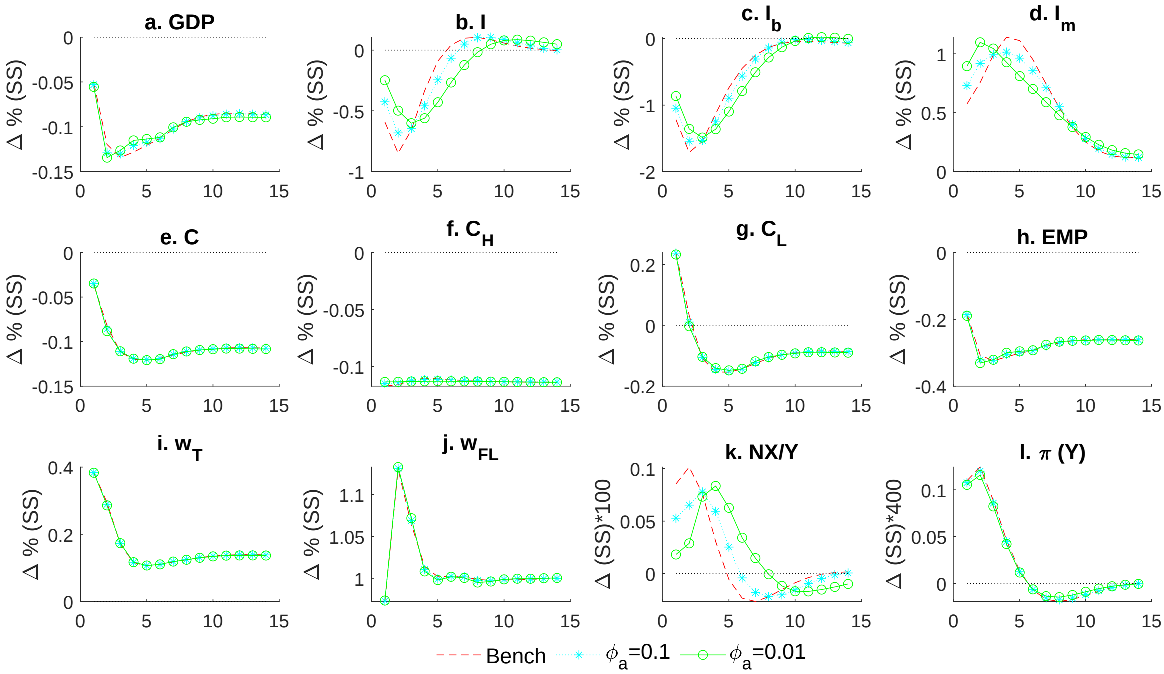


Note: The vertical axis shows the percentage difference with respect to the initial steady state except for the interest rate, R, and inflation, π (annualized absolute difference). H stands for High-skilled, F for formal low-skilled, I for informal, and L for low-skilled.

C Appendix: Sensitivity to the Debt-Elastic Interest rate

Finally, we examine how our results, in particular net exports, are affected by the sensitivity of the risk premium to the debt-to-GDP ratio. For this, we consider two alternative values for the parameter ϕ_a. As shown in Figure C.1, the responses of net exports and investment depend on the sensitivity of the risk premium to changes in the debt-to-GDP ratio. If the sensitivity is low, households will find it easier to borrow abroad, allowing them to finance additional investments in machinery. Consequently, net exports increase less in response to the shock, and investment in machinery responds more on impact. We also observe that with a lower sensitivity, the convergence of the trade balance to the steady state takes longer. The other macroeconomic variables behave similarly.

Figure C.1: Impulse Response of Main Macroeconomic Aggregates to a 100 bp transitory increase in the minimum wage. Benchmark model and alternative parameters.



Note: The vertical axis shows the percentage difference with respect to the initial steady state except for the interest rate, R, and inflation, π (annualized absolute difference). H stands for High-skilled, F for formal low-skilled, I for informal, and L for low-skilled.

D Appendix: List of variables

- c^H: consumption high-skilled (individual)
- C^H: consumption high-skilled (aggregate)
- c^L: consumption low-skilled (individual)
- C^L: consumption low-skilled (aggregate)
- C: consumption (aggregate)
- $h^{F,s}$: formal labor supply low-skilled (individual)
- h^I: informal labor low-skilled (individual)
- i^b: investment in buildings (individual)
- I^b: investment in buildings (aggregate)
- i^m: investment in machinery (individual)
- I^m: investment in machinery (aggregate)
- k^b: capital in buildings (individual)
- K^b: capital in buildings (aggregate)
- k^m: capital in machinery (individual)
- K^m: capital in machinery (aggregate)
- P: price of domestic final goods
- P^f: price of foreign goods
- q: nominal exchange rate
- b: domestic bonds
- a^f: foreign debt (individual)
- A^f: foreign debt (aggregate)
- R^{pol}: domestic interest rate (policy)
- R^f: foreign interest rate
- Φ: risk premium
- W^H: nominal wage high-skilled
- w^H: real wage high-skilled
- W^F: nominal wage formal low-skilled
- w^F: real wage formal low-skilled
- W^I: nominal wage informal low-skilled
- w^I: real wage informal low-skilled

- R^b: nominal return on K^b
- r^b: real return on K^b
- R^m: nominal return on K^m
- r^m: real return on K^m
- Π: aggregate profits
- π: domestic inflation
- π^*: foreign inflation
- μ^b: lagrange multiplier for k^b
- μ^m: lagrange multiplier for k^m
- Z: discount factor shifter
- Z^a: total factor productivity
- L^F: aggregate low-skilled formal labor
- L^I: aggregate low-skilled informal labor
- L^H: aggregate high-skilled labor
- EMP: total employment
- Y: GDP
- L^L: composite of low-skilled labor (formal and informal)
- L^m: composite of capital in machinery and L^L
- L: composite of L^m and high-skilled labor
- T: government transfers
- w^L: real price of L^L
- w^m: real price of L^m
- w: real price of L
- MC: marginal cost
- $P^\#$: optimal price
- $\pi^\#$: $P^\#$ inflation
- X_1, X_2: Calvo recursive variables
- x_1, x_2: Calvo recursive variables in real terms
- v^p: price dispersion
- MP_L: marginal product of total labor
- u^F: low-skilled formal unemployment
- u^H: high-skilled unemployment
- NX: Net exports

