Macroeconomic effects of Minimum Wage Rules in a Small Open Economy

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Abstract

We analyze the adjustment of a small open economy, with real and nominal rigidities, to an unexpected increase in the minimum wage. Our model considers two heterogeneous households that differ in their access to financial markets, property rights, and the productivity of the labor they supply, high-skilled vs. low-skilled. Firms combine two types of capital with heterogeneous labor, and face price rigidities. The central bank sets the interest rate according to a standard Taylor rule. Finally, formal low-skilled labor is paid a minimum wage that evolves according to a rule based on productivity growth and past inflation. We calibrate the model for Colombia and found that after the unexpected increase in the minimum wage there are strong effects on the labor market and the main macroeconomic aggregates, while there are weaker effects on inflation and the interest rate. Formal low-skilled labor is substituted by informal jobs and machines, while output falls turning the output gap negative. In response, inflation rises and the monetary authority adjusts its interest rate. The effects are magnified as the production structure becomes more dependent on low-skilled formal labor.

JEL classification: E13, E50, J31, J46.

Keywords— Neoclassical model, minimum wage, informal labor markets, monetary policy, heterogeneous agents.

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1 Introduction

The minimum wage is a labor market policy designed for low-skilled workers, and aims to guarantee a subsistence level of consumption, or to ensure that their labor is not paid below its marginal productivity.[1] Since its introduction in 1894 in New Zealand, this policy has spread to over a hundred countries, with variations in its periodicity, the economic sectors covered and the adjustment rules. Economic literature has extensively analyzed the effects of the minimum wage on labor markets, welfare and income distribution (e.g. Neumark et al. (2004)). However, its macroeconomic implications have not been fully explored and might be relevant for policy makers, in particular, in economies with high informality rates, such as Latin American countries, where minimum wage policies might have important effects.

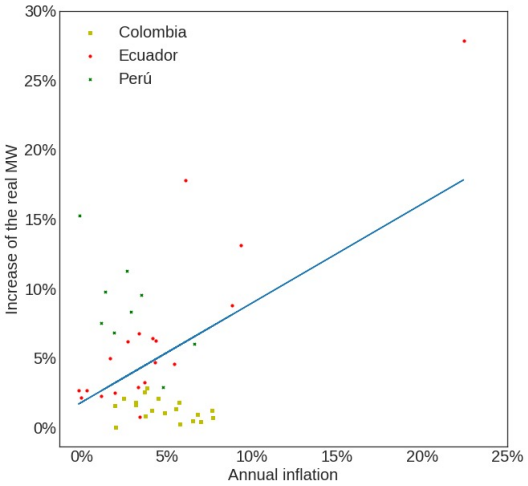
From a central bank perspective, minimum wage rules (the adjustment of the minimum wage) might be an important determinant of inflation and inflation expectations through labor costs. For instance, as indicated in the monetary policy reports from Colombia, inflation expectations receive a great deal of attention, besides the traditional demand and supply shocks, policymakers have monitored the annual increase of the minimum wage given their effects on production costs.[2] As shown in figure 1a there is a positive relationship between changes of the real minimum wage and inflation for some Latin American countries. Empirically, for the case of Colombia, a 10% increase in the minimum wage increases out-of-home food inflation by 1.33% L. E. Arango, Ardila, et al. (2011) and total-food inflation by 0.61% Lasso-Valderrama and López-Enciso (2011). The presence of informal labor markets, as it is the case of Latin America, adds an additional ingredient, and might weaken the relationship between the minimum wage and labor costs. Higher wages may incentive firms to substitute low skilled formal labor for informal workers and recompose labor costs, (Figure 1b).

The analysis of the implications of the minimum wage on the labor market begins with the division of the working population in two groups. Given that minimum wage policies do not affect all low-skilled workers equally, some of them will be *covered* by the regulation, while others not (e.g. Welch (1974) and Ashenfelter and Smith (1979)). Regarding the first group, the level of employment is determined by labor demand, while for the *non-covered* workers, wages and employment are determined by the interaction of labor supply and demand.[3] The literature finds that increases in the minimum wage either decreases or do not affect employment of the *covered* workers, while it increases wages and employment of *non-covered* workers. The

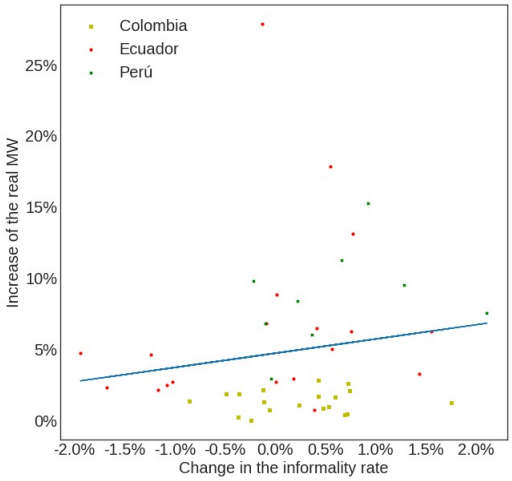
[1] Which is the case when the bargaining power of workers is weak Eurofond (2018)

[2] In particular, the minimum wage had been a matter of consideration in some of the meetings... specially at the end of the year, right before negotiations start and in the first quarter

[3] In some studies this classification may also reflect the formality of the firm, i.e. its ability to pay for all the expenses of a formal job.



(a) Inflation and real minimum wage changes.



(b) Informality and real minimum wage changes.

This figures present the evolution of inflation, informality rate and the real minimum wage increase between 2000 and 2019 for Ecuador, Perú, and Colombia. The adjustment rule in these countries considers past inflation and productivity growth.

effects on the labor market disseminates through the economy and the interactions during the dynamic adjustment of the labor market, with labor costs, consumption, and investment will drive the dynamics of the inflation rate, the output gap and therefore, monetary policy. These interactions are crucial to explain the channels through which minimum wage increases propagate through the economy and how economic policy should react. Moreover, as shown in Šauer (2018) and Glover (2019) for the U.S., the stance of monetary policy is key in determining the implications for the economy of the minimum wage.

