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No. 1153
2021

BANCO DE LA REPÚBLICA
COLOMBIA

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Abstract

We develop a small open economy model with nominal rigidities and fragmented labor markets to study the response of the monetary policy to a migration shock. Migrants are characterized by their productivity levels, their restrictions to accumulate capital, as well as by the flexibility of their labor income. Our results show that the monetary policy response depends on the characteristics of migrants and the local labor market. An inflow of low(high)-productivity workers reduces(increases) marginal costs, lowers(raises) inflation expectations and pushes the Central Bank to reduce(increase) the interest rate. The model is calibrated to the Colombian economy and used to analyze a migratory inflow of financially constraint workers from Venezuela into a sector with flexible and low wages.

JEL classification: E13, J31, J46, J61, E50

Keywords: Neoclassical Model; Wage Differentials; Informal Labor Markets; Migration; Monetary Policy

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Migración y política monetaria: Un análisis para una economía pequeña y abierta

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Resumen:

En este artículo analizamos la respuesta de política monetaria ante un choque migratorio, mediante el desarrollo de modelo de economía pequeña y abierta con mercados de trabajo fragmentados. Los migrantes se caracterizan por sus bajos niveles de productividad, restricciones de acumulación de capital y la mayor flexibilidad de su ingreso laboral. Los resultados evidencian que la respuesta de política monetaria depende de las características de los migrantes y del mercado laboral. Una entrada de trabajadores de baja(alta) productividad reduce(aumenta) los costos marginales, disminuye(incrementa) las expectativas de inflación y lleva al Banco Central a reducir(aumentar) la tasa de interés. El modelo se calibra para la economía colombiana y se usa para analizar un influjo migratorio de trabajadores venezolanos en un sector de salarios bajos y flexibles.

Palabras clave: modelo neoclásico, diferenciales salariales, mercados informales de trabajo, migración, política monetaria

Clasificación JEL: E13, J31, J46, J61, E50

1 Introduction

Between 2014 and 2019, around 5 million people emigrated from Venezuela due to the degradation of the social and economic conditions. This event has been described as the largest migratory movement in Latin America and one of the most important in the world due to the high number of migrants and its short span of duration (WorldBank (2018a)). Colombia has been the main receptor of this population given the proximity and the low mobility costs.[1] During this period 1.9 million migrants joined Colombian working age population (WAP) (5% of the WAP in 2019), and 1.3 million were employed (3.4% of the WAP), mainly in industries with low capital intensity, lack of formal labor contracts and low wages (*Migración Colombia* and National Statistics Department (DANE).

The economic literature has analyzed the effects of migration shocks on local labor markets, finding some positive effects on production and ambiguous responses of wages and employment (Borjas et al. (1997); Borjas (2003); Card & DiNardo (2000); Card (2001)). More recently, the literature has focused on other macroeconomic variables, such as production, consumption and investment,[2] but has remained silent about the effects on inflation, the output gap, and the role of monetary policy. However, migration may affect monetary policy through the output gap. For instance, the Central Bank of Chile, in its monetary policy report of June 2019, updated the projections for potential output including the effect of migration from Venezuela. The new projections highlighted a negative opening of the output gap, due to the slow adjustment of the economy to absorb the increase in the labor supply. This fact and other economic concerns motivated the central bank to lower its interest rate 50 basis points (CentralBankofChile (2019)).

From a central's bank perspective in a small open economy (SOE), migration inflows may affect the policy response through changes in inflation and the output gap. This paper provides a quantitative model to analyze the macroeconomic effects of a migration shock in a SOE, and its implications on monetary policy. We introduce a general equilibrium model with two population groups: formal and informal. The former are employed under rigid contracts and face no financial constraints; while the latter have flexible wages and are hand-to-mouth consumers. Workers also differ in their productivity levels.

We use the model to analyze the recent migration shock of Venezuelan workers to Colombia. First, we provide a characterization of migrants, and using a Bayesian Vector Autoregression (BVAR) analysis, we quantify and identify the effects of the Venezuelan migratory shock on the main macroeconomic variables. Secondly, we calibrate the model to reflect some

[1] Colombia and Venezuela share a terrestrial and fluvial border with seven official border crossing points and over a hundred underground border crossing trails that ease illegal immigration of more than 60% of the migrants.

[2] See Coleman & Landon-Lane (2007); Smith & Thoenissen (2019); Lozej (2019)

characteristics of the Colombian economy. Then, we consider that the economy receives an inflow of informal workers. The results show less than proportional increases in output, consumption and investment, implying reductions in per capita variables. The consumption and wage gaps between population groups increase, making the hand to mouth consumers relatively poorer.[3] The monetary policy response is expansionary and moderate, inflationary pressures are not strong enough because the new population is employed in a sector with flexible wages. As an alternative scenario, we analyze the effects of an inflow of formal workers. The aggregate effects in terms of output, consumption and investment are qualitatively similar to the previous case but stronger in magnitude. However, monetary policy responds more actively to control the inflationary pressures that arise from the nominal rigidities in the formal sector.

Our paper contributes to the economic literature that studies the macroeconomic effects of migration shocks and provides a novel tool to analyze the monetary authority response in a SOE. Most of the literature has focused on establishing a causal relationship between migration and labor market outcomes (see e.g. Borjas et al. (1997); Borjas (2003), Card & DiNardo (2000); Card (2001), and Kerr & Kerr (2011)). Theoretical studies argue that immigrants accept lower wages in comparison with local workers which raises firms' profits and boost job creations for both native and immigrants workers (see Battisti et al. (2018); Moreno-Galbis & Tritah (2016); Iftikhar & Zaharieva (2019)).

The macroeconomic effects of migration shocks have also been analyzed using VAR and general equilibrium models. On the empirical side Coleman & Landon-Lane (2007); Smith & Thoenissen (2019); Lozej (2019) find a positive effect on aggregate GDP, consumption and investment, while, Boubtane et al. (2012); Kiguchi & Mountford (2019) show that the effect on GDP per capita is ambiguous. Regarding theoretical models, Canova & Ravn (2000); Ben-Gad (2004); Hazari & Sgro (2003); Burda (2006); Palivos & Yip (2010) show that an immigration shock of low-skill workers has a positive effect on wages and employment of high-skill workers; and negative effects on wages, employment and welfare of low-skill workers. They also highlight that the degree of substitution between migrants and locals is a key determinant of the effects of immigration on wages, consumption and investment. Furthermore, Canova & Ravn (2000); Palivos & Yip (2010) show that in SOE immigration shocks rise the return of capital and widens the income gap between high and low skilled workers.

Becker & Ferrara (2019) argue that forced migration resulting from wars or civil conflicts affects local labor markets depending on the informality rate, labor complementarities, and labor productivity.[4] For Colombia, Calderón-Mejía & Ibáñez (2016); Morales (2018) analyze the internal migration resulting from the armed conflict, finding negative effects on unskilled wages in urban territories. Recently, the World Bank and the IMF studied the effects of Venezuelan

[3]Our results on real variables and the wage gap are similar to those reported in Canova & Ravn (2000).

[4]Venezuelan migration is close to forced migration due to the rapid and large number of people migrating and the lack of opportunities

migration on some Latin American Economies, (WorldBank (2018a,b); IMF (2019)), finding positive effects on GDP growth, and short-run pressures on public services and labor markets that could increase informality. Valencia et al. (2020) analyze the same migration process on Colombian fiscal variables.

Our paper contributes to the understanding of migration shocks in SOEs with fragmented labor markets and nominal rigidities. The rest of the paper is organized as follows: In the next section we introduce a general equilibrium model with formal and informal workers, we then extend the model to consider nominal rigidities and monetary policy. Section 3 characterizes the Venezuelan migration episode into Colombia between 2014 and 2019. In Section 4, we calibrate the model for the Colombian economy and analyze the effects of a migration shock on macroeconomic variables and the monetary policy response. The final section concludes.

2 Model

In this section we develop a SOE model to understand the main transmission mechanisms of a permanent migration shock and its effects on monetary policy through changes in inflation and the output gap. To this end, we first consider a model with a fragmented labor market and no nominal rigidities. Then, we extend it to include nominal rigidities and a central bank that conducts monetary policy according to a standard Taylor rule.

2.1 Small Open Economy with a fragmented labor market

The model considers an economy populated by two groups of households, that differ in their capital and firm's ownership, labor productivity and access to financial markets. On the production side, a representative firm uses capital and labor to produce final goods that are allocated into consumption, investment and net exports.

We assume that the economy is populated by two groups of agents: *Formal (F)* and *Informal (I)*. Formal agents have an exogenous mass of N_F individuals, they consume c_F, provide formal hours h_F, own capital k_F, make investment decisions i_F, have access to international financial markets, and get any profits from the firms Π_t.

The optimization problem of a representative formal agent is given by:

$$\max_{c_F, i_F, h_F, k_F, d_F} \quad \sum_{t=0}^{\infty} \beta^t \left(\frac{c_{F,t}^{1-\sigma}}{1-\sigma} - \frac{\eta_F}{\eta_F - 1} h_{F,t}^{\frac{\eta_F - 1}{\eta_F}} \right) \tag{1}$$

subject to her budget constraint, capital law of motion, and debt-elastic foreign interest rate (equations 2 to 4).[5]

[5]The debt-elastic interest rate follows Schmitt-Grohé & Uribe (2003).

$$P_t(c_{F,t} + i_{F,t}) + R_t^* d_{F,t+1} = W_{F,t} h_{F,t} + R_t k_{F,t} + d_{F,t} + \Pi_t / N_{F,t} \tag{2}$$

$$k_{F,t+1} = (1-\delta)k_{F,t} + i_{F,t} - \frac{\phi}{2}\left(\frac{i_{F,t}}{i_{F,t-1}} - 1\right)^2 \tag{3}$$

$$R_t^* = (R^*\mu)^{\phi_d exp\left(\frac{D_t}{Y_t} - \overline{D}_Y\right)} \tag{4}$$

From the first order conditions (F.O.C.) we find the usual relations for marginal rate of substitution between leisure and consumption (equation 5) and the Euler equations of capital and foreign bonds (equations 6 and 7).

$$\frac{h_{F,t}^{-1/\eta_F}}{c_{F,t}^{-\sigma}} = \frac{W_{F,t}}{P_t} \tag{5}$$

$$c_{F,t}^{-\sigma} = Q_t \left(1 - \frac{\phi}{2}\left(\frac{i_{F,t}}{i_{F,t-1}} - 1\right)^2 - \phi\left(\frac{i_{F,t}}{i_{F,t-1}} - 1\right)\frac{i_{F,t}}{i_{F,t-1}}\right) + \beta E_t Q_{t+1}\phi\left(\frac{i_{F,t+1}}{i_{F,t}} - 1\right)\frac{i_{F,t+1}}{i_{F,t}} \tag{6}$$

$$c_{F,t}^{-\sigma} = \beta E_t c_{F,t+1}^{-\sigma} R_{t+1}^* \tag{7}$$

where $Q_t = \beta E_t\left(c_{F,t+1}^{-\sigma} R_{t+1} + Q_{t+1}(1-\delta)\right)$, $d_{F,t}$ is foreign bonds, R_t^* the debt-elastic interest rate, $W_{F,t}$ the wage of formal workers, R_t and P_t are the prices of capital and final goods (consumption and investment), respectively, D_t is the aggregate level of bonds ($N_{F,t}d_{F,t}$), and Y_t is the level of GDP. The list of the parameters of the model can be found on table 1.

