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The labor market in Colombia:
Structural features and the role
of wages in the post-pandemic
inflationary surge

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No. 1232
2023



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**The labor market in Colombia:
Structural features and the role of wages in the post-pandemic inflationary surge**

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Abstract

We provide an overview of the primary structural features of the labor market in Colombia and survey the margins of adjustment of the market during the pandemic. Given the decline of real wages amid the post-pandemic inflationary surge, mainly due to the formal wage rigidity in the short run, we investigate whether the dynamics of nominal wages and their expected adjustments to catch up with prices could fuel the post-pandemic inflationary escalation. For this, we estimate the long-term relationship between wages, prices, and labor productivity using a small open economy framework. We find that up until the third quarter of 2022, wages were not among the primary drivers of the observed inflation escalation. However, wages have typically contributed to restoring long-run equilibrium. Thus, their adjustment towards equilibrium, which can occur through indexation, could imply risks for the convergence of inflation to the target. These risks are significant if the observed sources of the inflationary surge persist.

JEL Classification: E24, E31, J30, O54

Keywords: Labor market, employment, wages, prices, pandemic

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**El mercado laboral colombiano:
Aspectos estructurales y el rol de los salarios en el brote inflacionario postpandemia**

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Resumen

Examinamos las principales características estructurales del mercado laboral en Colombia y sus márgenes de ajuste durante la pandemia. Dada la caída de los salarios reales en medio del brote inflacionario que ocasionó la pandemia, debido a la poca capacidad de los salarios nominales para ajustarse en el corto plazo, evaluamos si la dinámica observada y prevista de los salarios nominales para compensar los ajustes en los precios puede retroalimentar la escalada inflacionaria. Para ello, estimamos la relación de largo plazo entre precios, salarios y productividad laboral utilizando un marco de economía pequeña y abierta. Encontramos que, hasta el tercer trimestre de 2022, los salarios no estuvieron entre los principales impulsores de la escalada inflacionaria. Sin embargo, los salarios típicamente han contribuido a restaurar el equilibrio a largo plazo. Por lo tanto, su ajuste hacia el equilibrio, que puede ocurrir a través de la indexación, podría implicar riesgos para la convergencia de la inflación a la meta. Estos riesgos son significativos si persisten las fuentes observadas del brote inflacionario.

Clasificación JEL: E24, E31, J30, O54

Palabras claves: Mercado laboral, empleo, salarios, precios, pandemia

* Investigador, Gerente Técnico y Subgerente de Política Monetaria e Información Económica del Banco de la República, respectivamente. Agradecemos a Didier Hermida por su valiosa asistencia estadística y a Leonardo Villar por sus valiosos comentarios a una versión previa de este manuscrito.

1. Introduction

Like many other developing economies, despite some progress over the past few decades, the labor market in Colombia continues to exhibit several signs of dysfunctionality. Notable symptoms include a high incidence of informality and unemployment; an inflexible formal sector with rigid salaries heavily influenced by the legal minimum wage (MW hereafter); and remarkable regional and demographic disparities in the labor market outcomes, among other issues. Against this backdrop, the COVID-19 pandemic introduced new channels of adjustment of the labor market in response to the sizeable economic activity drop. The heterogeneous impacts of the crisis across occupations and demographic groups, coupled with the response of firms and workers to the multiple stimulus policies implemented to mitigate the effects of confinement and social distancing measures, represent some of the most prominent margins of adjustment in the labor market during the pandemic.

Meanwhile, in the wake of the pandemic, as with many other economies, Colombia's inflation rose to levels not observed in the last two decades. Several cost-push shocks, including the reversion of relief measures, the rise of food prices, and the currency's depreciation, among others, mainly caused the inflation escalation. In addition, strong aggregate demand in 2022 also contributed to the inflationary surge. In this context, workers' real incomes, especially those in the salaried sector, declined due to the inability of nominal wages to adjust in the short run. Hence, a natural question arises regarding the inflationary pressures resulting from the dynamics of nominal wages and their expected adjustments to catch up with prices. How might these adjustments fuel the inflationary escalation or make it more challenging to converge inflation to the target?