Considering these elements, we develop a TANK model to study the effects of the minimum wage in a small, open and developing economy, with a minimum wage evolving according to a rule known by all agents, with a fragmented labor market and informality enabling the existence of a market wage lower than the legal minimum wage, nominal rigidities and a standard monetary policy. We pay particular attention to the following characteristics, common in small and developing economies and which capture the key mechanisms by which the minimum wage influences the main macroeconomic variables. *i)* The economy is inhabited by two types of households which differ in terms of the productivity of the labor they supply; *ii)* high-skilled households, which participate in the formal labor market, have access to both domestic and international financial markets, own capital and firms, and receive a wage determined by the interaction between market demand and supply; *iii)* low-skilled households' only earnings is their wage income since they lack access to savings and investment opportunities; in turn, these *hand-to-mouth* households offer their labor in both the formal and informal labor market; *iv)* low-skilled formal workers are paid the minimum wage; *v)* low-skilled informal workers are paid

less than the minimum wage required by law.

In order to account for the potential direct effect on the employment of low-skilled formal workers after an increase in the minimum wage, *vi)* there are two types of capital that differ in the way they substitute/complement labor. On the one hand, machinery capital is a substitute for low-skilled labor. This substitutability implies that, faced with an increase in the minimum wage, firms can lay off low-skilled workers and buy machines to replace them. In contrast, capital in buildings is complementary to labor. *vii)* the minimum wage is adjusted following a rule that takes into account observed inflation and productivity growth, but leaves some leeway for additional adjustments (unexpected increases). *viii)* The minimum wage has a lighthouse effect, which increases its impact on the economy by acting as a signal for the calculation of other formal wages. Otherwise, the model is standard.

This paper, contributes to two strands of the literature. On the one hand, it adds to the analysis of the effects of the minimum wage on short run dynamics, which focuses primarily on the cases of the United States and other developed countries and says little about the effects of the minimum wage in developing countries where a larger percentage of workers receive the minimum wage and where, generally speaking, political and legal institutions differ considerably. On the other hand, by proposing a general equilibrium macroeconomic analysis, the model in this paper considers interactions between the minimum wage and other macroeconomic variables, that partial equilibrium models do not account for, such as, inflation, the output gap and monetary policy,

We calibrate the model to replicate the wage gaps in Colombia and other macroeconomic stylized facts, and analyze the effects of an exogenous 100 basis point (bp) increase in the minimum wage. We observe larger effects on the labor market and the main macroeconomic variables, and moderate effects on inflation and monetary policy. That said, low-skilled formal labor falls by around 0.9% on impact, and is partially substituted by informal labor (0.2%) and investment in machinery (1%). In the short run, the demand for informal workers increases and drives up their wages (0.25%), however, when the income of low-skilled workers starts to fall, households supply more informal labor and drives down wages. High-skilled labor shows little variation, but their wages increase in the short run (0.1%) due to the minimum wage pass-through and fall in the long run (0.15%) as a result of lower demand. Higher production costs cause output to fall by about 0.1%, and open a negative output gap (0.04%) in the short run. On impact, low-skilled households increase their consumption due to the higher minimum wage, but as the economy transitions to the new equilibrium, their income sources shrink and so does their consumption. On the other hand, high-skilled households fare worse in terms of consumption, as they finance investment and their sources of income fall. Finally, in terms of inflation and the nominal monetary policy we observe small increases in both, however, their

magnitudes depend on the structure of the economy, in terms of how the minimum wage affects other wages and how easy it is for the firms to substitute low skilled workers.

This paper is divided into five sections, including this introduction. In the second section we discuss the elements of the model extending the works of Glover (2019) and Krusell et al. (2000) to capture the main dynamics in a SOE with heterogeneous households and fragmented labor markets, and real and nominal rigidities. In the third section, we discuss our calibration for Colombia and how the model fits the data. In the fourth section we describe the macroeconomic effects of an unexpected increase in the minimum wage, as well as four alternative scenarios that modify the monetary policy response and the production structure and under which the inflationary pressures are higher. Finally, we conclude in the fifth section.

2 MW adjustment rule

In Colombia, the minimum wage was introduced in 1949 and is annually adjusted in a two-stage process. In the first stage, unions and employers' organisations enter into a negotiations process to reach an agreement. If negotiations fail, in a second stage the government determines the minimum wage by decree based on a rule that depends on annual productivity growth, consumer inflation, and an unexpected change. According to Laws 278 (1996) and 990 (2005) and Sentence C-815 (1999), wage contribution to national income and GDP growth must also be considered. However, in practice they are barely mentioned in the decree or during the adjustment of the Minimum Wage. This adjustment process is similar in Peru, and Ecuador.[4]

3 Model

We develop a general equilibrium model that captures the main mechanisms through which the minimum wage affects inflation and the output gap in a small open economy. In particular, we consider an economy inhabited by two households that differ in their productivity, access to financial markets, and property rights, the types of labor they supply, access to financial markets. On the firms side, we consider two layers of production. In the first, a mass of heterogeneous firms uses capital and labor to produce differentiated goods. These firms operate under monopolistic competition and face price rigidities à la Calvo. At the second layer, a competitive firm combines the heterogeneous inputs and produces a homogeneous good that

[4]Examples can be found in https://www.gob.pe/institucion/mtpe/noticias/597306-gobierno-aumento-el-sueldo-minimo-a-s-1-025 and https://www.trabajo.gob.ec/

can be used for consumption, investment, and net exports. Finally, we consider that the central bank sets the interest rate according to a Taylor rule that responds to inflation and the output gap.

3.1 Households

A mass one of households is divided into high-skilled, N_h, and low-skilled, N_l. On the one hand, high-skilled households offer a highly productive type of labor, own physical capital and firms, and make consumption and investment decisions in two types of capital. They also have access to local and foreign financial markets. On the other hand, low-skilled households are hand-to-mouth and offer two types of low productive labor, formal and informal. A list of the model parameters is described in Table 1.