Parameter	Definition	Parameter	Definition
σ	Intertemporal elasticity of substitution	$\overline{D}_Y$	Debt over GDP
β	Discount factor	χ_I	Preference for labor (I)
η_F	Inverse of Frisch elasticity (F)	α	Capital share in production
η_I	Inverse of Frisch elasticity (I)	ν	Factor bias (F) labor
δ	Depreciation of capital	ξ	Elasticity of substitution (labor)
ϕ	Investment adjustment costs	$\overline{A}$	Long run productivity
R^*	Long run foreign interest rate	$\overline{N}_F$	Initial mass of (F) agents
μ	Foreign interest rate premium	$\overline{N}_I$	Initial mass of (I) agents
ϕ_d	Elasticity of foreign interest rate		

Table 1: List of Parameters

On the other hand, informal agents are an exogenous mass of N_I *hand to mouth* individuals. They consume c_I, provide informal labor hours h_I and receive a labor income

$W_I h_I$, where W_I is the informal wage. They do not have access to foreign financial markets or capital ownership.

The optimization problem of a representative informal agent is static and given by:

$$max_{c_I, h_I} \quad \left(\frac{c_{I,t}^{1-\sigma}}{1-\sigma} - \chi_I \frac{\eta_I}{\eta_I - 1} h_{I,t}^{\frac{\eta_I - 1}{\eta_I}} \right) \tag{8}$$

subject to

$$P_t c_{I,t} = W_{I,t} h_{I,t} \tag{9}$$

From the F.O.C we find the optimal allocation between consumption and leisure for informal agents:

$$\chi_I \frac{h_{I,t}^{-1/\eta_I}}{c_{I,t}^{-\sigma}} = \frac{W_{I,t}}{P_t} \tag{10}$$

Combining equations 9 and 10, we can re-write informal labor supply as a function of the real wage. The labor-wage elasticity depends on the sign of $\sigma_I = \frac{(1-\sigma)\eta_I}{\eta_I \sigma - 1}$. If $\sigma_I < 0$ there is a negative relationship between wages and hours, meaning that a drop in wages force informal workers to supply more hours.

$$h_{I,t} = \left(\frac{1}{\chi_I} \right)^{\frac{\eta_I}{\eta_I \sigma - 1}} \left(\frac{W_{I,t}}{P_t} \right)^{\frac{(1-\sigma)\eta_I}{\eta_I \sigma - 1}} \tag{11}$$

On the production side, we assume perfect competitive firms that use the aggregate levels of capital K_t, formal and informal labor, $L_{F,t}$ and $L_{I,t}$ respectively, to produce a homogeneous final good that is allocated into total consumption and investment. We consider a constant elasticity of substitution (CES) production function to aggregate formal and informal labor inputs (Lewis & Peri (2015). Following Fallon & Layard (1975), Krusell et al. (2000) and Canova & Ravn (2000) we define the production technology of the representative firm by:

$$Y_t = A_t K_t^{\alpha} \left(\left(\nu^{\frac{1}{\xi}} (L_{F,t})^{\frac{\xi - 1}{\xi}} + (1-\nu)^{\frac{1}{\xi}} (L_{I,t})^{\frac{\xi - 1}{\xi}} \right)^{\frac{\xi}{\xi - 1}} \right)^{1-\alpha} \tag{12}$$

where the aggregate levels of capital, formal and informal labor are: $K_t = N_{F,t} k_{F,t}, L_{F,t} = N_{F,t} h_{F,t}, L_{I,t} = N_{I,t} h_{I,t}$, respectively.

The representative firm maximizes profits according to:

$$max_{K_t, L_{F,t}, L_{I,t}} \Pi_t = P_t Y_t - W_{F,t} L_{F,t} - W_{I,t} L_{I,t} - R_t K_t \tag{13}$$

yielding the optimal allocations for factors of production

$$W_{F,t} = (1-\alpha) \nu^{1/\xi} Y_t L_t^{\frac{1-\xi}{\xi}} L_{F,t}^{1/\xi} \tag{14}$$

$$W_{I,t} = (1-\alpha)(1-\nu)^{1/\xi} Y_t L_t^{\frac{1-\xi}{\xi}} L_{I,t}^{1/\xi} \tag{15}$$

$$R_t = \alpha \frac{Y_t}{K_t} \tag{16}$$

where

$$L_t = \left(\nu^{\frac{1}{\xi}} (L_{F,t})^{\frac{\xi-1}{\xi}} + (1-\nu)^{\frac{1}{\xi}} (L_{I,t})^{\frac{\xi-1}{\xi}} \right)^{\frac{\xi}{\xi-1}} \tag{17}$$

Aggregate equilibrium implies that total output is allocated into formal and informal consumption, investment and net exports $Y_t = C_{F,t} + C_{I,t} + I_t + NX_t$, where the aggregate levels of consumption, investment and net exports are defined by $C_{F,t} = N_{F,t} c_{F,t}, C_{I,t} = N_{I,t} c_{i,t}, I_t = N_{F,t} i_{F,t}$ and $NX_t = d_{F,t+1} N_{F,t} - R_t^* d_{F,t} N_{F,t-1}$, respectively. The exogenous processes for the productivity and the masses of agents are given by $A_t = (1-\rho_A)\overline{A} + \rho_A A_{t-1} + \epsilon_{A,t}, N_{F,t} = \overline{N}_F + \epsilon_{F,t}$ and $N_{I,t} = \overline{N}_I + \epsilon_{I,t}$, respectively. In each case, $\epsilon_{i\in\{A,F,I\},t}$, represents an exogenous shock.

2.2 Small Open Economy with Nominal Rigidities

We extend the previous model to include price and formal wage rigidities while we hold the flexibility on informal wages. Finally we include a monetary authority whose role in the short-run adjustment of the economy becomes relevant given the slow adjustment of the nominal variables. We decided to include wage rigidities only on the formal agents in order to capture some characteristics of the Colombian labor market. In particular, we aim to reflect the fact that formal wages face institutional arrangements constraints (*e.g.* minimum wage) that do not allow immediate adjustments, while the wages on the informal sectors are freely negotiated and adjust faster. It is worth mentioning that the classification of formal and informal agents acquires more relevancy in the characterization of the economy relative to the model presented in the previous section.

The optimization problem of the formal agents differs with the model presented in the previous section on the decision of formal labor providing (h_F). We introduce a wage setting problem Erceg et al. (2000), in which the formal households are hired by a labor union (or intermediary firm) which operates in a perfectly competitive environment and offer differentiated labor in a monopolistically competitive labor market. The market power allows the formal agents to set their wage when they receive a random signal, $(1-\epsilon^{W_F})$, capturing a slower adjustment on formal wages. The labor union (or intermediary firm) combines the work effort of the formal agents and supplies a labor input (h_F). Formally, the demand for labor and the wage index each formal agent j faces are given by,

$$h_{F,t}(j) = \left(\frac{w_{F,t}(j)}{w_{F,t}}\right)^{-\theta^{W_F}} h_{F,t} \tag{18}$$

$$w_{F,t} \equiv \left[\int_0^1 w_{F,t}(j)^{1-\theta^{W_F}} dj\right]^{\frac{1}{1-\theta^{W_F}}} \tag{19}$$

Thus, the formal agents optimally set their wage each quarter with probability $(1 - \epsilon^{W_F})$ seeking to maximize their expected utility 1 subject to the budget constraint,

$$P_t(c_{F,t} + i_{F,t}) + R_t^* d_{F,t+1} + R_t^b b_{F,t+1} = W_{F,t} h_{F,t} + R_t k_{F,t} + d_{F,t} + b_{F,t} + \Pi_t / N_{F,t} \tag{20}$$

which shares a similar structure as the one presented in equation 2 with the exception that in this setup the formal agents have access to a domestic financial market, as it will be explained below. In this setup the formal agents take into account the probability that would not readjust the wage in the future. As a consequence, all the formal agents who are able to adjust, will choose the same wage. For those formal agents without the optimal adjustment possibility, the wage is adjusted in line with the dynamic of the previous period inflation, π_{t-1},

$$w_{F,t}^{rule}(j) = w_{F,t-1}(j) \frac{1 + \pi_{t-1}}{1 + \pi_t} \tag{21}$$

which entails that the aggregate formal wage is described by,

$$w_{F,t} = \left[\epsilon^{W_F} \left(w_{F,t-1} \frac{1 + \pi_{t-1}}{1 + \pi_t}\right)^{1-\theta^{W_F}} + \left(1 - \epsilon^{W_F}\right) \left(w_{F,T}^*\right)^{1-\theta^{W_F}}\right]^{\frac{1}{1-\theta^{W_F}}} \tag{22}$$

Finally, an additional channel in this setup is that the formal agents are able to smooth consumption by acquiring bonds domestically, $b_{F,t+1}$ as it was shown in equation 20. In this case, the household equilibrium condition is given by

$$c_{F,t}^{-\sigma} = \beta E_t c_{F,t+1}^{-\sigma} R_{t+1}^b \tag{23}$$

where R_{t+1}^b is the expected real return of domestic bonds, which is described by a Fisher equation $R_t^b = \frac{1+i_t}{1+E_t\pi_{t+1}}$, where i_t is the short-run nominal interest rate set by the Central Bank and $E_t\pi_{t+1}$ the expected inflation one quarter ahead. The remaining decisions presented in the previous section are kept unchanged and are described by equations 6 to 7.On the other hand, maintaining the informal wage adjustment flexibility assumption presupposes that the optimization problem of the informal agents is the same as the one described in the previous section by equations 8 to 10. With regard to the production, we break the price flexibility assumption by including rigidities *a lá* Calvo (1983). The inclusion of price rigidities implies breaking the assumption of the perfect competitive firms in order to include some

market power in a monopolistically competitive environment. We modify the production side problem as follows. We assume that there is a continuum of firms indexed by $m \in (0,1)$, each of them produces a differentiated product $y(m)$ sold at price $p(m)$ which is able to be adjusted optimally with a random signal. As in the previous section each firm combines capital (K_t), formal ($L_{F,t}$) and informal ($L_{I,t}$) labor when carrying on production. In this specification, each firm faces two problems: the demand of productive factors decision problem and the output price choice problem.