To address this question, we first describe some of Colombia's main features of its wage-setting process. We provide evidence of procyclical informal labor earnings and document that salaries in the formal sector are sticky and heavily influenced by the MW. Subsequently, we explore the long-term relationship between wages, prices, and labor productivity using an econometric approach based on a stylized small-open economy framework. This exercise gives us a measure of inflationary pressures from the labor market in the short run. Our findings show that, up until the third quarter of 2022, wages were below their "long-term" level, given the shocks to prices and the

exchange rate, consistent with the documented formal wage rigidity in the short run. Thus, wage increases above labor productivity growth were not among the main drivers of the observed inflation escalation up to that date. However, we find that wages have typically been one of the variables contributing to restoring long-run equilibrium. Their adjustment towards equilibrium, which we show may plausibly take place through indexation, can imply risks for the convergence of inflation to target. These risks are significant if the observed sources of the inflationary surge do not disappear.

We organize this paper into four sections, beginning with this introduction. In the second section, we provide an overview of the main structural aspects of the Colombian labor market, including its pre-pandemic trends and the cyclical properties of key labor market indicators. Interestingly, we show how a stylized model of a segmented labor market with a binding MW can rationalize the observed high (but declining) informality rate and the relatively stable unemployment rate. In the model, increases in formal labor productivity growth, associated with expanding human or physical capital, unambiguously decrease informality but have an ambiguous effect on unemployment if the MW is relatively high compared to the market wage. We also survey the major impacts of the COVID-19 pandemic on the Colombian labor market documented in the literature, highlighting its heterogeneous effects across demographic groups, occupations, and firms, as well as the findings on the response of labor demand and supply to stimulus policies. The third section focuses on wages and their role in the recent inflationary escalation. We begin by describing the main drivers of inflation in the wake of the pandemic and some of the main features of the wage-setting process in Colombia. Given the prominent role of the MW in this process, we survey some of the main findings of a recent comprehensive study on the macroeconomic impacts of the MW in Colombia (Arango et al., 2022). Subsequently, based on our small-open economy framework, we estimate the long-term relationship between wages, prices, and labor productivity. Finally, in the fourth section, we present our conclusions.