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

$$\max_{c_t^H, h_t^H, B_{t+1}, A_{t+1}^f, i_t^H, k_{t+1}^H} E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{(c_t^H)^{1-\sigma}}{1-\sigma} - \psi_H \frac{\nu_H}{1+\nu_H} \left(h_t^H\right)^{\frac{1+\nu_H}{\nu_H}} \right),$$

subject to the budget constraint,

$$P_t(c_t^H + i_t^{e,H} + i_t^{x,H}) + A_{t+1}^f + B_{t+1} \leq B_t R_{t-1} + \Phi_{t-1} R_{t-1}^f A_t^f + W_t^H h_t^H + R_t^e k_t^{e,H} + R_t^x k_t^{H,x} + \Pi_t / N_t^H,$$

where $P_t, W_t^H, R_{t-1}, R_{t-1}^f, \Phi_t, R_t^e, R_t^x, \Pi_t$ are final goods prices, high-skilled wages, interest rate for domestic bonds, interest rate for foreign bonds, risk premium, price of capital (e,x), and firm's profits.

investment adjustment costs,

$$i_t^{j,H} = k_{t+1}^{j,H} - (1-\delta_j) k_t^{j,H} + \frac{\phi_j}{2} \left(\frac{i_t^{j,H}}{i_{t-1}^{j,H}} - 1 \right)^2, j \in \{e, x\},$$

and the debt elastic interest rate,

$$\Phi_t = \Phi(A_t^f) = \widetilde{\phi} + \phi_a \left(A_t^f / Y_t - \overline{A}^f / \overline{Y} \right).$$

After normalizing the F.O.C by P_t we find the marginal rate of substitution between consumption and labor, $\psi_H (h^{H_t})^{1/\nu_H} = \frac{{w_t}^H {c_t^H}^{-\sigma}}{p_t}$, the Euler equations for domestic and foreign

bonds, $(c_t^H)^{-\sigma} = \beta\frac{(c_{t+1}^H)^{-\sigma}R_t}{\pi_{t+1}}; (c_t^H)^{-\sigma} = \beta\frac{(c_{t+1}^H)^{-\sigma}R_t^f\Phi_t}{\pi_{t+1}}$, for the two types of capital, $\mu_{j,t} = \beta\left((c_{t+1}^H)^{-\sigma}\left(\frac{r_{t+1}^{j,t}}{p_{t+1}}\right) + \mu_{t+1}^j(1-\delta_j)\right)$ for $j \in \{e,x\}$, and the two types of investment, $(c^{H_t})^{-\sigma} = \mu^{j_t}\left(1-\phi_j\left(\frac{i_t{}^{j,H}}{i_{t-1}{}^{j,H}}-1\right)\frac{1}{i_{t-1}{}^{j,H}}\right)+\beta\left(\mu^{j_{t+1}}\phi_j\left(\frac{i_{t+1}{}^{j,H}}{i_t{}^{j,H}}-1\right)\frac{i_{t+1}^{j,H}}{(i_t{}^{j,H})^2}\right)$ for j $\in \{e,x\}$. Where $w_{H,t} = W_{H,t}/P_t; r_t^e = R_t^e/P_t; r_t^x = R_t^x/P_t; p_t = P_t/P_t; \pi_t = P_t/P_{t-1}$, are the real factor prices and μ_t^j are the Lagrangian multipliers for the investment adjustment costs. Notice that π_t is 1 plus the inflation rate.

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

$$\max_{c_t^L, h_{I,t}, h_{F,t}}\left(\frac{(c_t^L)^{1-\sigma}}{1-\sigma} - \psi_I\frac{\nu_I}{1+\nu_I}\left(h_t^I\right)^{\frac{1+\nu_I}{\nu_I}} - \psi_F\frac{\nu_F}{1+\nu_F}\left(h_t^F\right)^{\frac{1+\nu_F}{\nu_F}}\right),$$

subject to

$$P_t c_t^L \leq W_t^I h_t^I + W_t^F h_t^F + P_t T_t / N_t^L.$$

From the normalized F.O.C, we find the marginal rates of substitution between consumption and labor (formal and informal), $\phi_I(h_t^I)^{\frac{1}{\nu_I}} = \frac{(c_t^L)^{-\sigma}}{p_t}w_t^I, \phi_F(h_t^F)^{\frac{1}{\nu_F}} = \frac{(c_t^L)^{-\sigma}}{p_t}w_t^F$. Where $w_t^I = W_t^I/P_t; w_t^F = W_t^F/P_t$ are the real informal and formal wages, and T_t are Government transfers.

Finally, aggregate domestic demand, consumption and investment, can be defined as $D_t = C_t + I_t^e + I_t^x$, where $C_t = N_t^H c_t^H + N_t^L c_t^L$, $I_t^e = N_t^H i_t^{e,H}$ and $I_t^x = N_t^H i_t^{x,H}$. Similarly, aggregate labor supply is given by, $L_t^H = N_t^H h_t^H$, $L_t^I = N_t^L h_t^I$, and $L_t^F = N_t^L h_t^F$.

3.2 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.[5] This firm maximizes its profits according to,

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

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

[5] An alternative approach is to include two production sectors (formal and informal). However, we prefer our approach given data limitation on the formal/informal production in Colombia and the fact that our approach allows us to characterize the main substitution channels in the labor market after the shock.

on its relative price and the aggregate demand for domestic goods, $Y_t(j) = \left(\frac{P_t(j)}{P_t}\right)^{-\xi} Y_t$, and that the aggregate price index of domestic goods is an average of heterogeneous input prices, $P_t = \left[\int_0^1 P_t(j)^{1-\xi} dj\right]^{\frac{1}{1-\xi}}$. The domestic production of the homogeneous good is allocated to consumption, investment, and net exports, $Y_t = D_t + NX_t$.