With regard to the first, each firm solves the cost minimization problem, where the optimal allocations for factors arise and are those described by equations 14 to 17. It is worth recalling that the firms demand the labor factor to the labor union (or intermediary firm) and the wage is subject to the nominal wage rigidities exposed above. On the other hand, the price setting problem entails that each firm m faces a demand curve of the form:

$$y_t^s(m) = \left(\frac{p_t(m)}{p_t}\right)^{-\theta^Y} y_t^d \tag{24}$$

Where,

$$y_t^d = \left[\int_0^1 (y_t^s(m))^{\frac{\theta^Y}{\theta^Y-1}}\, dm\right]^{\frac{\theta^Y-1}{\theta^Y}} \tag{25}$$

is the gross output demand, and

$$p_t = \left[\int_0^1 (p_t(m))^{1-\theta^Y}\, dm\right]^{\frac{1}{1-\theta^Y}}, \tag{26}$$

is the aggregate price. As in the wage setting problem, in the firms' price setting we assume that in each period firms face a constant probability $(1-\epsilon^Y)$ of receiving a random signal that allows them to adjust their price optimally. Each adjusting firm chooses the same optimal price, p_t^*, so that it expected profits will be maximized. The remaining firms set their price according to a rule described by

$$p_t^{rule}(m) = p_{t-1}(m)(1+\pi_{t-1}) \tag{27}$$

Thus, the inflation is given by

$$(1+\pi_t) = \left[\left(1-\epsilon^Y\right)\left(\frac{p_t^*}{p_t}\right)^{1-\theta^Y}(1+\pi_t)^{1-\theta^Y} + \epsilon^Y(1+\pi_{t-1})^{1-\theta^Y}\right]^{\frac{1}{1-\theta^Y}} \tag{28}$$

With this setup, we can distinguish two blocks in the model. The first is a block in which the agents (formal and informal) in the economy face nominal rigidities on prices and the formal agents on wages. In this block both nominal and real shocks affect the dynamics

in the model and the monetary policy plays an active role on the adjustment of the variables, as it will be illustrated below. The second block corresponds to the economy in absence of nominal rigidities (both on prices and wages), where only real shocks affect the dynamic of the variables. It is worth remarking two aspects of this latter block. First, the monetary policy does not play an active role on the adjustment of the variables as the prices and wages adjust immediately. Second, even if the nominal rigidities do not exist in this block, there still exists a market power of the firms which implies that the optimal price is affected by a constant markup. This characteristic makes the non-rigidities block of the model slightly differ from the one presented in the previous section. Distinguishing the two blocks of the model will be specially important when describing the role of the monetary policy.

As a consequence of the nominal rigidities we include a Central Bank whose role is to conduct the monetary policy by setting the short-run nominal interest rate, i_t, reacting to fluctuations in inflation and output by following a simple-standard Taylor (1993) rule:

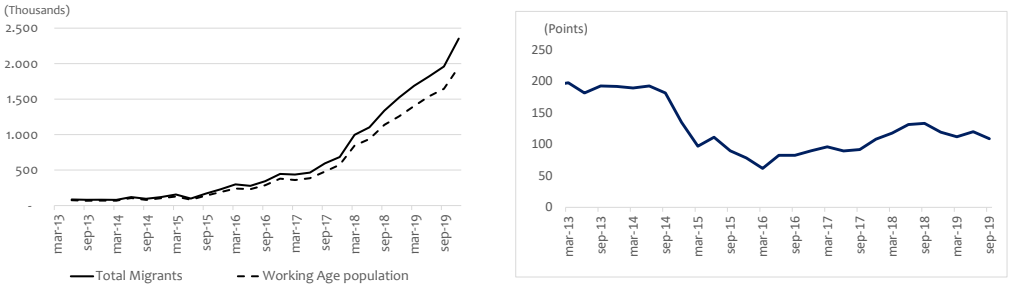
$$i_t = \rho^i i_{t-1} + \left(1-\rho^i\right)\left(\bar{i} + \varphi^\pi\left(\pi^4_{t+3} - \bar{\pi}\right) + \varphi^Y\left(Y_t - Y_t^{flex}\right)\right) + \varepsilon^i_t \tag{29}$$

where ρ^i refers to smoothing parameter of the the short-run nominal interest rate and is the long-run steady state value of the nominal interest rate, which refers to a situation in which both output and inflation are in their long-run values. The Central Bank's response to the inflation expectations deviations from its target, $\pi^4_{t+3} - \bar{\pi}$, is determined by the parameter φ^π. The response to the output is described by deviations of the output with nominal rigidities on prices and wages, Y_t from the allocation of the output in absence of nominal rigidities but in presence of monopolistic competition, Y_t^{flex}, known in the literature as the output gap. Finally, the last term, ε^i_t describes an exogenous process which allows for deviations of the nominal interest rate from the interest rate dictated by the rule.

The short-run nominal interest rate set by the Central Bank includes an additional channel of consumption smoothing for the formal households as is the possibility of acquiring domestic bonds. In this case the monetary policy affects the formal consumption by its intertemporal substitution direct effect. It is worth remarking that the formal households decision of domestically versus international indebtedness is guided by an uncovered interest parity relation which arises between the domestic and international bond equilibrium allocations.

3 Migration from Venezuela to Colombia (2014-2019): Characterization & Effects

Venezuela's migration started in 2014 and by the end of 2019, 2.4 million people had migrated to Colombia[6]. As seen in Figure 1 migration accelerated in 2017, coinciding with the drop in the international oil prices and the deepening of the economic crisis in Venezuela. Migrants and Colombian residents differ mainly three characteristics: 1) migrants participate relatively more in the labor market (WAP: 84% vs 80%), 2) they are younger (27% vs 32%), and 3) their occupation rate is higher (72% vs 59%). On the other hand, migrants face more difficulties finding a formal job. To argue this, we provide three facts. First, they are primarily employed in activities that have been traditionally characterized by a low capital intensity and a high informality rates, and their participation in commerce and construction is relatively high (Figure 2).[7] Second, nearly 90% of migrants do not contribute to social security; and third, more than 60% of migrants earn less than the minimum wage.



(a) Migrants and WAP.

(b) Oil price Index.

Figure 1: Migration and Oil price

Source: GEIH, Banco de la República, and authors calculations.

Low migrant's earnings combined with the uncertainty about their situation and their consumption needs limit their ability to save and their access to financial markets. Theses conclusions are not surprising given that only 42% of the migrants have a legal status in Colombia, that means that the big majority of the migrants cannot open a bank account nor qualify for public assistance programs. These facts characterize the migrants are key to understand that they will affect a special segment of the population, that is, migrants are going to work in an informal sector and they will have limited decisions.

[6]We consider migrants all the respondents of the GEIH that reported to live in Venezuela five years ago

[7]Retail trade, restaurants and hotels, communal services and Private services, and the building industries

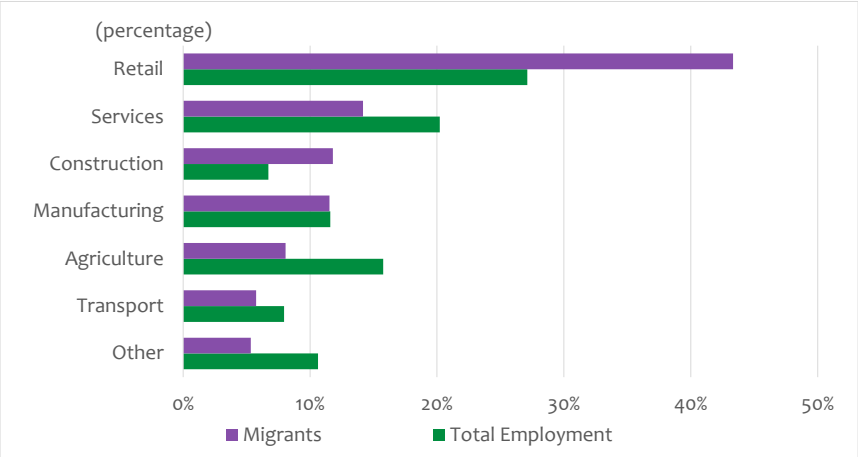


Figure 2: Total employment and migrants by economic sector
Source: GEIH, author's calculations.

In order to analyze the effect of migration on the Colombian economy we divide workers in the Colombian labor market into *informal* which refer to those workers with earnings lower than 1.1 minimum wage and *formal* with earnings above this threshold.[8] Using this criteria we find that between 2014 and 2019, 56.7% of the Colombian workers are informal, with earnings that corresponds to the 21.3% of the total labor income, and the hourly wage ratio between formal and informal is 3.7.

To characterize the effects of the recent migratory shock on the main Colombian macroeconomic variables, we use a Bayesian model of autoregressive vectors (BVAR). [9] We specify the econometric model in quarterly periodicity for the period 2010q1-2019q3, the widest time window allowed by the available data, incorporating eight variables and two lags.[10] In the

[8]Thresholds around the minimum wage can be understood as a measure of its compliance, given that in household surveys wages are directly reported by workers. However, they can report different values to the same question. For instance, their answer may reflect the actual amount of money they receive, that is their wage minus social security contributions paid by the employee, which in Colombia is around 90% of the wage. Another possible answer might be the wage stated in their verbal or written contract, and a third option might be their monthly wage plus transport subsidy, which is a compulsory cost for minimum wage workers and is around 10% of the minimum wage. We compute hourly wage dividing the monthly wage computed previously by the hours worked last week.

[9]Examples of the use of structural VAR models to study the effects of migration are found in Boubtane et al. (2012), Coleman & Landon-Lane (2007), D'Albis et al. (2017), Furlanetto & Ørjan Robstadb (2019), Kiguchi & Mountford (2019), Partridge & Rickman (2006) and Smith & Thoenissen (2019).

[10]The number of lags was determined largely to limit the number of parameters to be estimated given

choice of variables, and later in the identification strategy, we took into account the condition of Colombia as a SOE. Therefore, on the one hand, the BVAR(2) includes domestic variables such as real GDP, core inflation, unemployment rate, remittances in real terms and the ratio between formal and informal workers' wages. On the other hand, the model also includes foreign variables, considered exogenous in the model, such as the real GDP of Colombia's main trading partners and the real price of oil.