E Appendix: Model Equations, Steady State, and Calibration Strategy

E.1 Households

The representative high-skilled consumer maximizes the present value of her utility, choosing consumption (c_t^H), hours supplied (h_t^H), foreign assets (A_{t+1}^f), and investment ($i_t^{m,H}$, $i_t^{b,x}$) in two types of capital ($k_t^{m,H}$, $k_t^{b,x}$), according to the following dynamic problem:

$$\max_{c_t^H, h_t^H, a_{t+1}^f, i_t^m, i_t^b, k_{t+1}^m, k_{t+1}^b} \mathrm{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{(c_t^H)^{1-\sigma}}{1-\sigma} - \psi_H \frac{\nu_H}{1+\nu_H} \left(h_t^H\right)^{\frac{1+\nu_H}{\nu_H}} \right), \tag{E.1.1}$$

subject to the budget constraint,

$$\begin{aligned} &P_t(c_t^H + i_t^{m,H} + i_t^{b,H}) + q_t P_t^f a_{t+1}^f + P_t b_{t+1} \leq \\ &\Phi_{t-1} R_{t-1}^f q_t P_t^f a_t^f + P_t b_t R_{t-1} + W_t^H h_t^H + R_t^m k_t^{m,H} + R_t^b k_t^{b,H} + \Pi_t / N^H, \end{aligned} \tag{E.1.2}$$

the law of one price,

$$P_t = q_t P_t^* \tag{E.1.3}$$

investment adjustment costs,

$$i_t^{x,H} = k_{t+1}^{q,H} - (1-\delta_x) k_t^{j,H} + \frac{\phi_x}{2} \left(\frac{i_t^{x,H}}{i_{t-1}^{x,H}} - 1 \right)^2, x \in \{m, b\}, \tag{E.1.4}$$

debt elastic interest rate (risk premium),

$$\Phi_t = \Phi\left(A_t^f\right) = \widetilde{\phi} + \phi_a \left(\frac{q_t P_t^f A_t^f}{P_t Y_t} - \frac{A_{ss}^f}{Y_{ss}} \right) \tag{E.1.5}$$

and foreign interest rate

$$R_t^f = (1-\rho_f) R_{ss}^f + \rho_f R_{t-1}^f + \epsilon_t^f. \tag{E.1.6}$$

After normalizing the budget constraint by P_t, we find the marginal rate of substitution between consumption and labor,

$$\psi_H \left(h_t^H\right)^{\frac{1}{\nu_H}} = w_t^H (c_t^H)^{-\sigma}, \tag{E.1.7}$$

This equation would be irrelevant in the presence of market rigidities in the short run. The Euler equations for domestic and foreign bonds are as follows:

$$\left(c_t^H\right)^{-\sigma} = \beta \mathrm{E}_t \Big[\exp(Z_{t+1} - Z_t) \left(c_{t+1}^H\right)^{-\sigma} \Big] \frac{R_t^{pol}}{1+\pi_{t+1}}, \tag{E.1.8}$$

$$\left(c_t^H\right)^{-\sigma} = \beta \mathrm{E}_t \Big[\exp(Z_{t+1} - Z_t) \left(c_{t+1}^H\right)^{-\sigma} \Big] \frac{R_t^f \Phi_t}{(1+\pi_{t+1}^*)}, \tag{E.1.9}$$

capital in machinery and buildings,

$$\mu_t^x = \beta \mathrm{E}_t \Big[\exp(Z_{t+1} - Z_t) \Big(\left(c_{t+1}^H\right)^{-\sigma} r_{t+1}^x + \mu_{t+1}^x (1-\delta_x) \Big) \Big] \text{ for } x \in \{b, m\}, \tag{E.1.10}$$

and the corresponding two types of investment,

$$\left(c_t^H\right)^{-\sigma} = \mu_t^x \left[1 - \phi_x \left(\frac{i_t^x}{i_{t-1}^x} - 1 \right) \frac{1}{i_{t-1}^x} \right] + \beta \mathrm{E}_t \left[\mu_{t+1}^x \exp(Z_{t+1} - Z_t) \phi_x \left(\frac{i_{t+1}^x}{i_t^x} - 1 \right) \frac{i_{t+1}^x}{(i_t^x)^2} \right] \text{ for } x \in \{b, m\},$$

(E.1.11)

Similarly, the representative low-skilled consumer maximizes the present value of her utility by choosing consumption (c_t^L), formal and informal labor supply (h_t^F, h_t^L), according to the following problem:

$$\max_{c_t^L, h_t^I, h_t^F} \sum_{t=0}^{\infty} \beta^t \left(\frac{(c_t^L)^{1-\sigma}}{1-\sigma} - \psi_I \frac{\nu_I}{1+\nu_I} \left(h_t^I\right)^{\frac{1+\nu_I}{\nu_I}} - \psi_F \frac{\nu_F}{1+\nu_F} \left(h_t^F\right)^{\frac{1+\nu_F}{\nu_F}} \right), \tag{E.1.12}$$

subject to

$$P_t c_t^L \leq W_t^I h_t^I + W_t^F h_t^F + P_t T_t / N^L. \tag{E.1.13}$$

From the F.O.C, we find:

$$\psi_I (h_t^I)^{\frac{1}{\nu_I}} = \frac{(c_t^L)^{-\sigma}}{P_t} W_t^I \text{ and} \tag{E.1.14}$$

$$\psi_F (h_t^F)^{\frac{1}{\nu_F}} = \frac{(c_t^L)^{-\sigma}}{P_t} W_t^F. \tag{E.1.15}$$

The latter equation is irrelevant in the presence of a binding minimum wage.

Aggregate consumption, investment, capital, and labor supply are given by:

$$C_t = N^H c_t^H + N^L c_t^L, \tag{E.1.16}$$

$$I_t^m = N^H i_t^{m,H}, \tag{E.1.17}$$

$$I_t^b = N^H i_t^{b,H}, \tag{E.1.18}$$

$$K_t^m = N^H K_t^{m,H}, \tag{E.1.19}$$

$$K_t^b = N^H K_t^{b,H}, \tag{E.1.20}$$

$$L_t^H = N^H h_t^H, \tag{E.1.21}$$

$$L_t^I = N^L h_t^I \text{ and} \tag{E.1.22}$$

$$L_t^F = N^L h_t^F. \tag{E.1.23}$$

E.2 Production

We divide the production process into two stages. In the top stage, a competitive firm combines a continuum of heterogeneous domestic inputs to produce a homogeneous good. This firm maximizes its profits according to,

$$\max_{Y_t(j)} P_t Y_t - \int_0^1 P_t(j) Y_t(j) dj \text{ where} \tag{E.2.1}$$

$$Y_t = \left(\int_0^1 Y_t(j)^{\frac{\xi-1}{\xi}} dj \right)^{\frac{\xi}{\xi-1}}, \tag{E.2.2}$$

is domestic production, and $Y_t(j)$ is the input produced by the heterogeneous firm (j). From the F.O.C. we find that the demand for input (j) depends on its relative price and the aggregate demand for domestic goods,

$$Y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\xi} Y_t, \tag{E.2.3}$$

and that the aggregate price index of domestic goods is an average of heterogeneous input prices,

$$P_t = \left[\int_0^1 P_t(j)^{1-\xi} dj \right]^{\frac{1}{1-\xi}}. \tag{E.2.4}$$