At the inner level, we have a continuum of heterogeneous firms making static and dynamic decisions. Regarding the static ones, a producer (j) minimizes costs by choosing her optimal demands for two types of capital, and three types of labor. Her optimization problem is given by:

$$\min_{K^e_{t,j}, K^x_{t,j}, L^H_{t,j}, L^I_{t,j}, L^F_{t,j}} \tau_t w^H_t L^H_{t,j} + w^I_t L^I_{t,j} + \tau_t w^F_t L^F_{t,j} + r^e_t K^e_{t,j} + r^x_t K^x_{t,j},$$

subject to

$$Y_{t,j} = A_t (K^e_{t,j})^{\alpha} (L_{t,j})^{1-\alpha}, \tag{1}$$

where,

$$L_{t,j} = \left[\theta (L^x_{t,j})^{\frac{\eta-1}{\eta}} + (1-\theta)(L^H_{t,j})^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}, \tag{2}$$

$$L^x_{t,j} = \left[(1-\theta_x)(L^L_{t,j})^{\frac{\eta_x-1}{\eta_x}} + \theta_x (K^x_{t,j})^{\frac{\eta_x-1}{\eta_x}}\right]^{\frac{\eta_x}{\eta_x-1}}, \text{ and} \tag{3}$$

$$L^L_{t,j} = \left[\theta_L (L^I_{t,j})^{\frac{\eta_L-1}{\eta_L}} + (1-\theta_L)(L^F_{t,j})^{\frac{\eta_L-1}{\eta_L}}\right]^{\frac{\eta_L}{\eta_L-1}}. \tag{4}$$

According to the production function we have different ways of aggregating the factors of production. In particular, low-skilled labor, L^L_t, is a combination of low productive formal and informal labor (equation 4). Similarly, we define a low productive factor, L^x_t, which is the combination of low-skilled labor and machinery and equipment, (K^x_t) (Equation 3). We then combine the high-skilled labor with the low-skilled factor to generate L_t, equation 2 which is later combined with buildings K^e_t. Note that the C.E.S. structure gives us enough flexibility to capture different dynamics after a minimum wage shock. From the normalized F.O.C we find the relative demand of factors as functions of their relative prices, $\frac{w^x_t}{\tau_t w^H_t} = \frac{\theta}{1-\theta}\left(\frac{L^H_t}{L^x_t}\right)^{1/\eta}$; $\frac{w^{IL}_t}{\tau_t w^{FL}_t} = \frac{\theta_L}{1-\theta_L}\left(\frac{L^{FL}_t}{L^{IL}_t}\right)^{1/\eta_L}$; $\frac{r^x_t}{w^L_t} = \frac{\theta_x}{1-\theta_x}\left(\frac{L^L_t}{K^x_t}\right)^{1/\eta_x}$; and $\frac{L_t}{K^e_t} = \frac{(1-\alpha)}{\alpha}\left(\frac{r^e_t}{w_t}\right)$.

We also obtain the aggregate factor prices, $w_t = \left(\theta^{\eta}(w^x_t)^{1-\eta} + (1-\theta)^{\eta}(\tau_t w^H_t)^{1-\eta}\right)^{1/(1-\eta)}$; $w^x_t = \left((1-\theta_x)^{\eta_x}(w^L_t)^{1-\eta_x} + \theta^{\eta_x}_x (r^x_t)^{1-\eta_x}\right)^{1/(1-\eta_x)}$; $w^L_t = \left(\theta^{\eta_L}_L (w^I_t)^{1-\eta_L} + (1-\theta_L)^{\eta_L}(\tau_t w^F_t)^{1-\eta_L}\right)^{1/(1-\eta_L)}$;

and the real marginal cost $mc_t = \frac{1}{A_t}\left(\frac{\alpha}{r_t^e}\right)^{\alpha}\left(\frac{1-\alpha}{w_t}\right)^{1-\alpha}$.

This group of firms also makes dynamic pricing decisions. Specifically, we consider heterogeneous producers facing price rigidities à la Calvo, according to which, each period a firm has an exogenous probability of changing prices, $1-\phi$. The remaining ϕ firms adjust their prices according to past inflation. The optimal decision of a firm that can change prices in period t is given by:

$$\max_{P_t(j)} E_t \sum_{k=0}^{\infty} (\beta\phi)^k \frac{U_{c,t+k}}{U_{c,t}} \left(\left(\frac{\pi_{t+k-1}^{1_k} P_t(j)}{P_{t+k}} \right)^{1-\xi} Y_{t+k} - mc_{t+k} \left(\frac{\pi_{t+k-1}^{1_k} P_t(j)}{P_{t+k}} \right)^{-\xi} Y_{t+k} \right),$$

where 1_k is an indicator function that takes the value of 0 if $k=0$ and 1 otherwise. From the F.O.C

$$P_t(j) = \frac{\xi}{\xi-1} \frac{E_t \sum_{k=0}^{\infty} (\beta\phi)^k U_{c,t+k} mc_{t+k} P_{t+k}^{\xi} Y_{t+k}}{\sum_{k=0}^{\infty} (\beta\phi)^k U_{c,t+k} P_{t+k}^{\xi-1} Y_{t+k}}.$$

This equation implies that the optimal price of a firm that can change prices is given by $P_t^{\#} = \frac{\xi}{\xi-1}\frac{X_{1,t}}{X_{2,t}}$, where, $X_{1,t} = U_{c,t} mc_t P_t^{\xi} Y_t + \beta\phi E_t X_{1,t+1}$ and $X_{2,t} = U_{c,t} P_t^{\xi-1} + \beta\phi E_t X_{2,t+1}$. This optimal decision plus the law of large numbers, coming from the continuum of firms, imply that aggregate prices can be written as a weighted average of optimal and lag prices $P_t^{1-\xi} = (1-\phi)(P_t^{\#})^{1-\xi} + \phi P_{t-1}^{1-\xi}$. After normalizing we find the inflation rate, $(\pi_t)^{1-\xi} = (1-\phi)(\pi_t^{\#})^{1-\xi} + \phi(\pi_{t-1})^{1-\xi}$, where, $\pi_t^{\#} = \frac{\xi}{\xi-1}\frac{x_{1,t}}{x_{2,t}}\pi_t$, $x_{1,t} = C_t^{-\sigma} mc_t Y_t + \beta\phi E_t x_{1,t+1}(\pi_{t+1}/\pi_t)^{\xi}$, and $x_{2,t} = C_t^{-\sigma} Y_t + \beta\phi E_t x_{2,t+1}(\pi_{t+1}/\pi_t)^{\xi-1}$. Finally, due to price rigidities, total output in the economy is given by:

$$Y_t = \frac{(K_t^e)^{\alpha}(L_t)^{1-\alpha}}{v_t^p},$$

where v_t^p us the price dispersion: $v_t^p = \int_0^1 \left(\frac{P_t(j)}{P_t}\right)^{-\xi} dj = (1-\phi)(\frac{\pi_t}{\pi_t^{\#}})^{\xi} + \phi(\frac{\pi_t}{\pi_{t-1}})^{\xi} v_{t-1}^p$.

3.3 Labor market

As described before our economy has three types of labor: high-skilled, provided by the more productive households and formal and informal low-skilled labor supplied by the less productive households. Employment and wages for informal low-skilled labor are determined by the interaction of demand and supply, given the optimal choices of firms and households. With respect to low-skilled formal work the minimum wage sets a distortion and implies that the demand side is responsible of determining the level of employment. This strategy shows the interconnection between the two types of labor in the low-skilled households, reflecting the mobility across formal and informal sectors and capturing the main features of a standard two

sector model used to analyzed the effect of the minimum wage (e.g. Gramlich (1976) and Mincer (1976)). We define an adjustment rule for the wages of low-skilled formal workers following the rule used in Colombia, i.e. We assume that each period the nominal minimum wage evolves according to past inflation, total marginal productivity of labor, and an exogenous shock:

$$\Delta W_t^F = \frac{W_t^F}{W_{t-1}^F} = \pi_{t-1} \Delta MP_{L,t-1}(1 + \epsilon_t^F), \tag{5}$$

where, $MP_{L,t} = (1-\alpha)\left(\frac{Y_t v_t^p}{L_t}\right)$, is the marginal product of labor, and $\Delta MP_{L,t-1} = MP_{L,t}/MP_{L,t-1}$. As discussed in the introduction, this rule reflect the main elements of the annual adjustment of the minimum in Colombia, and generates that the nominal unexpected increase becomes real. Given this setting, we define the adjustment of real wages as:

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

where, $\Delta w_t^F = \Delta W_t^F - \pi_t$. For this wage setting to be relevant, we assume that in the steady state, w_{ss}^F, the wage of low-skilled workers wage is higher than the one from the clearing market equilibrium. This condition implies that the market for this factor clears only using the demand equation, and supply becomes irrelevant.

Finally, and consistent with the empirical evidence for Colombia and the lighthouse effect of the minimum wage (e.g. Bell (1997), Maloney and Mendez (2004), and Neumark et al. (2004)), we assume that in the short run there is some transmission of the shock to high-skilled wages, as well as some rigidity in the adjustment of wages. This distorts the competitive equilibrium for high skilled wages in the short run, but guaranties that in the long run the equilibrium is competitive. In particular, we consider that:

$$w_t^H = \max\{w_t^{H,market}, (w_{t-1}^H)^{\rho_H}(w_{t-1}^{H,market})^{1-\rho_H}(1 + \epsilon_t^F - \epsilon_{t-1}^F)\}. \tag{6}$$

3.4 Policy institutions

On the policy side, we have two institutions: the central bank and the government. Regarding the central bank, we define a standard Taylor rule that depends on inflation and the output gap:

$$log\left(\frac{R_t}{R}\right) = \rho_r log\left(\frac{R_{t-1}}{R}\right) + (1-\rho_r)\left(r_\pi log\left(\frac{\pi_{t+1}}{\pi}\right) + r_y log\left(\frac{Y_t}{Y_t^{flex}}\right)\right) + \epsilon_r, \tag{7}$$

where, Y_t^{flex} is the output level consistent with the flexible price equilibrium. This specification is optimal in models with similar structure, Faia and Monacelli (2008). On the government

side, we assume that each period the budget is balanced, meaning that revenues from taxes on formal wages taxes are equal lump-sum subsidies:

$$T_t/P_t = (\tau_t - 1)(w_t^F L_t^F + w_t^H L_t^H).$$

4 Parameters and Calibration

We calibrate the model for the Colombian economy for the period (2010 - 2019). We take most of the parameter values from González et al. (2011), Whalen and Reichling (2017), and Krusell et al. (2000) while choosing the remaining ones to normalize the variables in the steady state or to match some particular stylized facts for Colombia (Table 1). Specifically, we calibrate θ and θ_L to match wage ratios of 2.70 between high- and low-skilled and 2.24 between formal and informal low-skilled workers. The parameters ψ_I and N_h generate a wage mass for high-skilled workers of 83%, and a mass of this type of workers of 52%. These values were constructed using information between 2010 and 2019 from the Colombian Households survey (GEIH, by its acronym in Spanish).[6] We divide workers according to their productivity with respect to some thresholds of the minimum hourly wage. All employed workers with earnings above 1.1 minimum hourly wage are considered high-skilled, workers whose hourly earnings are between 0.9 and 1.1 minimum hourly wage are considered low-skilled and formal, while the remaining workers are low-skilled informal. The range for the formal low-skilled employment is due to the fact that, being a survey, sometimes workers would not respond to the wage value in the contract but to the amount they receive (discounting social security, for instance, or including the transportation subsidy).

Finally, we calibrate α and θ_x to equal 30% investment over GDP and the share of investment in machinery of 30%. Additionally, we consider that in the long run the domestic and foreign inflation rates are zero, implying that $\pi = \pi^f = 1$, since $\pi_t = p_t/p_{t-1}$. Net foreign assets, LR, is consistent with $\overline{a}^f = 50\%$ and the LR risk premium $\overline{\Phi} = 1.0037$ reflects the average value for Colombia, while labor taxes are 20%, $\tau_{ss} = 1.20$.