The selection of the variables seeks to model, in addition to the interrelations between the main macroeconomic variables, two noteworthy stylized facts observed recently. First, the clear synchrony between the fall in oil prices, the slowdown in trade partners, the first substantial increase in migration from Venezuela and the growth in international remittances that took place in the period 2014-2017. Second, the break, in early 2018, of the declining trend in the ratio of formal to informal wages, which coincides with the increased rate of migration to Colombia (Figure 10 in the appendix).[11]

Given the large number of parameters to be estimated and the relatively low number of observations, we opted for a Bayesian estimation using normal-diffuse priors. Using these priors allows the likelihood of the data to dominate the estimation process. We specify all variables in levels since with the Bayesian methodology the results are valid regardless of the presence of non-stationarity in the series.[12] Except for the unemployment rate and annual core inflation, which enter the VAR in percentage points (pp), we take the natural logarithm of the other series and correct the unemployment rate and real remittances for seasonal effects. The identification of the shocks was achieved through the Cholesky decomposition, in which the most exogenous variables were ordered first. Figure 10 in Appendix A.2 shows the variables in the implemented order. Finally, and to complement the assumption of Colombia as a small and open economy, we imposed exogeneity for migration, real GDP of the main trading partners and the real price of oil, by means of block exogeneity.[13]

Figure 3 shows the response of the main variables to a shock corresponding to a 10% increase in the migrant population in a quarter, which is approximately equivalent to the arrival of 200,000 people in that period. In the figure, the responses according to the model without sign restrictions (unconditioned model) are shown in blue; those according to the model with positive sign restriction for unemployment (conditioned model) are shown in red. The responses of the annual basic inflation and the unemployment rate are expressed in basis points (bp), while

the relatively low number of observations available. The AIC criterion supports the use of two lags in the specification.

[11] As usual, the BVAR includes constants in all its equations. Appendices A.1 and A.2 show a detailed description of the variables included as well as their behavior over time.

[12] See Sims (1988) and Sims & Uhlig (1991).

[13] We use the standard priors in the literature, namely: autoregressive coefficient, 0.8; overall tightness 0.1; cross-variable weighting, 0.5; lag decay, 2; exogenous variable tightness, 100 and block exogeneity shrinkage, 0.001. For the estimations we used 4000 iterations with 2000 burn-it iterations.

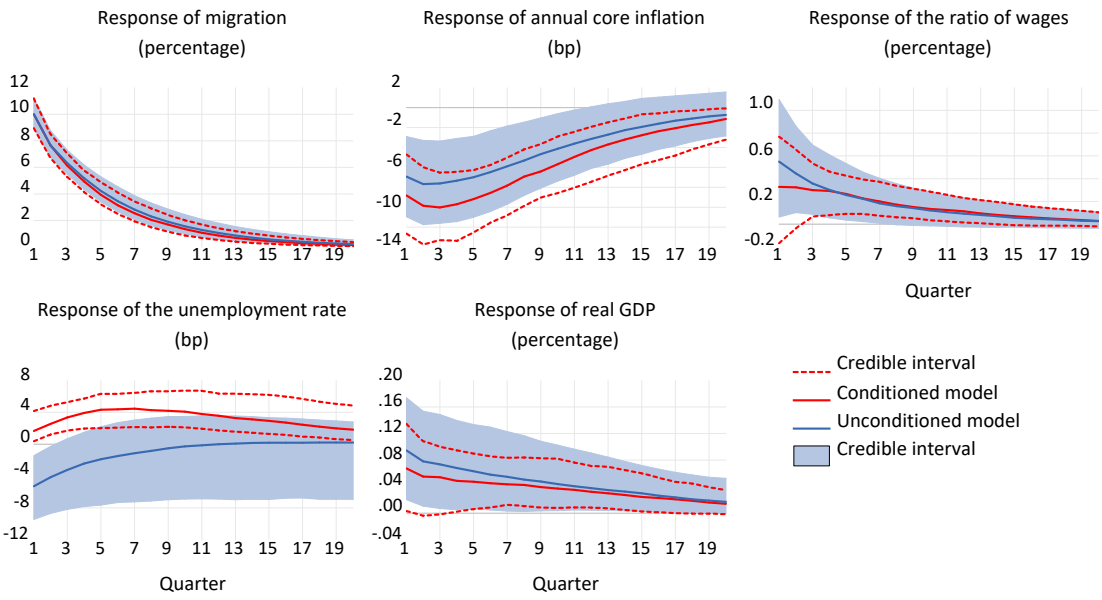


Figure 3: Responses to a 10% migration shock. Unconditioned and conditioned models

Note: The results correspond to the responses to a migration shock of 10% in a quarter in a BVAR(2) model, using the Cholesky identification and imposing block exogeneity. The blue lines represent the responses in the unconditioned model. The red lines represent the responses in the conditioned model imposing a positive sign restriction on the unemployment response. Credible intervals at 65%.

those of the rest of the variables are expressed in percentage points.

As we can see, the migration shock is highly persistent, since its effects on the migrant population only disappear after about five years following the shock. Focusing, for the time being, on the unconditioned model, Figure 3 shows that the high persistence of the migratory shock is also clear in the response of real GDP. In this case we find that the increase in migration raises real GDP by almost 0.1% on impact and its effects can be felt even 17 quarters later. In fact, even two years after the occurrence of the shock, real GDP is about 0.05% higher than on impact. The increase in real GDP is accompanied by a reduction in the unemployment rate of 5.3 bp on impact, but contrary to the dynamics observed for real GDP, the decline in unemployment lasts only two quarters. We will investigate this apparently counter-intuitive positive response of unemployment below. The wage gap between formal and informal workers increases by 0.6% and remains positive for almost two years, thus corroborating that migrants tend to enter the informal sector, as we mentioned in Section 3, downward pressuring wages in that sector. Finally, Figure 3 shows that the migration shock generates a decrease in annual core inflation of almost 7 bp. This decrease in inflation, which could be associated with a reduction in labour costs through lowering the wages of informal workers, lasts three years.[14]

Given that the arrival of working-age migrants would be expected to increase the

[14]In annualized terms, the increases in real GDP and the wage gap are 0.38% and 2.2% respectively.

number of people seeking employment, and that the economy would not be able to immediately absorb this influx of workers, the aforementioned drop in the unemployment rate following the migration shock seems counter-intuitive.[15] To explore the robustness of the results we estimate the BVAR(2) by imposing sign restrictions à la Arias et al. (2018), conditioning the unemployment rate to increase at the time of the impact of the migration shock, as intuition suggests.

The red lines in Figure 3 show that the sign restriction does not significantly change the response of the unconditioned variables to the migration shock. The effect on unemployment, positive by construction, is still small on impact (around 2 bp) but now shows greater persistence with a response that remains active even after 5 years. Regarding real GDP, the increase on impact is 0.07%, slightly lower in comparison but with similar dynamics to that observed in the unconditioned model. The wage gap between formal and informal workers increases by 0.3% on impact, but given that the credible interval includes zero, it is reasonable to conclude that this response is only observed with a lag of two or three quarters. Its persistence, however, is like that found in the unconditioned model.[16] The response of annual core inflation in the conditioned model is again negative although slightly higher (8.8 bp) and shows greater persistence as the effect of the migration shock survives for five years. In summary, an increase in the working-age migrant population leads to an increase in real GDP growth and in the wage gap between formal and informal labor, a reduction in core inflation, and a negligible effect on the unemployment rate.

4 Application: The Colombian case

The model described in section 2 captures some characteristics of the recent migration episode from Venezuela to Colombia. In particular, the fact that migrants earn low wages and have limited options to save and invest.[17] In this section we calibrate the model to replicate some aggregate moments of the Colombian economy and analyze the macroeconomic effects of a migration inflow of informal workers.

The periodicity of the model is quarterly and most of the parameters are taken from the literature; in particular, from models used for policy analysis in Colombia. Table 2 presents the values and sources of the parameters. To find the equilibrium we normalize the price of

[15]It should be noted that Furlanetto & Ørjan Robstadb (2019), Peri (2012), Armstrong & McDonald (2016) and D'Albis et al. (2018) also found a drop in the unemployment rate after a migration shoc k, in a similar context to this document, for Norway, US, New Zealand and France, respectively.

[16]In annualized terms, the increases in real GDP and the wage gap are 0.27% and 1.32% respectively.

[17]The migration status, the lack of a domestic credit score, or a stable source of income are constraints that limit the access of migrants to formal banking. In order to provide credit, commercial banks in Colombia asks for official identification documents and a credible collateral. Most of the migrants don't fulfill these conditions.

final goods to 1, meaning that all the prices are expressed in terms of final goods. We pick the productivity level ($\overline{A}$) to normalize GDP to 1 in the steady state. Also, we normalize the mass of formal agents to 1 ($\overline{N}_F = 1$) and set the debt to GDP ratio to 50% ($\overline{D}_Y = -50\%$).

Parameter	Value	Source	Parameter	Value	Source
σ	1.1	GMPR	$\overline{D}_Y$	50%	Calibrated
β	0.9878	GMPR	χ_I	3.13	Calibrated
η_F	3.7	WR	α	0.32	GMPR
η_I	2.5	WR	ν	0.73	Calibrated
δ	2.5%	GMPR	ξ	0.8	KORV
ϕ	3.25	GMPR	$\overline{A}$	0.32	Calibrated
R^*	1.0086	GMPR	$\overline{N}_F$	1.0	Calibrated
μ	1.0037	GMPR	$\overline{N}_I$	1.33	Calibrated
ϕ_d	0.01	GMPR			

Table 2: Parameters. Small Open Economy. GMPR stands for González et al. (2011); WR for Whalen & Reichling (2017); and KORV for Krusell et al. (2000)

Given the characteristics of the model other parameters are calibrated to target some particular moments of the Colombian economy, such as: 1) the relative mass of formal workers ($N_F/(N_F + N_I) = 0.43$); 2) the wage premium of formal agents ($W_F/W_I = 3.71$); and 3) the share of labor income of formal agents ($W_F L_F/(W_F L_F + W_I L_I) = 0.78$). To match these targets we choose three parameters that speak directly to the moments: 1) the mass of informal agents $\overline{N}_I$; 2) the factor bias for formal labor in the production of final goods ν; and 3) the scale parameter related to the preference for labor of informal agents χ_I.

A couple of things are worth noticing from the calibration and the values of some parameters. First, the elasticity of substitution between formal and informal labor in the production of final goods is $\xi = 0.8$, this value is taken from Krusell et al. (2000) and means that the two types of labor are more complementary than substitutes; in other words, increasing the amount of one type of labor is going to increase the productivity of the other. Second, the factor bias for formal labor is $v = 0.73$, which implies that firms use more intensively formal workers than informal workers. This also means that formal workers are more productive, since one additional unit of formal labor has a bigger effect on production. Third, the Frisch elasticity of informal workers is lower than the one of formal workers, meaning that they respond less to a given change in wages. Finally, by assumption from the Cobb Douglas production function in capital and the compound of labor, we have that any increase in one of the factors is going to increase the productivity of the other.