The domestic production of the homogeneous good is allocated to consumption, investment, and net exports, $Y_t = C_t + I_t^b + I_t^m + NX_t$, subject to

$$Y_t = \left(\int_0^1 Y_t(j)^{\frac{\xi-1}{\xi}} dj \right)^{\frac{\xi}{\xi-1}}. \tag{E.2.5}$$

First order conditions:

$$[Y_t(j)] : P_t \left(\int_0^1 Y_t(j)^{\frac{\xi-1}{\xi}} dj \right)^{\frac{\xi}{\xi-1}-1} Y_t(j)^{\frac{\xi-1}{\xi}-1} - P_t(j) = 0. \tag{E.2.6}$$

After organizing terms:

$$P_t Y_t^{\frac{1}{\xi}} Y_t(j)^{-\frac{1}{\xi}} = P_t(j). \tag{E.2.7}$$

Demand for inputs:

$$Y_t(j) = \left(\frac{P_t}{P_t(j)} \right)^{\xi} Y_t. \tag{E.2.8}$$

Aggregate price. Multiplying both sides by $P_t(j)$ and integrating, we obtain:

$$P_t(j) Y_t(j) = \frac{P_t^{\xi} Y_t}{P_t(j)^{\xi-1}}, \tag{E.2.9}$$

$$\int_0^1 P_t(j) Y_t(j) dj = P_t^{\xi} Y_t \int_0^1 P_t(j)^{1-\xi} dj, \tag{E.2.10}$$

$$P_t Y_t = P_t^{\xi} Y_t \int_0^1 P_t(j)^{1-\xi} dj \text{ and} \tag{E.2.11}$$

$$P_t^{1-\xi} = \int_0^1 P_t(j)^{1-\xi} dj. \tag{E.2.12}$$

Equilibrium:

$$Y_t = C_t + I_t^b + I_t^m + NX_t. \tag{E.2.13}$$

E.3 Intermediate Inputs: Monopolistic competition

Static optimization problem:

$$\max_{P_t(j), K_t^m(j), K_t^b(j), L_t^H(j), L_t^F(j), L_t^I(j)} P_t(j) Y_t(j) - ((1+\tau^H) W_t^H L_t^H(j) + (1+\tau^F) W_t^F L_t^F(j) + W_t^I L_t^I(j) + R_t^m K_t^m(j) + R_t^b K_t^b(j)), \tag{E.3.1}$$

subject to

$$Y_t(j) = Z_t^a (K_t^b(j))^{\alpha} (L_t(j))^{1-\alpha}, \tag{E.3.2}$$

$$Z_t^a = (1-\rho_a) Z^a + \rho_a Z_{t-1}^a + \epsilon_t^A, \tag{E.3.3}$$

$$L_t(j) = \left[\theta (L_t^m(j))^{\frac{\eta-1}{\eta}} + (1-\theta)(L_t^H(j))^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \tag{E.3.4}$$

$$L_t^m(j) = \left[(1-\theta_m)(L_t^L(j))^{\frac{\eta_m-1}{\eta_m}} + \theta_m (K_t^m(j))^{\frac{\eta_m-1}{\eta_m}} \right]^{\frac{\eta_m}{\eta_m-1}}, \tag{E.3.5}$$

$$L_t^L(j) = \left[\theta_L (L_t^I(j))^{\frac{\eta_L-1}{\eta_L}} + (1-\theta_L)(L_t^F(j))^{\frac{\eta_L-1}{\eta_L}} \right]^{\frac{\eta_L}{\eta_L-1}} \text{ and} \tag{E.3.6}$$

$$Y_t(j) = \left(\frac{P_t}{P_t(j)} \right)^{\xi} Y_t. \tag{E.3.7}$$

From the FOCs, we find the optimal factor demands:

$$[K_t^b(j)] : \alpha \frac{Y_t(j)}{K_t^b(j)} = \frac{R_t^b}{P_t(j)}, \tag{E.3.8}$$

$$[L_t^H(j)] : (1-\alpha)\frac{Y_t(j)}{L_t(j)}(1-\theta)\left(\frac{L_t(j)}{L_t^H(j)}\right)^{1/\eta} = (1+\tau^H)\frac{W_t^H}{P_t(j)}, \tag{E.3.9}$$

$$[K_t^m(j)] : (1-\alpha)\frac{Y_t(j)}{L_t(j)}\theta\left(\frac{L_t(j)}{L_t^m(j)}\right)^{1/\eta}\theta_m\left(\frac{L_t^m(j)}{K_t^m(j)}\right)^{1/\eta_m} = \frac{R_t^m}{P_t(j)}, \tag{E.3.10}$$

$$[L_t^F(j)] : (1-\alpha)\frac{Y_t(j)}{L_t(j)}\theta\left(\frac{L_t(j)}{L_t^m}\right)^{\frac{1}{\eta}}\frac{(1-\theta_m)}{(1-\theta_L)^{-1}}\left(\frac{L_t^m(j)}{L_t^L(j)}\right)^{\frac{1}{\eta_m}}\left(\frac{L_t^L(j)}{L_t^F(j)}\right)^{\frac{1}{\eta_L}} = (1+\tau^F)\frac{W_t^F}{P_t(j)} \text{ and} \tag{E.3.11}$$

$$[L_t^I(j)] : (1-\alpha)\frac{Y_t(j)}{L_t(j)}\theta\left(\frac{L_t(j)}{L_t^m(j)}\right)^{1/\eta}(1-\theta_m)\left(\frac{L_t^m(j)}{L_t^L(j)}\right)^{1/\eta_m}\theta_L\left(\frac{L_t^L(j)}{L_t^I(j)}\right)^{1/\eta_L} = \frac{W_t^I}{P_t(j)}. \tag{E.3.12}$$

Marginal cost (real):

First, find total cost of low skilled labor $TC_t^L(j) = w_t^I L_t^I(j) + (1+\tau^F)w_t^F(j)L_t^F(j)$. Using the FOCs for $L_t^I(j)$ and $L_t^F(j)$, we have:

$$L_t^I(j) = \left(\frac{\theta_L}{1-\theta_L}\frac{(1+\tau^F)w_t^F}{w_t^I}\right)^{\eta_L} L_t^F(j). \tag{E.3.13}$$