4.1 Adjustment to the Colombian Economy. TBD

In this section we compare some macroeconomic stylized facts from the Colombian economy with those implied by the simulated model with productivity, demand, monetary and foreign

[6]The GEIH is a continuous household survey made by National Administrative Department of Statistics (DANE, for its Spanish acronym). This survey investigates employment, income, hours and other labor market related variables. It started in July 2006 and replace the Continuous household Survey (ECH) that runs between 2001 and June 2006.

Parameter	Definition	Value	Source
σ	Intertemporal Elast. Subs	2.0	Glover (2019)
β	Discount factor	0.9878	González et al. (2011)
ν_H	Labor elasticity	1.0	Glover (2019)
$\nu_{FL} = \nu_{IL}$	Labor elasticity	3.0	
ψ_H	Disutility of Skill labor	1.0	Glover (2019)
$\psi_I = \psi_F$	Disutility of low skill labor	2.16	Calibrated
η	Elast. subs. L_x vs L_H	0.7	Krusell et al. (2000)
η_x	Elast. subs. L_L vs K_x	1.25	
η_L	Elast. subs. L_I vs L_F	1.50	Krusell et al. (2000)
α	Capital share	0.2537	Calibrated
θ	Productivity L_L vs L_H	0.3113	Calibrated
θ_L	Productivity L_{FL} vs L_{IL}	0.2561	Calibrated
θ_x	Productivity L_L vs K_x	0.3587	Calibrated
ϕ	Price rigidity	0.75	González et al. (2011)
ξ	Elast. subs. intermediates	12	González et al. (2011)
π	Long run inflation	$(1.0)^{0.25}$	Normalization
$\overline{a}^f$	Net foreign assets LR	0.50	Data
$\overline{\Phi}$	LR risk premium	1.0037	Data
ϕ_a	Risk premium elast. to debt	0.01	
ρ_r	Persistence R	0.70	González et al. (2011)
r_π	Taylor π	1.50	Glover (2019)
r_y	Taylor y	0.25	
w_{min}	LR real minimum wage	50%	
A	Productivity	1.0	Normalization
π^f	LR foreign inflation	$(1.0)^{0.25}$	Normalization
τ_{ss}	Labor taxes	1.2	Data

Table 1: Parameters

shocks.

Moment	Data	Model

Table 2: Data vs Model

5 Results

5.1 Unexpected increase in the minimum wage

In this subsection we present the response of the economy to an unexpected of 100 bp increase in the nominal minimum wage, which permanently distorts the real wage of low-skilled formal

workers. We divide the analysis into three groups of variables. The first focuses on employment and wages dynamics (direct effects of the shock). While the second group considers the main real macroeconomic variables (consumption, investment, GDP), and the third group analyzes the response of inflation and the policy rate.

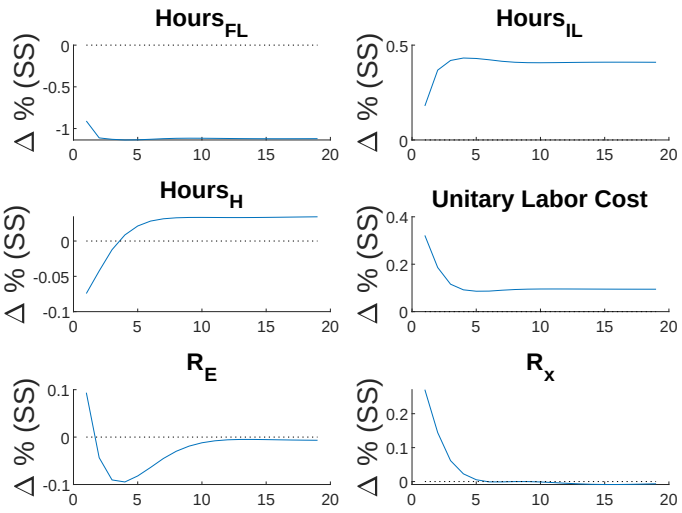


Figure 2: Impulse Response of the labor market after an unexpected increase in the minimum wage

This figure presents the dynamic response of hours (formal low-skilled $Hours_{FL}$, informal low-skilled $Hours_{IL}$, and skilled $Hours_H$), unitary labor cost, and the returns to investment in buildings R_e and machines R_x to an unexpected increase in 100 bp of the minimum wage. THe vertical axis shows the difference with respect to the initial steady state.

The unexpected increase in the minimum wage implies higher costs of hiring low-skilled formal workers, in response, firms reduce their demand and substitute these workers with informal labor and machines (Figure 2). Quantitatively, we observe that the response of low-skilled formal labor depends on the time horizon. In the short run, substitution is weaker due to the presence of investment adjustment costs and the low response of informal jobs. However, in the long run, low-skilled formal labor falls more as substitution strengthens. These falls in low-skilled employment are similar in magnitude to previous findings in the literature that analyzes the industrial employment for Colombia where the own wage elasticity ranges from 0.7 to 1.4 (e.g. L. Arango et al. (2019) and Cardenas and Bernal (2003)) and to findings of Dinkelman and Ranchhod (2012) and Carneiro (2004) and Canelas (2014) in which *covered* employment either decreases or remains constant. On the other hand, temporal differences in the responses of the informal labor market are also observed, in the short run demand forces play an important role, due to labor substitution, and push wages up by 0.2%, behaviour similar to the one found by