4.1 Change in the mass of informal population

As already mentioned in section 3 most of the recent migrants from Venezuela have been employed in sectors with high rates of informality and earn low wages. Given these characteristics, in this section we analyze the effects of a permanent increase in the mass of informal agents. Specifically, we consider an initial increase of 5% that grows linearly during the next two years to reach a total raise of 10%. The first panel on the top left of figure 4 plots the behavior of informal, formal and total populations after the shock. In this figure we also plot the main macroeconomic aggregates of the economy during the transition to the new equilibrium.

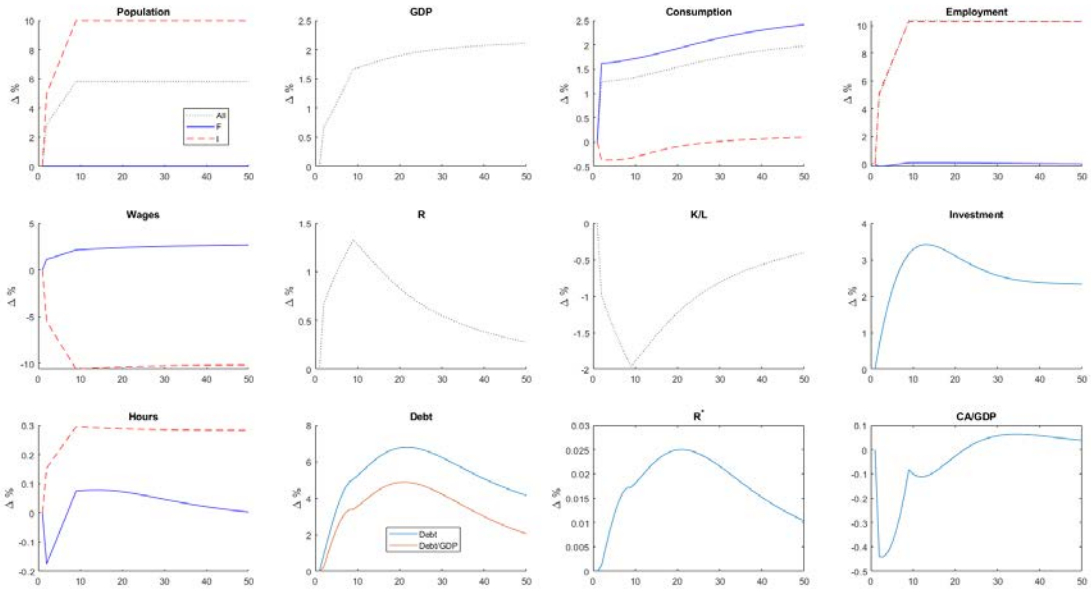


Figure 4: Aggregate effects of a permanent shock in the informal population. Percentage changes from the initial steady state.

To understand the effects of the shock we first need to focus on the labor market of informal agents. An increase in the mass of informal population raises the supply of this kind of labor and reduces its wage. Cheaper informal labor allows firms to produce more. Since the two types of labor are imperfect complements, firms increase the demand for formal workers, pushing their wages up, as seen in figure 4. Higher labor, formal and informal, reduce the capital-labor ratio and increase the marginal productivity of capital, which translate into higher prices of capital. This also incentives formal consumers to invest more during the transition. Since formal consumers own the capital, they not only benefit from higher wages, but also from the higher price of capital. This allows them to consume more and reduce their labor supply in the short run.[18] On the other hand, due to the drop in wages, informal agents consume less and increase their individual supply of labor, which decreases their wages even more. The

[18]The effects on labor supply are small.

overall effect on consumption is positive. To sum up, a permanent increase in the informal population has a positive effect on GDP, Consumption, and Investment; and a negative effect on two measures of inequality: wage and consumption dispersion increases after the shock. In terms of foreign outcomes, formal consumers smooth their consumption and finance part of the investment decisions by borrowing from abroad. This increases the debt to GDP ratio and the trade deficit in the short run.

Even-though the migration shock has a positive effect on aggregate outcomes, per-capita variables behave differently due to the re-composition of population that comes out of the shock. For instance, if we look at figure 4 carefully, we can see that GDP increases less than total population, both in the short and in the long run. This means that, relative to the initial equilibrium, GDP per person falls not only on impact, but also in the new equilibrium. The initial drop comes from the fact that capital is fixed in the short and production cannot respond symmetrically to the increase in the number of informal agents, specially, when the formal workers are supplying marginally less labor, and the production function implies decreasing returns to scale with respect to one factor (holding everything else constant).

On the other hand, the long run reduction in the per-capita GDP can be explained using some properties of the production function. The first thing we know is that due to constant returns to scale and constant factor shares, from the Cobb Douglas assumption, the capital-labor ratio (K/L) in the new equilibrium has to be the same as in the initial steady state. Here, the relevant labor for K/L is the compound of the two types of workers, as in equation 17. This implies that:

If we decompose the growth of L from the initial steady state to the new equilibrium we find that:

$$\frac{\Delta L}{L_0} \approx \left(\left(\frac{\nu}{1-\nu} \right)^{1/\xi} \left(\frac{N_{F,0} h_{F,0}}{N_{I,0} h_{I,0}} \right)^{\frac{\xi-1}{\xi}} + 1 \right)^{-1} \frac{\Delta N_I}{N_{I,0}} \approx 2.2\% \tag{30}$$

which is close enough to the long run change in GDP with respect to the initial equilibrium, see figure 4. Similarly we can approximate the population growth by:

$$\frac{\Delta N}{N_0} \approx \frac{N_{I,0}}{N_0} \frac{\Delta N_I}{N_{I,0}} \approx 5.8\% \tag{31}$$

Using these relations we find that the drop in GDP per capita from the initial equilibrium to the final one is around 3.6%. Finally, notice that the effect on the GDP per capita depends on the comparison between the following terms:

$$\left(\left(\frac{\nu}{1-\nu} \right)^{1/\xi} \left(\frac{N_{F,0} h_{F,0}}{N_{I,0} h_{I,0}} \right)^{\frac{\xi-1}{\xi}} + 1 \right)^{-1} \quad vs \quad \frac{N_{I,0}}{N_0}$$

According to the initial calibration, the relative employment of the two types of labor

is close to one, $L_{F,0}/L_{I,0} = 0.96$, which implies that the value on the left hand side depends mainly on the factor bias for formal labor, ν ,and the elasticity of substitution between the two types of labor, ξ. Since the latter is smaller than 1 it scales up the effect of the factor bias. Under the current set up, GDP per capita falls because the economy is increasing the type of labor that uses less intensively.

4.2 Migration with Nominal Rigidities

In addition to the parameters of the model presented in the previous section (see table 2), we include the parameters related to the formal agents' wage setting problem, the firms' price setting problem and the Central Bank's monetary policy Taylor rule (see table 3).

Parameter	Definition	Value	Source
$\bar{\pi}$	Inflation target	0.03	GMPR
θ^{W_F}	Elasticity of substitution between formal labor varieties	2.00	GMPR
1-ϵ^{W_F}	Wages adjustment probability	0.25	Calibrated
θ^{Y}	Elasticity of substitution between product varieties	12.1	Calibrated
1-ϵ^{Y}	Prices adjustment probability	0.25	Calibrated
ρ^{i}	Smoothing parameter in Taylor rule	0.70	Calibrated
φ^{π}	Taylor rule elasticity to deviations of inflation from target	4.50	Calibrated
φ^{Y}	Taylor rule elasticity to output gap fluctuations	2.25	Calibrated

Table 3: Parameters. Small Open Economy with nominal rigidities. GMPR stands for González et al. (2011)

With respect to the formal agents' wage setting problem, we choose the formal wage adjustment probability, $(1 - \epsilon^{W_F})$, equal to 0.25 which implies that the agents are able to set their optimal wage in average once every four quarters. This assumption reflects the fact that, in Colombia, formal wages face institutional arrangements constraints (*e.g.* minimum wage) that do not allow for immediate adjustments.[19] On the other hand, the elasticity of substitution between formal labor varieties, θ^{W_F}, is set equal to 2, as in González et al. (2011).

With regard to the firms' price setting problem, we set the output price adjustment probability, $(1 - \epsilon^{Y})$, equal to 0.25, reflecting that the firms are able to adjust their prices on average once in a year. We set the value of this parameter equal to the wages adjustment probability in order to not taking an *ad-hoc* stance on the relative degree of rigidity between wages and prices. Bonaldi et al. (2010) estimate the mode of the adjustment probabilities between 0.29 and 0.52 under different model specifications of a DSGE model for Colombia.

[19]In Colombia the minimum wage that operates during a year is negotiated between firms' representatives, the government and labor unions at the end of the previous year.

With respect to the elasticity of substitution between product varieties, θ^Y, we calibrate the parameter to match that in the long run, the profits-to-GDP ratio of the economy is equal to 11.7%, resulting in a value for θ^Y of 12.15.

Finally, with regard to the parameters of the monetary policy Taylor rule, we choose the smoothing parameter, ρ^i, equal to 0.7. The inflation expectations response, φ^π, equal to 4.5 and the output gap response, φ^Y, equal to 2.25. The Taylor rule parameterization imply that the Central Bank reacts 2 times to inflation expectations fluctuations relative to the output gap fluctuations, which, on one side, ensures the accomplishment of the Taylor Principle and is also common in the literature.

4.2.1 Change in the mass of informal population

In this section we illustrate the effect of a permanent increase in the mass of informal agents in a small open economy with nominal rigidities. As in the section 4.1, we consider an initial increase of 5% that grows linearly the next two years to reach a total raise of 10%. We focus on the effects of the migration shock on both real and nominal variables after the inclusion of nominal rigidities. In order to disentangle the effects of including the assumption of monopolistic competition, which entails that, the firms have market power and the price will capture the existence of a constant mark-up, we compare the results of the Small Open Economy model presented in section 2.1 with the flexible prices block of the model with nominal rigidities. The qualitative response of the two models is the same as can be evidenced in Figure 5 and the quantitative differences are due to the inclusion of market power even when the adjustment is immediate.

As we discussed, the parameterization of the model assumes that the formal agents are able to adjust optimally their wages once a year on average, reflecting that the formal wages are subject to institutional arrangements in Colombia. On the other hand, the price setting of the firms follows the same slow adjustment scheme as the wages. In Figure 6 we compare the allocations of some of the main variables between the nominal rigidities block and those of the flexible prices block of the Small Open Economy with nominal rigidities and monopolistic competition model. As in the case of the Small Open Economy model under perfect competition, the increase in the mass of informal agents raises the supply of informal labor and reduces the wages in this sector. Given the complementarity assumption between the two types of labor and the capital, the cheaper informal labor allows the firms to increase the production, which is done by demanding more for both types of labor and for capital.[20] Given the nominal rigidities, during the migration shock, the formal wages do not increase in 2.4% but in 2%, which results on a cheaper formal labor relative to the model withoud

[20]In Appendix A.3, we show a robustness analysis under different degrees of substitution between the types of labor. See Figure 11.