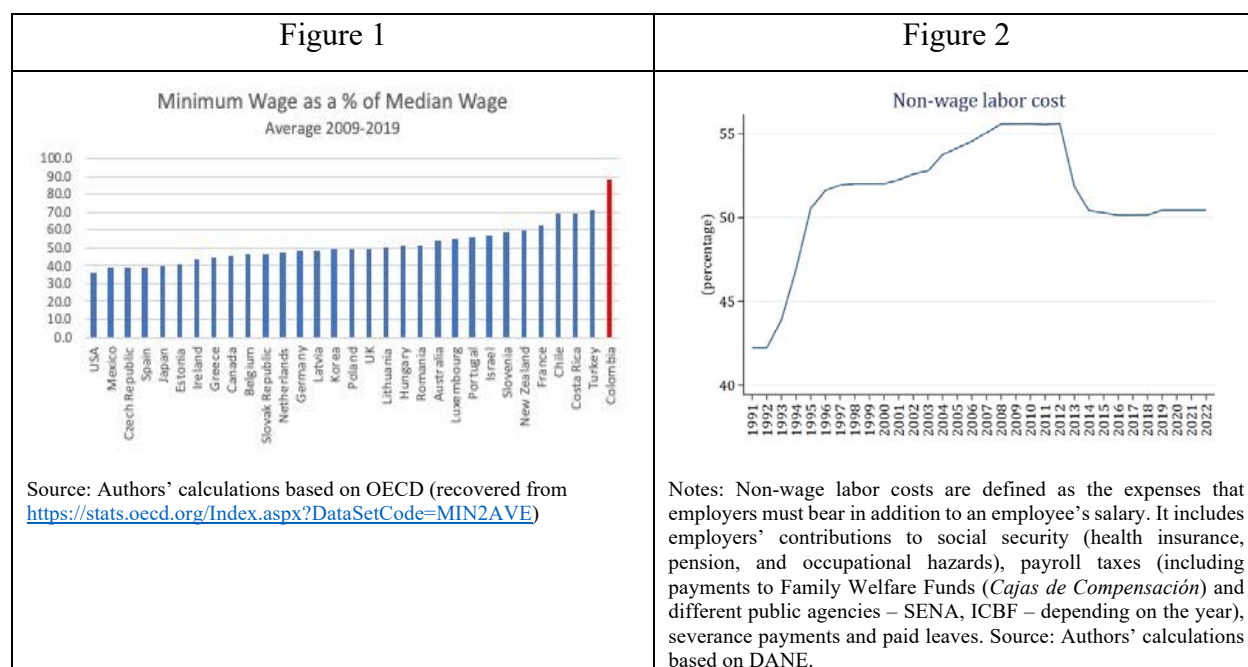
2. The labor market in Colombia

In this section we describe some features of the labor market in Colombia and overview its evolution during the COVID-19 pandemic. We first summarize the long-run trends of the key labor

market indicators. Next, we characterize the properties of those indicators in relation to the business cycle. Finally, we survey the main mechanisms of adjustment of the Colombian labor market during the pandemic according to the recent literature.

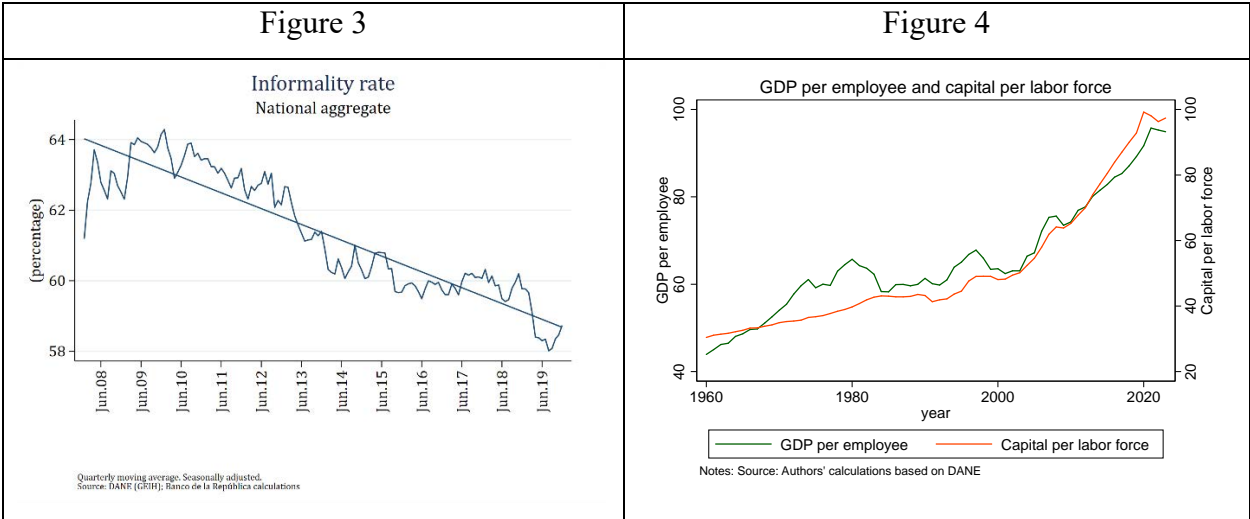
2.1. Labor market trends before the pandemic

As in other developing countries, the labor market in Colombia is characterized by a high incidence of informal labor relationships, defined as those performed outside the scope of domestic regulation. Just before the pandemic broke out, informal workers accounted for almost half of the labor force.¹ Among the reasons behind this informality is a relatively high MW coupled with high hiring/firing costs and payroll surcharges (e.g., Arango & Florez, 2020a). The MW as a percentage of the median wage in Colombia was the highest in a sample of OECD advanced and emerging economies in 2021 (Figure 1), while non-wage labor cost surcharges represent around 50% of wages (Figure 2).