Replacing this condition into $L_t^L(j)$ we find:

$$[L_t^L(j) = \left[\theta_L\left(\left(\frac{\theta_L}{1-\theta_L}\frac{(1+\tau^F)w_t^F}{w_t^I}\right)^{\eta_L} L_t^F(j)\right)^{\frac{\eta_L-1}{\eta_L}} + (1-\theta_L)(L_t(j)^F)^{\frac{\eta_L-1}{\eta_L}}\right]^{\frac{\eta_L}{\eta_L-1}}, \tag{E.3.14}$$

$$L_t^L(j) = L_t^F(j)\left[\theta_L\left(\frac{\theta_L}{1-\theta_L}\frac{(1+\tau^F)w_t^F}{w_t^I}\right)^{\eta_L-1} + (1-\theta_L)\right]^{\frac{\eta_L}{\eta_L-1}} \text{ and} \tag{E.3.15}$$

$$L_t^L(j) = L_t^F(j)\left(\frac{(1+\tau^F)w_t^F}{1-\theta_L}\right)^{\eta_L}\left[\theta_L^{\eta_L}(w_t^I)^{1-\eta_L} + (1-\theta_L)^{\eta_L}((1+\tau^F)w_t^F)^{1-\eta_L}\right]^{\frac{\eta_L}{\eta_L-1}}. \tag{E.3.16}$$

Now, replacing into the total cost of hiring low skilled workers:

$$TC_t^L(j) = w_t^I L_t^I(j) + (1+\tau^F)w_t^F(j)L_t^F(j), \tag{E.3.17}$$

$$TC_t^L(j) = L_t^F(j)\left(w_t^I\left(\frac{\theta_L}{1-\theta_L}\frac{(1+\tau^F)w_t^F}{w_t^I}\right)^{\eta_L} + (1+\tau^F)w_t^F\right), \tag{E.3.18}$$

$$TC_t^L(j) = L_t^F(j)\left(\theta_L^{\eta_L}(w_t^I)^{1-\eta_L}\left(\frac{(1+\tau^F)w_t^F}{1-\theta_L}\right)^{\eta_L} + (1+\tau^F)w_t^F\right), \tag{E.3.19}$$

$$TC_t^L(j) = L_t^F(j)\left(\frac{(1+\tau^F)w_t^F}{1-\theta_L}\right)^{\eta_L}\left(\theta_L^{\eta_L}(w_t^I)^{1-\eta_L} + (1-\theta_L)^{\eta_L}((1+\tau^F)w_t^F)^{1-\eta_L}\right), \tag{E.3.20}$$

$$TC_t^L(j) = L_t^L(j)\left(\frac{\left(\theta_L^{\eta_L}(w_t^I)^{1-\eta_L} + (1-\theta_L)^{\eta_L}((1+\tau^F)w_t^F(j))^{1-\eta_L}\right)}{\left(\theta_L^{\eta_L}(w_t^I)^{1-\eta_L} + (1-\theta_L)^{\eta_L}((1+\tau^F)w_t^F)^{1-\eta_L}\right)^{\frac{\eta_L}{\eta_L-1}}}\right) \text{ and} \tag{E.3.21}$$

$$TC_t^L(j) = L_t^L(j)\left(\theta_L^{\eta_L}(w_t^I)^{1-\eta_L} + (1-\theta_L)^{\eta_L}((1+\tau^F)w_t^F)^{1-\eta_L}\right)^{1/(1-\eta_L)} = L_t^L(j)w_t^L. \tag{E.3.22}$$

Now, we find the total cost of L_t^m. $TC_t^m(j) = TC_t^L(j) + R_t^m K_t^m(j) = w_t^L L_t^L + R_t^m K_t^m(j)$. From the FOCs

$$\frac{\theta_m}{(1-\theta_m)}\left(\frac{L_t^L(j)}{K_t^m(j)}\right)^{1/\eta_m} = \frac{r_t^x}{(1+\tau^F)w_t^F}(1-\theta_L)\left(\frac{L_t^L(j)}{L_t^F(j)}\right)^{1/\eta_L} \text{ and} \tag{E.3.23}$$

$$K_t^m(j) = L_t^L(j)\left(\frac{\theta_x}{1-\theta_m}\right)^{\eta_m}\left(\frac{(1+\tau^F)w_t^F}{r_t^m(1-\theta_L)}\left(\frac{L_t^F}{L_t^L}\right)^{1/\eta_L}\right)^{\eta_m}, \tag{E.3.24}$$

where the lower case letters are prices in real terms. Notice that:

$$\left(\frac{(1+\tau^F)w_t^F}{(1-\theta_L)}\left(\frac{L_t^F}{L_t^L}\right)^{1/\eta_L}\right) = \left[\theta_L^{\eta_L}(w_t^I)^{1-\eta_L} + (1-\theta_L)^{\eta_L}((1+\tau^F)w_t^F)^{1-\eta_L}\right]^{\frac{-1}{\eta_L-1}} = w_t^L, \text{ then} \tag{E.3.25}$$

$$K_t^m = L_t^L\left(\frac{\theta_m}{1-\theta_m}\frac{w_t^L}{r_t^m}\right)^{\eta_m}. \tag{E.3.26}$$

Replacing in L_t^m :

$$L_t^m(j) = \left[(1-\theta_m)(L_t^L(j))^{\frac{\eta_m-1}{\eta_m}} + \theta_m\left(L_t^L(j)\left(\frac{\theta_m}{1-\theta_m}\frac{w_t^L}{r_t^m}\right)^{\eta_m}\right)^{\frac{\eta_m-1}{\eta_m}}\right]^{\frac{\eta_m}{\eta_m-1}}, \tag{E.3.27}$$

$$L_t^m(j) = L_t^L(j)\left[(1-\theta_m) + \theta_m\left(\frac{\theta_m}{1-\theta_m}\frac{w_t^L}{r_t^m}\right)^{\eta_m-1}\right]^{\frac{\eta_m}{\eta_m-1}} \text{ and} \tag{E.3.28}$$

$$L_t^m(j) = L_t^L(j)\left(\frac{w_t^L}{1-\theta_m}\right)^{\eta_m}\left[(1-\theta_m)^{\eta_m}(w_t^m)^{1-\eta_m} + (\theta_m)^{\eta_m}(r_t^m)^{1-\eta_m}\right]^{\frac{\eta_m}{\eta_m-1}}. \tag{E.3.29}$$

After organizing terms:

$$TC_t^m(j) = L_t^m(j)\left((1-\theta_m)^{\eta_m}(w_t^L)^{1-\eta_m} + (\theta_m)^{\eta_m}(r_t^m)^{1-\eta_m}\right)^{1/(1-\eta_m)} = L_t^m(j)w_t^m. \tag{E.3.30}$$

Then, we find the total cost of

$$L_t(j),\ TC_t^{Lab}(j) = (1+\tau^H)w_t^H L_t^H(j) + TC_t^m(j) = (1+\tau^H)w_t^H L_t^H(j) + w_t^m L_t^m(j). \tag{E.3.31}$$