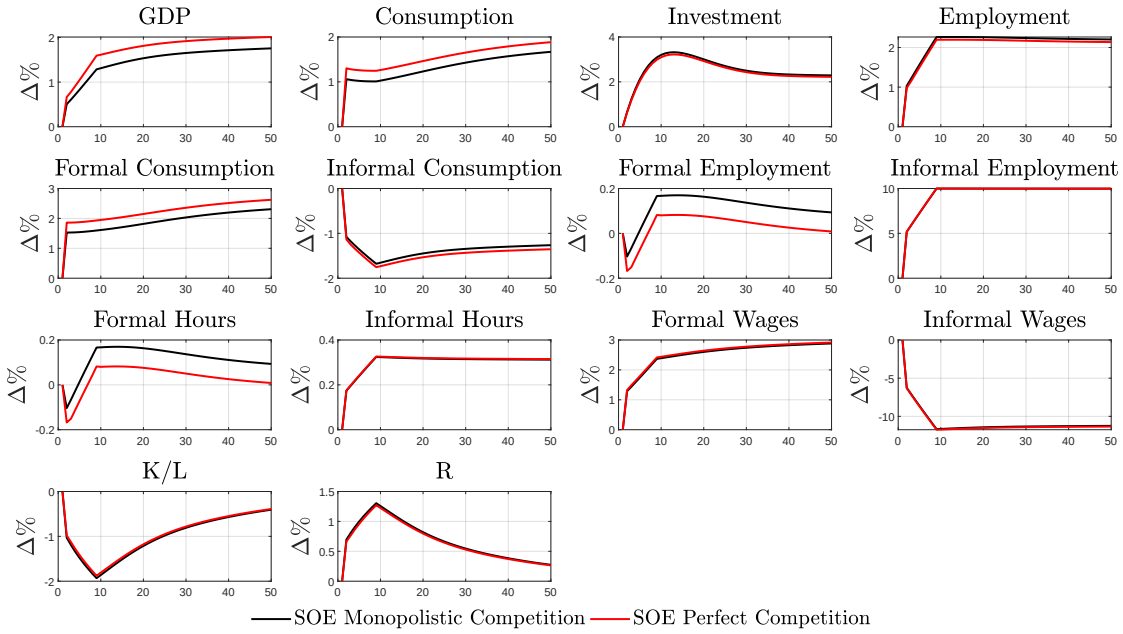


Figure 5: Comparison of the aggregate effects of a permanent shock in the informal population between the monopolistic competition SOE with flexible prices and the perfect competition SOE. Percentage changes from the initial steady state.

nominal rigidities. Following the same intuition described above, the cheaper the formal labor, the greater the demand for all the factors involved in the production. The greater demand for productive factors of the model with nominal rigidities, relative to the model in absence of those rigidities, is reflected on the slightly higher informal wages and price of capital. In summary, the worsening of the informal wages plus the slow adjustment of the formal wages lead to a negative present value of the marginal cost (-0.9%), implying less inflationary pressures in the economy, which are evidenced in a reduction of the inflation expectations in 30 basis points.[21]

The relatively higher demand for productive factors in the model with nominal rigidities implies that the output level is nearly 50 basis points higher than the flexible-prices output level in the short run, resulting in a positive output gap in the short run. In line with the specification of the reaction function of the Central Bank, the result of a reduction in the inflation expectations and an increase in the output gap, is a reduction of 35 basis points.

Finally, with regard to the per-capita variables, the results are similar to those of the Small Open Economy model without rigidities (see subsection 2.1). In Figure 7 we show the dynamic of output, aggregate consumption and of each type of worker in per capita terms. While the informal migration has a negative effect on per-capita output, consumption and

[21]Note that in absence of nominal rigidities, the present value of the marginal cost is always zero by the assumption of constant returns on scale implying that when the agents are able to adjust the prices or wages each period, they do so optimally.

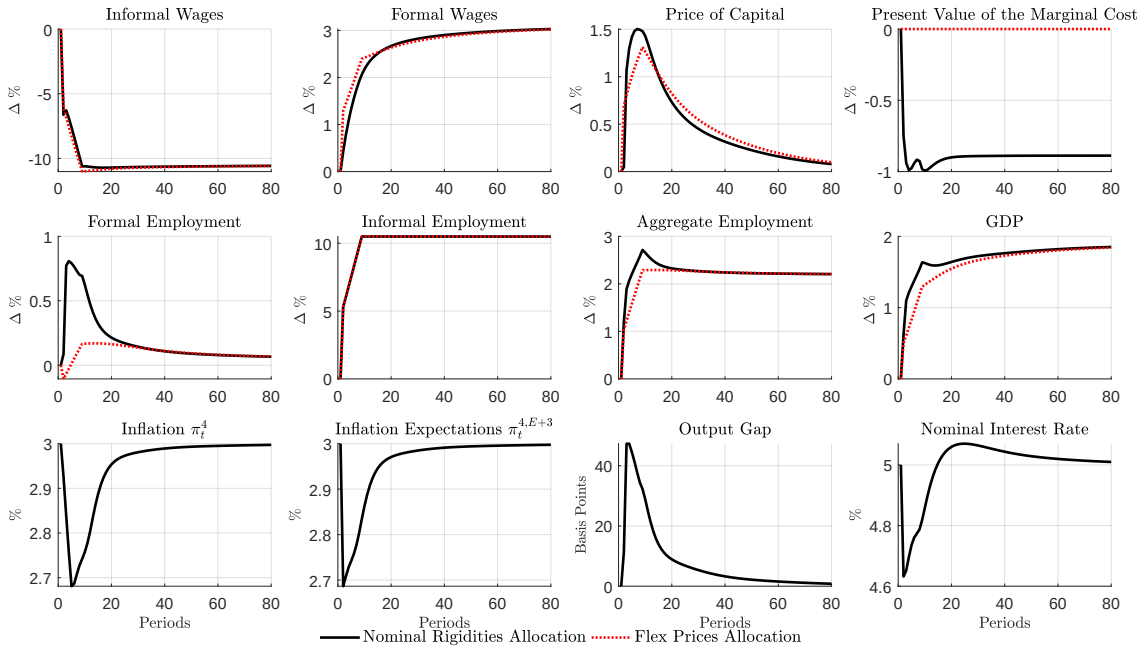


Figure 6: Aggregate effects of a permanent shock in the informal population in presence of nominal rigidities. Percentage changes from the initial steady state.

informal consumption, the effects are positive on formal consumption.

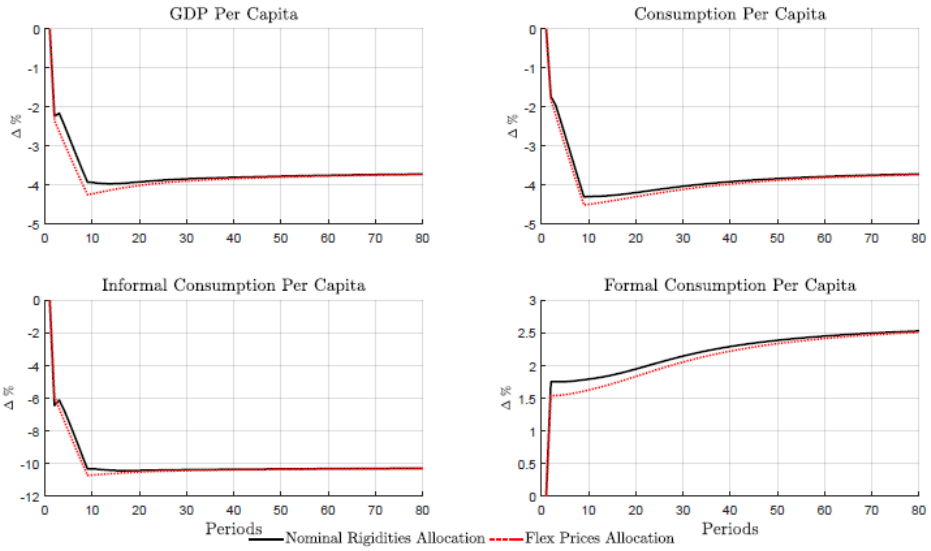


Figure 7: Per capita effects of a permanent shock in the informal population in presence of nominal rigidities. Percentage changes from the initial steady state.

4.2.2 Change in the mass of formal population

To illustrate the importance of the characterization of the agents, we now explore the effects on the aggregate variables of an increase on the mass of formal population instead of the informal population. The setup is similar to the already described with the informal population. We consider an initial increase of 5% of the mass of formal population that grows linearly the next two years to reach a total raise of 10%.

In Figure 8 we illustrate the aggregate effects of a migration shock when the migrant population is characterized as formal agents. Recall that formal agents are owners of capital, have access to international financial markets and their decisions on labor supplying is more elastic than the informal agents. In this experiment, an increase in the mass of formal population raises the supply of this kind of labor and reduces its wage. Nonetheless, as a consequence of the nominal rigidities, the formal wages do not adjust immediately and, therefore, do not fall as they would in absence of rigidities. The reduction in the formal wages increase the demand for formal workers, and given that the factors are imperfect complements, there is an increase in the demand for informal labor, which in turn, pushes their wages up. The increase in the demand for labor, deteriorates the capital-to-labor ratio, making the existing capital more productive and increasing the price of capital. In this point, the effect of the formal migration is reinforced given that the formal agents, as owners of the capital, increase further their demand for capital. In summary, higher informal wages and price of capital, plus the slow reduction in formal wages, entails a positive present value of the marginal costs, which traduces on higher inflationary pressures and on higher inflation expectations (80 basis points).

As can be noted in Figure 8, the increase in the demand for formal labor in presence of rigidities is not as strong as in the flex-prices allocation, which implies that the firms will demand less formal labor than their short-run demand capacity, resulting on a negative output gap (120 basis points). In this experiment, the Central Bank reaction to higher inflation expectations and a negative output gap is an increment of the nominal interest rate in 90 basis points.

It is worth noting that in this experiment, the terminal steady state of the GDP is nearly 3.5 times higher than the case in which the immigration is composed by informal agents. This result goes in hand with two characteristics of the model. First, the assumption of the higher productivity of the formal workers relative to the informal workers which results in a higher aggregate efficient labor. Second the capital ownership of the formal agents which increases further the investment financed by a higher indebtedness (see Figure **??**). However, in the short run, the low adjustment of the formal wages do not allow the firms to carry on the production as in absence of nominal rigidities, explaining the negative output gap.