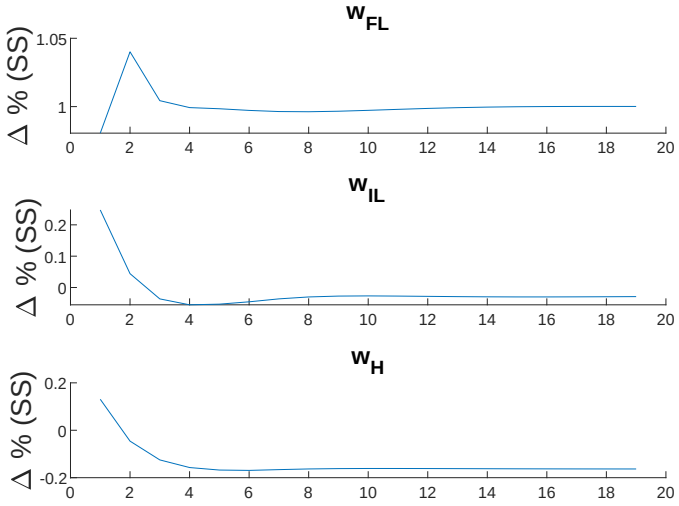


Figure 3: Impulse Response of wages after an unexpected increase in the minimum wage

This figure presents the dynamic response of formal low-skilled wage (W_{FL}), informal low-skilled wage W_{IL}, and skilled wage W_H to an unexpected increase of 100 bp of the minimum wage. THe vertical axis shows the difference with respect to the initial steady state.

Lemos (2009) and Canelas (2014) (Figure 4). In the long run, as low-skilled income declines, households supply more informal labor and wages fall, i.e. we observe an additional worker effect.[7] Note that the unit labor costs, defined as the wage bill divided by the total number of hours worked, increase 0.3% on impact, meaning that a 1% increase in low-skilled formal wages implies an increase of almost one-third in labor costs.

The recomposition of inputs following the impact and the short-term transmission of the minimum wage shock to high-skilled wages affects the demand for high-skilled workers and investment in buildings. On the one hand, high-skilled wages increase by about 0.1% on impact, while demand falls by 0.07%. In the long run, supply-side considerations are the main driver of the adjustment and there is a small increase in lower wage employment.These findings are consistent with the increments in wage of all salaried workers increases, even for those not close to the minimum wage, found by Khamis (2013), Gindling and Terrell (2005), and Ham (2018) and Lemos (2009). On the other hand, investment in buildings rises on impact due to higher labor costs, but falls during the transition as high-skilled labor becomes cheaper. Quantitatively, the response of high-skilled hours is smaller than that of low-skilled hours (both formal

[7]Evidence of the added worker effect in Colombia is presented in Cardona-Sosa and Morales (2015) who showed that during the first six months after job loss of the main income receiver, spouses increase their participation between 9% y 20%. Additionally, L. E. Arango, Parra, et al. (2015) showed that participation increases six times more during recessions than in expansions, showing that during the Business cycle the added worker effect is higher than the discouraged worker.

and informal). Labor supply elasticities, hand-to-mouth constraints, and direct effects explain this behavior.

Regarding macroeconomic variables, low-skilled household consumption increases on impact, but less than 1% due to the fall in formal employment. During the transition, consumption starts to fall as formal labor income declines, and is not fully offset by the increase in informal labor (Figure 4). High-skilled households are also affected by the shock, however, their consumption falls both on impact and in the long run. The fall in consumption is due to lower income and the need to finance investment in machinery. Given the higher labor costs, firms reduce their production and the output gap turns negative, as GDP in the flexible price equilibrium fall less due to the competitive adjustment of high-skilled wages. Quantitatively, GDP falls on impact 0.12% and 0.08% in the long-run, while the output gap is around -0.05%.

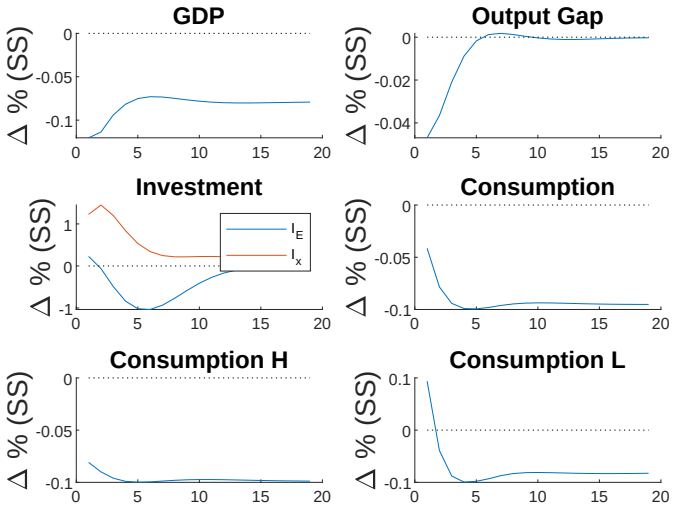


Figure 4: Impulse response of the GDP, output GAP, investment and consumption after an unexpected increase in the minimum wage

This figure presents the dynamic response of GDP, output GAP, investment in buildings I_E and machines I_x, high skilled Consumption (Consumption H), and low skilled consumption (Consumption L) after an unexpected increase of 100 bp of the minimum wage.

As in any New Keynesian model, prices are determined by the present value of production costs, so the minimum wage increase raises total inflation and its expectations, Figure 5. On impact, annualized inflation increases by about eight bp, almost one-tenth of the overall minimum wage increase, and one-third of the increase in unit labor costs, implying a relatively low transmission of minimum wages to inflation. The monetary policy response depends on the sensitivity of the central bank to the output gap and the deviation of inflation from its target. In this application, the results show a slight increase in the nominal interest rate (about one bp), while the real

interest rate falls given inflation dynamics. As for foreign variables, we observe a deterioration of about 20 bp in the trade balance as percentage of GDP and a 10 bp reduction in the net foreign asset position.