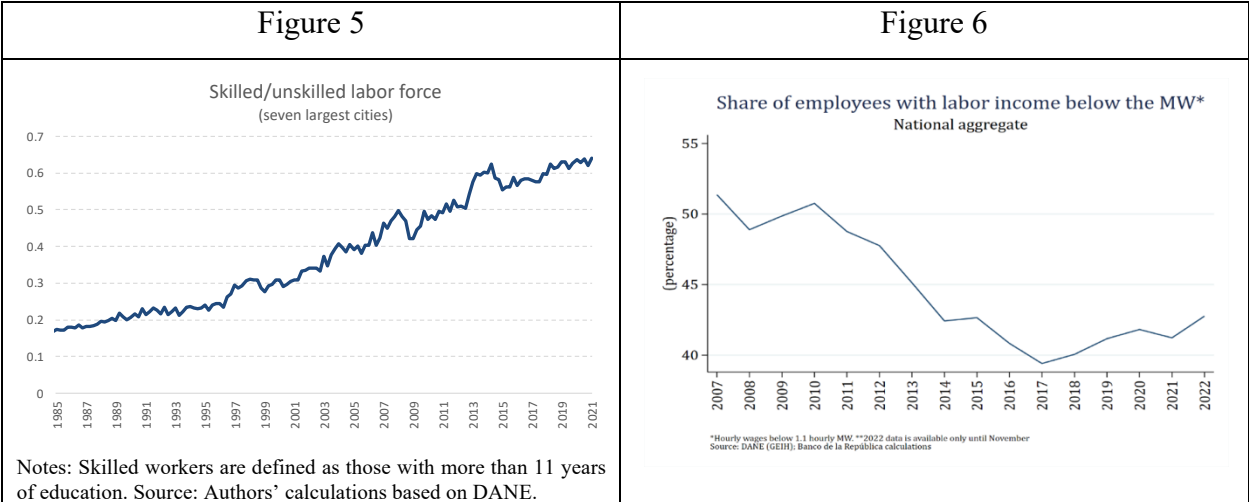


¹ Here, we use a definition of informality that categorizes workers as informal if they are either salaried employees working in firms with fewer than five employees or self-employed individuals lacking higher education. This was the prevailing official definition before the pandemic. More recently, the definition of informality has evolved to encompass additional criteria such as whether firms are registered with the Chamber of Commerce. However, during the period in which both definitions overlap, the two definitions show very similar records of informality.

Nevertheless, in the decade before the COVID-19 crisis, the Colombian labor market showed an increasing trend in favor of salaried employment, resulting in a decreasing trend of informality. The ratio of salaried workers to working-age population increased by 3 percentage points (pp) until 2016, while the informality rate dropped 5 pp from 2009 to 2019 (Figure 3). The drop in informality resulted in an improvement in the average quality of jobs in the Colombian economy. Rising labor productivity, supported by physical and human capital accumulation in a period of high commodity prices and improved business investment climate (tax incentives and better security conditions), seems to be at the root of this trend (Figures 4 and 5).² The increased demand for labor resulted in a declining share of workers whose earnings are less than the minimum wage between 2010 and 2017 (Figure 6).



² In Appendix A we show, through the lens of a stylized model of a segmented labor market with a binding minimum wage, how increases in formal labor productivity growth, which may be associated with expanding human or physical capital, unambiguously decrease the informality rate. However, their effects on unemployment are ambiguous (please refer to footnote 6 for a detailed explanation of the effects on unemployment) and depend non-linearly upon the level of the minimum wage relative to the market wage.