Finally, with regard to the per-capita dynamics, the absorption of a formal immigrant population leads to a higher GDP and consumption per-capita, even-though the formal consumption per-capita decreases, figure 9.

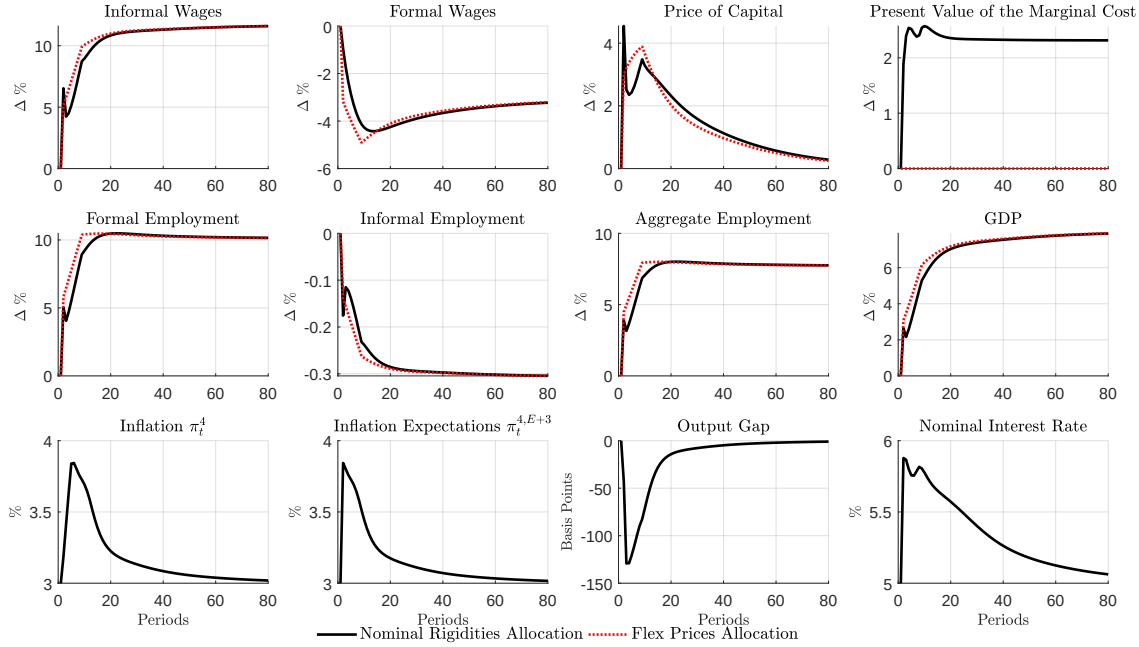


Figure 8: Aggregate effects of a permanent shock in the formal population in presence of nominal rigidities. Percentage changes from the initial steady state.

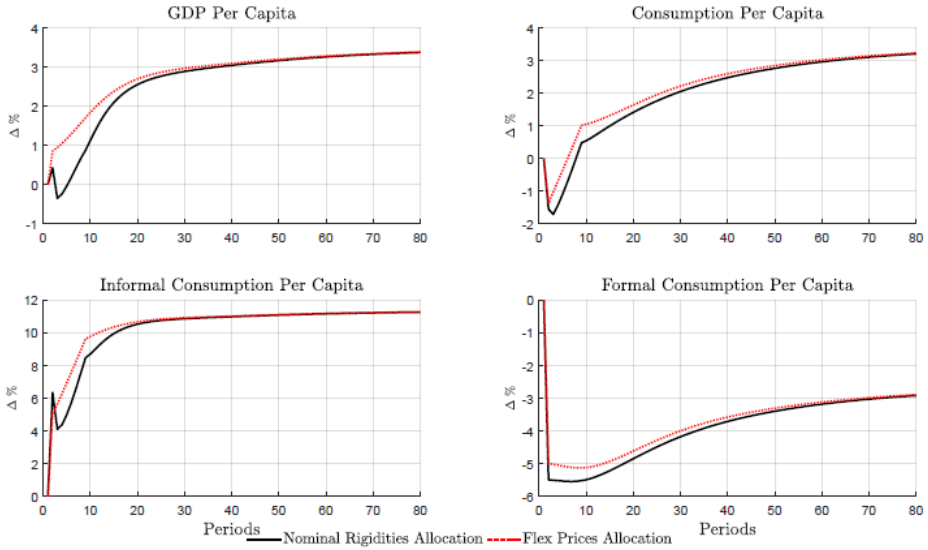


Figure 9: Per capita effects of a permanent shock in the formal population in presence of nominal rigidities. Percentage changes from the initial steady state.

5 Conclusions

During the last decades internal conflicts and poor economic conditions have intensified migration flows around the world. Latin America has not been the exception and in recent years

several countries have absorbed a mass influx of migrants coming from Venezuela. Since 2015 Colombia has received approximately 2 million people coming from the neighbouring country looking for better opportunities. In a country with a total population of 48 million, this influx is not negligible and may have affected some macroeconomic outcomes. As the economic literature highlights migration inflows might have a negative effect on the wages of domestic workers with similar characteristics, but positive effects on other kinds of workers due to complementary links and general equilibrium effects through demand channels.

The literature is broad in terms of studying the labor market outcomes of a migration inflow, however it has remained silent regarding the short-run response of monetary policy. In the presence of nominal frictions a mass influx of workers can affect inflation and the output gap in the short run, both determinants of standard Taylor rules. In this paper, we extend a simple small open economy model with nominal rigidities and endogenous monetary policy, to include heterogeneous agents in terms of productivity, capital ownership and wage flexibility. The model captures the main characteristics of the recent migration wave from Venezuela to Colombia and allows us to analyze the response of monetary policy.

The model predicts that after a positive migration shock aggregate production, consumption and investment increase, while the wages of the population with similar characteristics to the migrants fall. The novel feature of the model is the response of monetary policy. In the case of a massive inflow of low-productive workers, that are allocated in a sector with flexible wages, the model shows a moderate response of the central bank. Inflation and inflation expectations fall due to the lower wages, while the output gap becomes positive thanks to the wage rigidities of high-productivity workers that allow firms to hire more. Given that the central bank reacts by more to inflation, it lowers the interest rate. On the other hand, if the inflow of workers is of the high-productive type, inflation increases due to the wage-rigidities and the output gap turns negative, as a response the central bank increases more actively the interest rate. These results show that the response of the monetary policy is sensitive to the type of worker that migrates and to the characteristics of the sector that absorbs these new workers. This model highlights the importance to characterize the migration waves and the receiving economies in terms of i) workers-productivity, ii) interaction with existing workers; and iii) nominal rigidities of the sectors that absorb the migrants. It also shows that monetary policy plays a role in the short-run to stabilize prices and the output gap.

References

Arias, J. E., Rubio-Ramírez, J. F., & Waggoner, D. F. (2018). Inference Based on Structural Vector Autoregressions Identified With Sign and Zero Restrictions: Theory and Applications. *Econometrica*, *86*(2), 685–720.

Armstrong, J., & McDonald, C. (2016). Why the drivers of migration matter for the labour market. *Reserve Bank of New Zealand Analytical Notes*(2), 1-19.

Battisti, M., Felbermayr, G., Peri, G., & Poutvaara, P. (2018). Immigration, Search and Redistribution: A Quantitative Assessment of Native Welfare. *Journal of the European Economic Association*, *16*(4), 1137-1188.

Becker, S., & Ferrara, A. (2019). Consequences of forced migration: A survey of recent findings. *Labour Economics*, *59*, 1-16.

Ben-Gad, M. (2004). The economic effects of immigration–a dynamic analysis. *Journal of Economic Dynamics and Control*, *28*(9), 1825-1845.

Bonaldi, P., González, A., & Rodriguez, D. (2010). Importancia de las rigideces nominales y reales en Colombia: un enfoque de equilibrio general dinámico y estocástico. *Borradores de Economía*, *591*.

Borjas, G. J. (2003). The labor demand curve is downward sloping: Reexamining the impact of immigration on the labor market. *The Quarterly Journal of Economics*, *118*(4), 1335-1374.

Borjas, G. J., Freeman, R. B., Katz, L. F., DiNardo, J., & Abowd, J. M. (1997). How much do immigration and trade affect labor market outcomes? *Brookings Papers on Economic Activity*, *1*, 1-90.

Boubtane, E., Coulibaly, D., & Rault, C. (2012). Immigration, Growth, and Unemployment: Panel VAR Evidence from OECD countries. *IZA Institute of Labor Economics, Discussion Paper Series*(6966), 1–28.

Burda, M. C. (2006). Factor Reallocation in Eastern Germany after Reunification. *American Economic Review*, *96*(2), 368-374.

Calderón-Mejía, V., & Ibáñez, A. M. (2016). Labour market effects of migration-related supply shocks: evidence from internal refugees in Colombia. *Journal of Economic Geography*, *16*(3), 695-713.

Calvo, G. A. (1983). Staggered prices in a utility-maximizing framework. *Journal of Monetary Economics*, *12*(3), 383-398.

Canova, F., & Ravn, M. O. (2000). The Macroeconomic Effects of German Unification: Real Adjustments and the Welfare State. *Review of Economic Dynamics*, *3*(3), 423–460.

Card, D. (2001). Immigrant Inflows, Native Outflows, and the Local Market Impacts of Higher Immigration. *Journal of Labor Economics*, *19*(1), 22-64.

Card, D., & DiNardo, J. (2000). Do Immigrant Inflows Lead to Native Outflows? *American Economic Review*, *90*(2), 360-367.

CentralBankofChile. (2019). Monetary policy report, june. *Central Bank of Chile*.

Coleman, A., & Landon-Lane, J. (2007). Housing Markets and Migration in New Zealand, 1962-2006. *Reserve Bank of New Zealand Discussion Paper Series*(September), 1962–2006.

D'Albis, H., Boubtane, E., & Coulibaly, D. (2017). International Migration and Regional Housing Markets: Evidence from France. *IZA Institute of Labor Economics, Discussion Paper Series*(10516), 1–34.

D'Albis, H., Boubtane, E., & Coulibaly, D. (2018). Immigration and Government Spending in OECD Countries. *HAL archives-ouvertes. PSE.*, *41*, 1–31.

Erceg, C. J., Henderson, D. W., & Levin, A. T. (2000). Optimal monetary policy with staggered wage and price contracts. *Journal of Monetary Economics*, *46*(2), 281-313.

Fallon, P. R., & Layard, P. R. G. (1975). Capital-Skill Complementarity and Inequality: A Macroeconomic Analysis. *Journal of political economy*, *83*(2), 279–302.

Furlanetto, F., & Ørjan Robstadb. (2019). Immigration and the macroeconomy: Some new empirical evidence. *Review of Economic Dynamics*, *34*, 1-19.