Following a similar procedure, we find:

$$TC_t^{Lab}(j) = L_t(j)\left((\theta)^\eta(w_t^m)^{1-\eta} + (1-\theta)^\eta((1+\tau^H)w_t^H)^{1-\eta}\right)^{1/(1-\eta)} = L_t(j)w_t. \tag{E.3.32}$$

Finally, total costs are given by: $TC_t(j) = r_t^b K_t^b(j) + w_t L_t(j)$ where

$$w_t(j) = \left(\theta^\eta(w_t^L)^{1-\eta} + (1-\theta)^\eta((1+\tau^H)w_t^H)^{1-\eta}\right)^{1/(1-\eta)}, \tag{E.3.33}$$

$$TC_t(j) = Y_t(j)\left(\frac{1}{Z_t^a}\left(\frac{r_t^b}{\alpha}\right)^\alpha\left(\frac{w_t}{1-\alpha}\right)^{1-\alpha}\right) \text{ and} \tag{E.3.34}$$

$$mc_t = \left(\frac{1}{Z_t^a}\left(\frac{r_t^b}{\alpha}\right)^\alpha\left(\frac{w_t}{1-\alpha}\right)^{1-\alpha}\right). \tag{E.3.35}$$

Note that the marginal costs are the same for all firms.

Dynamic optimization: Price setting. The dynamic optimization of intermediate firms is related to their price decisions. We adopt the framework proposed by Calvo (1983), in which intermediate firms set their prices to maximize the present value of profits given the expected demand for their products. In each period, a firm has an exogenous probability, $1-\phi$, of being able to change its price. The remaining ϕ firms that cannot change their prices in a given period apply indexation, adjusting their prices according to past inflation. The optimal decision for a firm that can change its price in period t is given by:

$$\max_{P_t(j)} \mathrm{E}_t \sum_{k=0}^{\infty} (\beta\phi)^k \frac{U_{c,t+k}}{U_{c,t}} \left[\left(\frac{\chi_{tk} P_t(j)}{P_{t+k}} \right)^{1-\xi} Y_{t+k} - mc_{t+k} \left(\frac{\chi_{tk} P_t(j)}{P_{t+k}} \right)^{-\xi} Y_{t+k} \right], \tag{E.3.36}$$

where χ_{tk} is the cumulative inflation up to period $t+k$. From the F.O.C

$$P_t(j) = \frac{\xi}{\xi-1} \mathrm{E}_t \left[\frac{\sum_{k=0}^{\infty} (\beta\phi)^k U_{c,t+k} mc_{t+k} (\chi_{tk} P_{t+k})^{\xi} Y_{t+k}}{\sum_{k=0}^{\infty} (\beta\phi)^k U_{c,t+k} (\chi_{tk} P_{t+k})^{\xi-1} Y_{t+k}} \right]. \tag{E.3.37}$$

This equation implies that the optimal price of a firm that can change prices is given by

$$P_t^{\#} = \frac{\xi}{\xi-1} \frac{X_{1,t}}{X_{2,t}}, \text{ where} \tag{E.3.38}$$

$$X_{1,t} = U_{c,t} mc_t P_t^{\xi} Y_t + \beta\phi \mathrm{E}_t \left[\left(\frac{\chi_{tk+1}}{\chi_{tk}} \right)^{\xi} X_{1,t+1} \right], \text{ and} \tag{E.3.39}$$

$$X_{2,t} = U_{c,t} P_t^{\xi-1} + \beta\phi \mathrm{E}_t \left[\left(\frac{\chi_{tk+1}}{\chi_{tk}} \right)^{\xi-1} X_{2,t+1} \right]. \tag{E.3.40}$$

By applying the law of large numbers to the continuum of firms, it can be demonstrated that aggregate prices may be expressed as a weighted average of optimal and lag prices, resulting from the optimal decision-making of individual firms,

$$P_t^{1-\xi} = (1-\phi) \left(P_t^{\#} \right)^{1-\xi} + \phi (\pi_{t-1} P_{t-1})^{1-\xi}. \tag{E.3.41}$$

After normalization we find the inflation rate,

$$\pi_t^{1-\xi} = (1-\phi) \left(\pi_t^{\#} \right)^{1-\xi} + \phi \pi_{t-1}^{1-\xi}, \text{ where} \tag{E.3.42}$$

$$\pi_t^{\#} = \frac{\xi}{\xi-1} \frac{x_{1,t}}{x_{2,t}} \pi_t, \tag{E.3.43}$$

$$x_{1,t} = C_t^{-\sigma} mc_t Y_t + \beta\phi \mathrm{E}_t \left[x_{1,t+1} \left(\frac{\pi_{t+1}}{\pi_t} \right)^{\xi} \right] \text{ and,} \tag{E.3.44}$$

$$x_{2,t} = C_t^{-\sigma} Y_t + \beta\phi \mathrm{E}_t \left[x_{2,t+1} \left(\frac{\pi_{t+1}}{\pi_t} \right)^{\xi-1} \right]. \tag{E.3.45}$$

Finally, due to price rigidities, total output in the economy is given by:

$$Y_t = \frac{Z_t^a \left(K_t^b \right)^{\alpha} L_t^{1-\alpha}}{v_t^p}, \tag{E.3.46}$$

where v_t^p is the price dispersion:

$$v_t^p = \int_0^1 \left(\frac{P_t(j)}{P_t} \right)^{-\xi} dj = (1-\phi) \left(\frac{\pi_t}{\pi_t^{\#}} \right)^{\xi} + \phi \left(\frac{\pi_t}{\pi_{t-1}} \right)^{\xi} v_{t-1}^p. \tag{E.3.47}$$

E.4 Labor market

Real minimum wage of low-skilled formal workers:

$$w_t^F = w_{ss}^F \left(1 + \epsilon_t^F\right) \frac{\pi_{t-1}}{\pi_t} \Delta MP_{L,t-1} \tag{E.4.1}$$

where ϵ_t^F is a shock to the minimum wage, and $\Delta MP_{L,t}$ is the change in the marginal product of labor, defined as

$$\Delta MP_{L,t} = \frac{(Y_t/Y_{t-1})}{(EMP_t/EMP_{t-1})} \text{ and} \tag{E.4.2}$$

$$EMP_t = N^H h_t^H + N^L(h_t^F + h_t^I). \tag{E.4.3}$$

Given this rule, the labor market for formal low-skilled workers clears using only the labor demand equation. On the other hand, for high-skilled workers, we assume some rigidity in the short run and partial transmission in the long run of the minimum wage.

$$w_t^H = \left(w_{t-1}^H\right)^{\rho_H} \left(w_t^{H,market}\right)^{1-\rho_H} \left(\frac{w_t^F}{w_{t-1}^F}\right)^{\rho_F}, \tag{E.4.4}$$

where $w^{H,market}$ is the competitive equilibrium wage for high-skilled workers. This equation guarantees that, in the long run, the market clearing conditions are as in perfect competition.