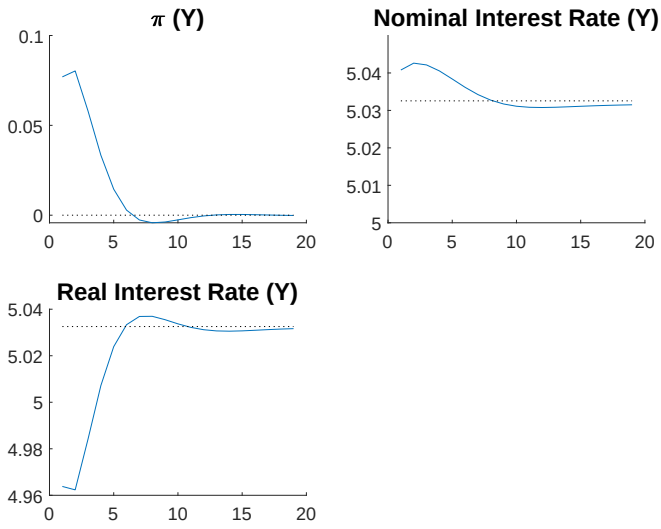


Figure 5: Impulse response of inflation and monetary policy variables

This figure presents the dynamic response of annual inflation $\pi(y)$, and the real and nominal annualized interest rates, after an unexpected increase of 100 bp of the minimum wage.

5.2 Alternative Scenarios

The benchmark model shows important effects of minimum wage shocks on the labor market and the main macroeconomic variables, but relatively small effects on inflation and monetary policy. In this subsection we explore some mechanisms that generate different inflationary pressures in the model in four alternative scenarios and compare their results with the baseline model (Figure 6). The first one introduces a central bank that reacts more strongly to deviations of inflation expectations, we implement this by increasing the relative importance of this deviation r_π in equation 7. Under this assumption, agents in the economy know the more strict behavior of the central bank, leading to a lower real interest rate and inflation than in the baseline model after the unexpected increase in the minimum wage. However, GDP falls further and so does the output gap. The second scenario analyzes the dynamics of the economy under a higher transmission of the shock to skilled wages, thus we modified equation 6 to guarantee that transmission was the double than in the baseline, leading to an even higher increase in overall production costs. Thus, we observe higher inflationary pressures, a stronger monetary policy response and a further reduction in GDP and the output gap. It is worth

noting that the new specification of the Taylor rule and the higher transmission do not change the long-run structure of the economy and thus its steady state. Therefore, the only differences we will observe are in the short run and in the dynamic adjustment of the economy.

In a third scenario we consider a more labor-intensive economy, so that the increase in the minimum wage affects a larger percentage of production costs. In this scenario, the effects on inflation and output gap are stronger, leading also to a stronger response from the monetary authority. In our final scenario we assess how an economy will react in which there are no sources of substitution, i.e., we eliminate low-skilled informal labor and machines in the productive process of the economy and also increase adjustment costs in buildings. Thus, we set $\theta_L = 0$ in equation 4 and $\theta_x = 0$ in equation 3, then the aggregate labor input described in equation 2 will become: $L_{t,j} = \left[\theta(L^F_{t,j})^{\frac{\eta-1}{\eta}} + (1-\theta)(L^H_{t,j})^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$. By construction, after the unexpected increase in the minimum wage, firms will be more affected due to the lack of inputs for substitution. This scenario shows a further deterioration of the economy both in terms of output and inflation.

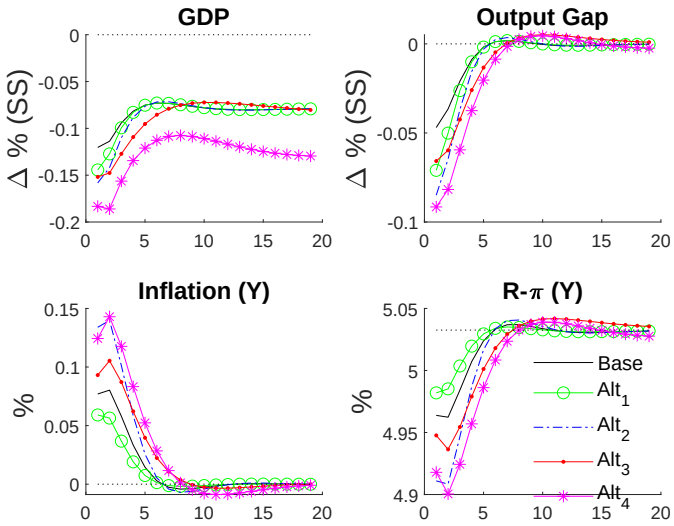


Figure 6: Impulse Response under alternative Scenarios

This figure presents the dynamic response of GDP, output GAP, inflation and the real interest rate after an unexpected increase of 100 bp of the minimum wage under 4 alternative scenarios and the baseline.

6 Conclusions

The presence of a minimum wage and its process of adjustment are issues that have gained relevance in public discussion, generating controversy in both political and economic spheres. The

literature has not agreed on the potential benefits or drawbacks of a minimum wage. On the one hand, opponents of a minimum wage argue it's detrimental to less qualified workers by pushing them into informality or unemployment. In addition, some argue that firms would respond to an increase in the minimum wage by increasing their prices generating higher inflation. On the other hand, proponents of the minimum wage argue that its effects on employment are small (they may even be positive) while it can help maintain or increase the income of low-skilled workers, their consumption and reduce income inequality.

In this paper, we propose a New Keynesian model to study the macroeconomic effects of the minimum wage in a small open economy with labor heterogeneity and in which the evolution of the minimum wage follows a rule known to all agents. Specifically, our model considers two households that differ in their access to financial markets, property rights, and the productivity of the labor they supply (low-skilled and high-skilled). Firms use in their production labor and two types of capital, differentiated according to their substitutability with labor, and face price rigidities. The central bank sets the interest rate according to a standard Taylor rule. Finally, there is a minimum wage that affects low-skilled labor and evolves according to a rule that depends on productivity and inflation. We calibrate the model for Colombia and analyze the effects of an unexpected increase in the minimum wage, i.e., an increase higher than that dictated by the rule.

The results show that a permanent and unexpected increase in the (nominal and real) minimum wage has important effects on the main macroeconomic aggregates, especially on the labor market. These effects, however, depend on the horizon considered. In particular, the responses of formal low-skilled labor, low-skilled household consumption, and the informal wage vary substantially in the short, medium, and long run. Finally, short-term inflationary effects depend on the response of the central bank, the pass-through of the minimum wage to other wages in the economy, and the ability of firms to adjust.

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