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.

Hazari, B. R., & Sgro, P. M. (2003). The simple analytics of optimal growth with illegal migrants. *Journal of Economic Dynamics and Control*, *28*(1), 141-151.

Iftikhar, Z., & Zaharieva, A. (2019). General equilibrium effects of immigration in Germany: Search and matching approach. *Review of Economic Dynamics*, *31*, 245-276.

IMF. (2019). Outlook for Latin America and the Caribbean: Stunted by Uncertainty. *Regional Economic Outlook: Stunted by Uncertainty*.

Kerr, S. P., & Kerr, W. R. (2011). Economic Impacts of Immigration: A Survey. *NBER Working Paper No. 16736*.

Kiguchi, T., & Mountford, A. (2019). Immigration And Unemployment: A Macroeconomic Approach. *Macroeconomic Dynamics*, *23*, 1313-1339.

Krusell, P., Ohanian, L. E., Ríos-Rull, J.-V., & Violante, G. L. (2000). Capital-Skill Complementarity and Inequality: A Macroeconomic Analysis. *Econometrica*, *68*(5), 1029–1053.

Lewis, E., & Peri, G. (2015). Immigration and the Economy of Cities and Regions. *Handbook of Regional and Urban Economics*, *5*, 625-685.

Lozej, M. (2019). Economic migration and business cycles in a small open economy with matching frictions. *Economic Modeling*, *81*, 604-620.

Morales, J. (2018). The impact of internal displacement on destination communities: Evidence from the Colombian conflict. *Journal of Development Economics*, *131*, 132-150.

Moreno-Galbis, E., & Tritah, A. (2016). The effects of immigration in frictional labor markets: Theory and empirical evidence from EU countries. *European Economic Review*, *84*, 76-98.

Palivos, T., & Yip, C. K. (2010). Illegal immigration in a heterogeneous labor market. *Journal of Economics*, *101*(1), 21-47.

Partridge, M. D., & Rickman, D. S. (2006). An SVAR Model of Fluctuations in U.S. Migration Flows and State Labor Market Dynamics. *Southern Economic Journal*, *72*(4), 958-980.

Peri, G. (2012). The effect of immigration on productivity: Evidence from U.S. states. *The Review of Economics and Statistics*, *94*(1), 348–358.

Schmitt-Grohé, S., & Uribe, M. (2003). Closing small open economy models. *Journal of international Economics*, *61*(1), 163-185.

Sims, C. A. (1988). Bayesian skepticism on unit root econometrics. *Journal of Economic Dynamics and Control*, *12*(2-3), 463–474.

Sims, C. A., & Uhlig, H. (1991). Understanding Unit Rooters: A Helicopter Tour. *Econometrica*, *59*(6), 1591–1599.

Smith, C., & Thoenissen, C. (2019). Skilled migration and business cycle dynamics. *Journal of Economic Dynamics and Control*, *109*, 103781.

Taylor, J. (1993). Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series on Public Policy*, *39*(1), 195-214.

Valencia, O., Angarita, M., Santaella, J., & De Castro, M. (2020). Do Immigrants Bring Fiscal Dividends? The Case of Venezuelan Immigration to Colombia. *Mimeo*.

Whalen, C., & Reichling, F. (2017). Estimates of the Frisch elasticity of labor supply: A review. *Eastern Economic Journal*, *43*(1), 37–42.

WorldBank. (2018a). Migration from Venezuela to Colombia : Short- and Medium-Term Impact and Response Strategy. *World Bank, Colombia.*.

WorldBank. (2018b). Oportunidad para todos: Los migrantes y refugiados venezolanos y el desarrollo del perú. *World Bank, Perú.*, *2*.

A Appendix

A.1 BVAR Data sources

This section details the transformations applied and the sources of the series used in the BVAR. Since we specify the BVAR on a quarterly basis, we apply a simple average to the monthly series. Except for the annual core inflation and the unemployment rate, which enter the BVAR in percentage points, the other series enter the model as the natural logarithm of their levels. Remittances and the unemployment rate were seasonally adjusted using TRAMO-SEATS.

Colombian real GDP: Seasonally adjusted and adjusted for calendar effects. Base year 2015. Source: National Administrative Department of Statistics (DANE, for its Spanish acronym).

Annual core inflation: Constructed on the basis of the total CPI excluding the subclasses corresponding to food, out-of-home meals and regulated prices. Base December 2018. Source: Banco de la República based on DANE data.

Unemployment rate: Corresponds to the measurement that takes into account the whole country. Source: DANE with data from the Continuous Household Survey and the Great Integrated Household Survey.

Remittances: Current transfers made by migrants to their country of origin, either in cash and/or in kind. We convert them to Colombian pesos using the representative market exchange rate (TRM, for its Spanish acronym) peso/dollar. We deflate remittances in pesos using total CPI. Source: Balance of Payments, Banco de la República.

Formal/informal wage ratio: This variable is constructed as mentioned in Section 3.

GDP index for trading partners: This variable is calculated as a weighted average of the GDP of Colombia's main trading partners. It was deflated using the World Bank's price index.

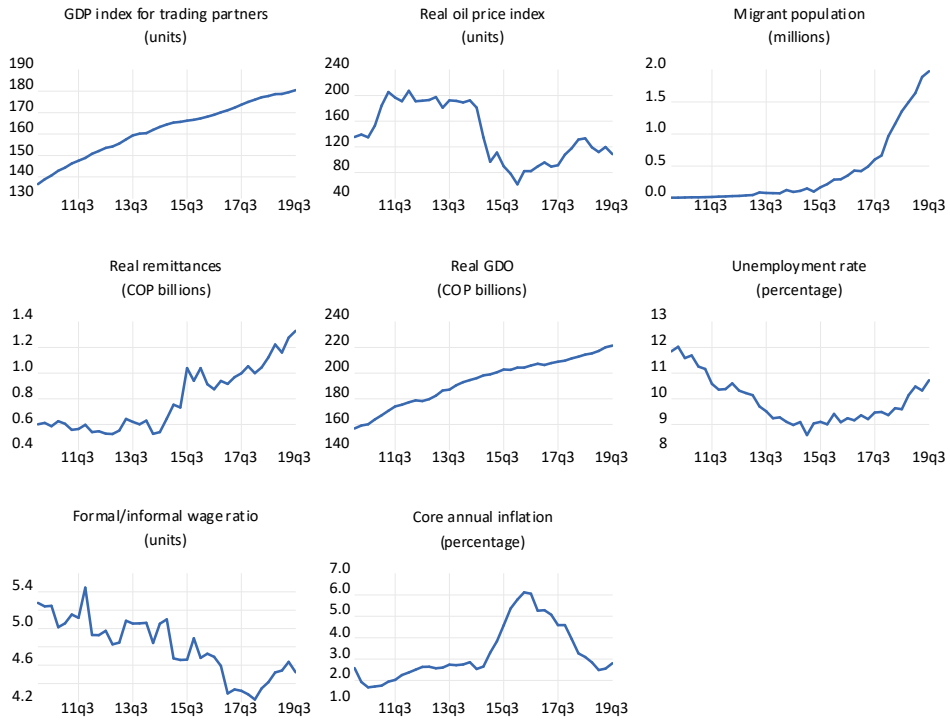
Real oil price index: This variable is calculated as the price of oil relevant to Colombia, deflated using U.S. inflation.

Migrant population: This variable is constructed as mentioned in Section 3.

A.2 Series included in the BVAR

Figure 10 shows the variables included in the BVAR and their order of exogeneity for Cholesky's decomposition. The most exogenous variable is the index of GDP for trading partners, while the most endogenous variable is annual core inflation.

Figure 10: Variables included in the BVAR



Note: Seasonally adjusted real GDP is calculated by DANE, core inflation corresponds to non-food and non-regulated inflation, the unemployment rate corresponds to that observed in the national total published by DANE, remittances in real terms are based on information from Banco de la República. The ratio between the salaries of formal and informal workers corresponds to the ratio between the salaries of employees earning more than 1.1 legal minimum wage and those earning less than that threshold. The real GDP indices of the principal trading partners and the oil price take into account the dynamics of the external economies and the oil price that most influence the Colombian economy.

Source: DANE, Banco de la República, Gran Encuesta Integrada de Hogares (GEIH) and own calculations.

A.3 Alternative Scenarios

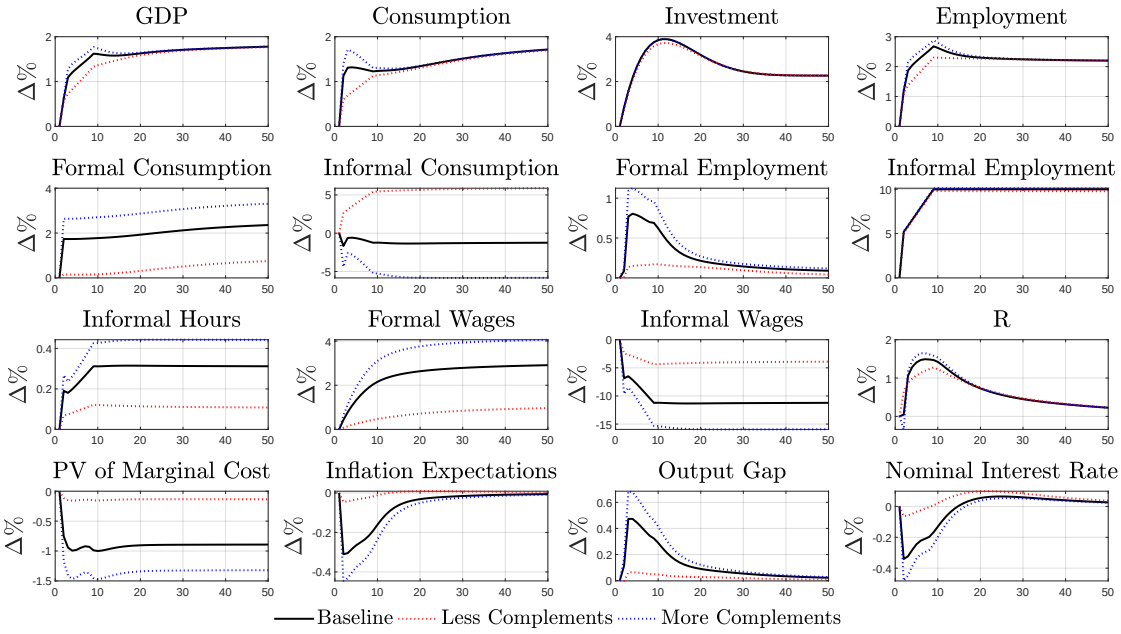


Figure 11: Robustness Analysis: Sensitivity to the elasticity substitution among labor. Permanent shock in the informal population in presence of nominal rigidities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