E.5 Government

$$T_t = \tau_t^H w_t^H + \tau^F w_t^F. \tag{E.5.1}$$

E.6 Taylor Rule

$$\log\left(\frac{R_t^{pol}}{R^{pol}}\right) = \rho_r \log\left(\frac{R_{t-1}^{pol}}{R^{pol}}\right) + r_\pi \log\left(\frac{\mathrm{E}_t \pi_{t+1}}{\pi}\right) + r_y \log\left(\frac{4Y_t}{\sum_{s=1}^4 Y_{t-s}}\right) + \epsilon_r. \tag{E.6.1}$$

E.7 Complete Model (Equations)

$$i_t^{b,H} = k_{t+1}^{b,H} - (1-\delta_b) k_t^{b,H} + \frac{\phi_b}{2}\left(\frac{i_t^{b,H}}{i_{t-1}^{b,H}} - 1\right)^2, \tag{E.7.1}$$

$$i_t^{m,H} = k_{t+1}^{m,H} - (1-\delta_m) k_t^{m,H} + \frac{\phi_m}{2}\left(\frac{i_t^{m,H}}{i_{t-1}^{m,H}} - 1\right)^2, \tag{E.7.2}$$

$$\Phi_t = \Phi\left(A_t^f\right) = \widetilde{\phi} + \phi_a \left(\frac{q_t P_t^f A_t^f}{P_t Y_t} - \frac{q_{ss} P_{ss}^f A_{ss}^f}{Y_{ss}}\right), \tag{E.7.3}$$

$$R_t^f = (1-\rho_f) R_{ss}^f + \rho_f R_{t-1}^f + \epsilon_t^f, \tag{E.7.4}$$

$$(c_t^H)^{-\sigma} = \beta \mathrm{E}_t\left[(c_{t+1}^H)^{-\sigma}\right] R_t^f \Phi_t, \tag{E.7.5}$$

$$\mu_t^b = \beta \mathrm{E}_t\left[(c_{t+1}^H)^{-\sigma}\left(r_{t+1}^b\right) + \mu_{t+1}^b (1-\delta_b)\right], \tag{E.7.6}$$

$$\mu_t^m = \beta \mathrm{E}_t\left[(c_{t+1}^H)^{-\sigma}\left(r_{t+1}^m\right) + \mu_{t+1}^m (1-\delta_m)\right], \tag{E.7.7}$$

$$(c_t^H)^{-\sigma} = \mu_t^b \left(1 - \phi_b \left(\frac{i_t^{b,H}}{i_{t-1}^{b,H}} - 1\right) \frac{1}{i_{t-1}^{b,H}}\right) + \beta \mathrm{E}_t\left[\mu_{t+1}^b \phi_b \left(\frac{i_{t+1}^{b,H}}{i_t^{b,H}} - 1\right) \frac{i_{t+1}^{b,H}}{(i_t^{b,H})^2}\right], \tag{E.7.8}$$

$$(c_t^H)^{-\sigma} = \mu_t^m \left(1 - \phi_m \left(\frac{i_t^{m,H}}{i_{t-1}^{m,H}} - 1\right) \frac{1}{i_{t-1}^{m,H}}\right) + \beta \mathrm{E}_t \left[\mu_{t+1}^m \phi_m \left(\frac{i_{t+1}^{m,H}}{i_t^{m,H}} - 1\right) \frac{i_{t+1}^{m,H}}{(i_t^{m,H})^2}\right], \tag{E.7.9}$$

$$c_t^L = w_t^I h_t^I + w_t^F h_t^F + T_t/N_t^L, \tag{E.7.10}$$

$$\psi_I (h_t^I)^{\frac{1}{\nu_I}} = (c_t^L)^{-\sigma} w_t^I, \tag{E.7.11}$$

$$C_t^H = c_t^H N^H, \tag{E.7.12}$$

$$C_t^L = c_t^L N^L, \tag{E.7.13}$$

$$I_t^b = i_t^{b,H} N^H, \tag{E.7.14}$$

$$I_t^m = i_t^{m,H} N^H, \tag{E.7.15}$$

$$K_t^b = k_t^{b,H} N^H, \tag{E.7.16}$$

$$K_t^m = k_t^{m,H} N^H, \tag{E.7.17}$$

$$L_t^H = N^H h_t^H, \tag{E.7.18}$$

$$L_t^F = N^L h_t^L, \tag{E.7.19}$$

$$L_t^I = N^L h_t^I, \tag{E.7.20}$$

$$EMP_t = L_t^H + L_t^F + L_t^I, \tag{E.7.21}$$

$$A_t^f = N^H a_t^f, \tag{E.7.22}$$

$$Y_t = C_t^H + C_t^L + I_t^b + I_t^m + NX_t, \tag{E.7.23}$$

$$Z_t^a = (1 - \rho_a) Z^a + \rho_a Z_{t-1}^a + \epsilon_t^A, \tag{E.7.24}$$

$$L_t = \left[\theta (L_t^m)^{\frac{\eta-1}{\eta}} + (1-\theta)(L_t^H)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}, \tag{E.7.25}$$

$$L_t^m = \left[(1-\theta_m)(L_t^L)^{\frac{\eta_m-1}{\eta_m}} + \theta_m (K_t^m)^{\frac{\eta_m-1}{\eta_m}}\right]^{\frac{\eta_m}{\eta_m-1}}, \tag{E.7.26}$$

$$L_t^L = \left[\theta_L (L_t^I)^{\frac{\eta_L-1}{\eta_L}} + (1-\theta_L)(L_t^F)^{\frac{\eta_L-1}{\eta_L}}\right]^{\frac{\eta_L}{\eta_L-1}}, \tag{E.7.27}$$

$$\alpha \frac{Y_t}{K_t^b} = r_t^b, \tag{E.7.28}$$

$$(1-\alpha)\frac{Y_t}{L_t}(1-\theta)\left(\frac{L_t}{L_t^H}\right)^{1/\eta} = (1+\tau^H) w_t^H, \tag{E.7.29}$$

$$(1-\alpha)\frac{Y_t}{L_t}\theta\left(\frac{L_t}{L_t^m}\right)^{1/\eta}\theta_m\left(\frac{L_t^m}{K_t^m}\right)^{1/\eta_m} = r_t^m, \tag{E.7.30}$$

$$(1-\alpha)\frac{Y_t}{L_t}\theta\left(\frac{L_t}{L_t^m}\right)^{1/\eta}(1-\theta_x)\left(\frac{L_t^m}{L_t^L}\right)^{1/\eta_m}(1-\theta_L)\left(\frac{L_t^L}{L_t^F}\right)^{1/\eta_L} = (1+\tau^F) w_t^F, \tag{E.7.31}$$

$$(1-\alpha)\frac{Y_t}{L_t}\theta\left(\frac{L_t}{L_t^m}\right)^{1/\eta}(1-\theta_m)\left(\frac{L_t^m}{L_t^L}\right)^{1/\eta_m}\theta_L\left(\frac{L_t^L}{L_t^I}\right)^{1/\eta_L} = w_t^I, \tag{E.7.32}$$

$$w_t^L = \left(\theta_L^{\eta_L}(w_t^I)^{1-\eta_L} + (1-\theta_L)^{\eta_L}((1+\tau^F)w_t^F)^{1-\eta_L}\right)^{1/(1-\eta_L)}, \tag{E.7.33}$$

$$w_t^m = \left((1-\theta_m)^{\eta_x}(w_t^L)^{1-\eta_m} + (\theta_m)^{\eta_m}(r_t^m)^{1-\eta_m}\right)^{1/(1-\eta_m)}, \tag{E.7.34}$$

$$w_t = \left((\theta)^{\eta}(w_t^m)^{1-\eta} + (1-\theta)^{\eta}((1+\tau^H)w_t^H)^{1-\eta}\right)^{1/(1-\eta)}, \tag{E.7.35}$$

$$MC_t = \left(\frac{1}{Z_t^a}\left(\frac{r_t^b}{\alpha}\right)^{\alpha}\left(\frac{w_t}{1-\alpha}\right)^{1-\alpha}\right), \tag{E.7.36}$$

$$\pi_t^{1-\xi} = (1-\phi)\left(\pi_t^{\#}\right)^{1-\xi} + \phi\pi_{t-1}^{1-\xi}, \tag{E.7.37}$$

$$\pi_t^{\#} = \frac{\xi}{\xi-1}\frac{x_{1,t}}{x_{2,t}}\pi_t, \tag{E.7.38}$$

$$x_{1,t} = C_t^{-\sigma} mc_t Y_t + \beta\phi \mathrm{E}_t\left[x_{1,t+1}\left(\frac{\pi_{t+1}}{\pi_t}\right)^{\xi}\right], \tag{E.7.39}$$

$$x_{2,t} = C_t^{-\sigma} Y_t + \beta\phi \mathrm{E}_t\left[x_{2,t+1}\left(\frac{\pi_{t+1}}{\pi_t}\right)^{\xi-1}\right], \tag{E.7.40}$$

$$Y_t = \frac{Z_t^a\left(K_t^b\right)^{\alpha} L_t^{1-\alpha}}{v_t^p}, \tag{E.7.41}$$

$$v_t^p = \int_0^1 \left(\frac{P_t(j)}{P_t}\right)^{-\xi} dj = (1-\phi)\left(\frac{\pi_t}{\pi_t^{\#}}\right)^{\xi} + \phi\left(\frac{\pi_t}{\pi_{t-1}}\right)^{\xi} v_{t-1}^p, \tag{E.7.42}$$

$$w_t^F = w_{ss}^F\left(1+\epsilon_t^F\right)\frac{\pi_{t-1}}{\pi_t}\Delta MP_{L,t-1}, \tag{E.7.43}$$

$$w_t^H = \left(w_{t-1}^H\right)^{\rho_H}\left(w_t^{H,market}\right)^{1-\rho_H}\left(\frac{w_t^F}{w_{t-1}^F}\right)^{\rho_F}, \tag{E.7.44}$$

$$\Delta MP_{L,t} = \frac{(Y_t/Y_{t-1})}{(EMP_t/EMP_{t-1})}, \tag{E.7.45}$$

$$T_t = \tau^H w_t^H + \tau^F w_t^F \text{ and} \tag{E.7.46}$$

$$\log\left(\frac{R_t^{pol}}{R}\right) = \rho_r \log\left(\frac{R_{t-1}^{pol}}{R}\right) + r_\pi \log\left(\frac{\mathrm{E}_t\pi_{t+1}}{\pi}\right) + r_y \log\left(\frac{4Y_t}{\sum_{s=1}^4 Y_{t-s}}\right) + \epsilon_r \tag{E.7.47}$$

$$P_t = q_t P_t^* \tag{E.7.48}$$

Variables: $c_t^H, c_t^L, h_t^H, h_t^F, h_t^I, i_t^{b,H}, i_t^{m,H}, k_t^{b,H}, k_t^{m,H}, R_t^f, \Phi_t, Y_t, C_t^H, C_t^L, L_t^H, L_t^F, L_t^I, I_t^b, I_t^m, K_t^b, K_t^m, w_t^H, w_t^F, w_t^I, w_t, w_t^m, w_t^L, r_t^b, r_t^m, MC_t, T_t, NX_t, \mu_t^b, \mu_t^m, L_t, L_t^m, L_t^L, A_t^f, a_t^f, \pi_t, \pi_t^{\#}, x_{1t}, x_{2t}, R_t, EMP_t, \Delta MPL_t, Z_t^a, R_t^{pol}, q_t$

Parameters: $\sigma, \beta, \delta_b, \delta_m, \phi_b, \phi_m, \tilde{\psi}, \phi_a, \overline{A}^f, \psi_H, \psi_F, \psi_I, \nu_H, \nu_F, \nu_I, N_H, N_L, A, \alpha, \theta, \eta, \theta_m, \eta_m, \theta_L, \eta_L, \xi, \tau^H, \tau^F, \rho_r, r_\pi, r_y, \rho_H, \rho_F, \rho_a$.

E.8 Mathematical Appendix: Steady State

$$i^{b,H} = \delta_b k^{b,H}, \tag{E.8.1}$$

$$i^{m,H} = \delta_m k^{m,H}, \tag{E.8.2}$$

$$\Phi = \widetilde{\phi}, \tag{E.8.3}$$

$$\psi_H (h^H)^{1/\nu_H} = (c^H)^{-\sigma} w^H, \tag{E.8.4}$$

$$1 = \beta R^f \Phi, \tag{E.8.5}$$

$$\mu_b = \beta\left((c^H)^{-\sigma}\left(r^b\right) + \mu^b(1-\delta_b)\right), \tag{E.8.6}$$

$$\mu_m = \beta\left((c^H)^{-\sigma}\left(r^m\right) + \mu^m(1-\delta_m)\right), \tag{E.8.7}$$

$$(c^H)^{-\sigma} = \mu^b, \tag{E.8.8}$$

$$(c^H)^{-\sigma} = \mu^m, \tag{E.8.9}$$

$$1 = \beta\left(r^b + 1 - \delta_b\right), \tag{E.8.10}$$

$$1 = \beta\left(r^m + 1 - \delta_m\right), \tag{E.8.11}$$
$$c^L = w^I h^I + w^F h^F + T/N^L, \tag{E.8.12}$$
$$\psi_I (h^I)^{\frac{1}{\nu_I}} = (c^L)^{-\sigma} w^I, \tag{E.8.13}$$
$$C^H = c^H N^H, \tag{E.8.14}$$
$$C^L = c^L N^L, \tag{E.8.15}$$
$$I^b = i^{b,H} N^H, \tag{E.8.16}$$
$$I^m = i^{m,H} N^H, \tag{E.8.17}$$
$$K^b = k^{b,H} N^H, \tag{E.8.18}$$
$$K^m = k^{m,H} N^H, \tag{E.8.19}$$
$$L^H = N^H h^H, \tag{E.8.20}$$
$$L^F = N^L h^L, \tag{E.8.21}$$
$$L^I = N^L h^I, \tag{E.8.22}$$
$$A^f = N^H a^f, \tag{E.8.23}$$
$$Y = C^H + C^L + I^b + I^m + NX, \tag{E.8.24}$$
$$L = \left[\theta (L^m)^{\frac{\eta-1}{\eta}} + (1-\theta)(L^H)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}, \tag{E.8.25}$$
$$L^m = \left[(1-\theta_m)(L^L)^{\frac{\eta_m-1}{\eta_m}} + \theta_m (K^m)^{\frac{\eta_m-1}{\eta_m}}\right]^{\frac{\eta_m}{\eta_m-1}}, \tag{E.8.26}$$
$$L^L = \left[\theta_L (L^I)^{\frac{\eta_L-1}{\eta_L}} + (1-\theta_L)(L^F)^{\frac{\eta_L-1}{\eta_L}}\right]^{\frac{\eta_L}{\eta_L-1}}, \tag{E.8.27}$$
$$\alpha \frac{Y}{K^b} = r^b, \tag{E.8.28}$$
$$(1-\alpha)\frac{Y}{L}(1-\theta)\left(\frac{L}{L^H}\right)^{1/\eta} = (1+\tau^H) w^H, \tag{E.8.29}$$
$$(1-\alpha)\frac{Y}{L}\theta\left(\frac{L}{L^m}\right)^{1/\eta}\theta_m\left(\frac{L^m}{K^m}\right)^{1/\eta_m} = r^m, \tag{E.8.30}$$
$$(1-\alpha)\frac{Y}{L}\theta\left(\frac{L}{L^m}\right)^{1/\eta}(1-\theta_m)\left(\frac{L^m}{L^L}\right)^{1/\eta_m}(1-\theta_L)\left(\frac{L^L}{L^F}\right)^{1/\eta_L} = (1+\tau^F) w^F, \tag{E.8.31}$$
$$(1-\alpha)\frac{Y}{L}\theta\left(\frac{L}{L^m}\right)^{1/\eta}(1-\theta_m)\left(\frac{L^m}{L^L}\right)^{1/\eta_m}\theta_L\left(\frac{L^L}{L^I}\right)^{1/\eta_L} = w^I, \tag{E.8.32}$$
$$w^L = \left(\theta_L^{\eta_L}(w^I)^{1-\eta_L} + (1-\theta_L)^{\eta_L}((1+\tau^F)w^F)^{1-\eta_L}\right)^{1/(1-\eta_L)}, \tag{E.8.33}$$
$$w^m = \left((1-\theta_m)^{\eta_m}(w^L)^{1-\eta_m} + (\theta_m)^{\eta_m}(r^m)^{1-\eta_m}\right)^{1/(1-\eta_m)}, \tag{E.8.34}$$
$$w = \left((\theta)^{\eta}(w^m)^{1-\eta} + (1-\theta)^{\eta}((1+\tau^H)w^H)^{1-\eta}\right)^{1/(1-\eta)}, \tag{E.8.35}$$
$$MC = \left(\frac{1}{A}\left(\frac{r^b}{\alpha}\right)^{\alpha}\left(\frac{w}{1-\alpha}\right)^{1-\alpha}\right), \tag{E.8.36}$$
$$T = \tau^H w^H + \tau^F w^F, \tag{E.8.37}$$
$$\pi = \pi^{\#}, \tag{E.8.38}$$
$$\frac{x_2}{x_1} = \frac{\xi}{\xi - 1}, \tag{E.8.39}$$

$$x_1 = \frac{1}{1-\beta\phi} C^{-\sigma} mcY, \tag{E.8.40}$$

$$x_2 = \frac{1}{1-\beta\phi} C^{-\sigma} Y, \tag{E.8.41}$$

$$Y = \frac{A\left(K^b\right)^\alpha L^{1-\alpha}}{v^p}, \tag{E.8.42}$$

$$v^p = 1, \tag{E.8.43}$$

$$w^F = w_{ss}^F \Delta MP_L, \tag{E.8.44}$$

$$\Delta MP_L = 1, \tag{E.8.45}$$

$$T_t = \tau^H w_t^H + \tau^F w_t^F \text{ and} \tag{E.8.46}$$

$$\pi = \overline{\pi}. \tag{E.8.47}$$

E.9 Mathematical Appendix: Calibration Strategy

To calibrate the model, we solve a system of equations that includes the steady state, normalization conditions, and targeted moments. This results in a final set of 15 equations that cannot be solved analytically due to the dimensionality of the model, 8 of these equations represent core variables from the model, while 7 are associated with targets.[17] In particular, the parameters are obtained from

- Literature: $\sigma, \beta, \delta_b, \delta_m, \nu_H, \nu_F, \nu_I, \xi, \eta, \eta_L, \eta_m, \rho_r, r_\pi, r_y, \psi_H$
- Business cycle: $\phi_a, \phi_b, \phi_m, \rho_a$
- Data: $\tau^H, \tau^F, N^H, N^L, \overline{A}^f, \tilde{\phi}$
- Steady-State calibration: $\psi_F, \psi_I, A, \alpha, \theta, \theta_L, \theta_m, w_{ss}^F, \overline{\pi}$
- Normalization:
  - $\pi = 1 = \overline{\pi}$
  - $\psi_F = \psi_L$
  - $Y = 1$
- Targets:
  - Wage gap high-skilled and formal low-skilled workers: w_H/w_F
  - Wage gap formal and informal low-skilled workers: w_F/w_I
  - Investment share in GDP: $(I^m + I_b)/Y$
  - Investment share buildings: $I^b/(I^b + I^m)$
  - Unemployment formal low-skilled: $h^F/h^{F,market}$
  - Mass of labor compensation for high-skilled workers: $(w^H L^H)/(w^H L^H + w^F L^F + w^I L^I)$

[17] We use MATLAB's *fsolve* function to obtain the solution numerically. Notably, this calibration process ensures precise alignment to all specified targets.