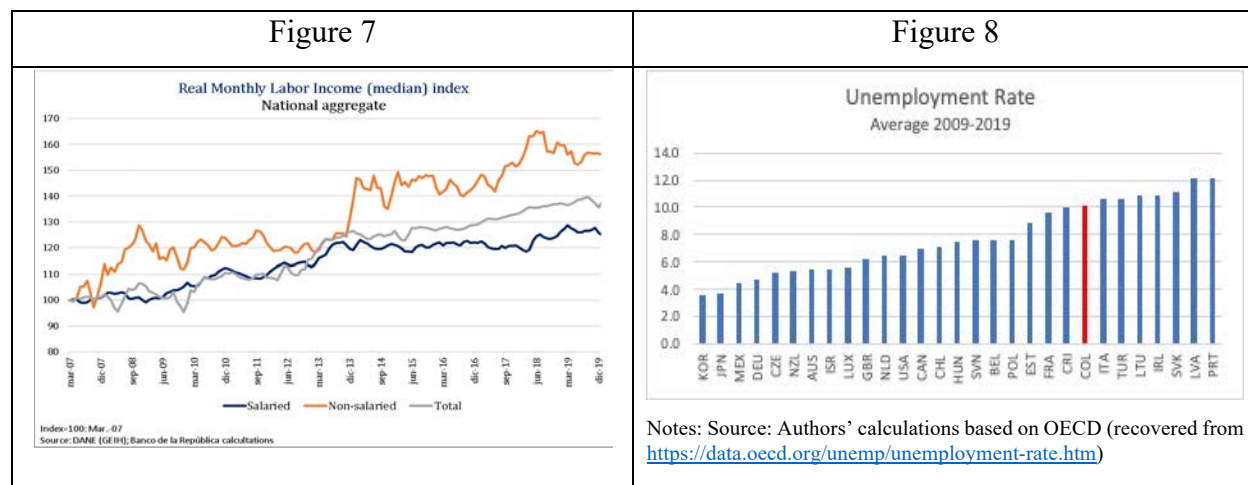
Moreover, there is also ample evidence that the formalization process was bolstered by multiple reforms reducing payroll taxes. A case that has been extensively documented is the 2013 reform that reduced payroll taxes by 13.5 pp, which explains the large drop in the non-wage cost measure shown in Figure 2. Several studies have found that this reform increased formal employment and reduced the informality rate. The magnitude of the fall in the informality rate varies between 2.3% and 3.6% depending on the study (see Fernández and Villar, 2017; Morales and Medina, 2017; Osorio, 2016).³

Worker earning dynamics are consistent with the above-mentioned trend of formalization. As the share of employees with labor income below the MW shrank (Figure 6), non-salaried workers' unit labor income rose faster than wages, an indication of increasing absorption of workers by the formal sector. We focus here on the trends of the median wages for the salaried segment and the median labor income for informal workers. Figure 7 shows their evolution in real terms before the pandemic.⁴ The accumulated growth rate of the median monthly income between 2007 and 2019 was 27% for salaried workers and 55% for non-salaried ones. The heterogeneous behavior of

³ The latter studies complement Kugler and Kugler (2009), who evaluate how the rise in payroll tax rates over the 1980s and 1990s affected the labor market. Their study finds that a 10% increase in payroll taxes lowered formal employment by between 4% and 5%.

⁴ The Figure shows their indices. Of course, there is a significant income premium between the formal and the informal sector that is present even when controlling for the composition of the workforce. For example, in a Mincerian regression controlling for the usual workers' observable characteristics (such as gender, working experience, years of education, and location), the premium for working in the formal sector is around 0.33 logarithm points (lp, or 39%) on average in the period 2009-2019; while controlling in addition for the composition of the workforce across industries or occupations, the within-industry premium is around 0.27 lp (31%).

earnings is more noticeable since 2013, and it is present even when accounting for differences in the median worked hours.

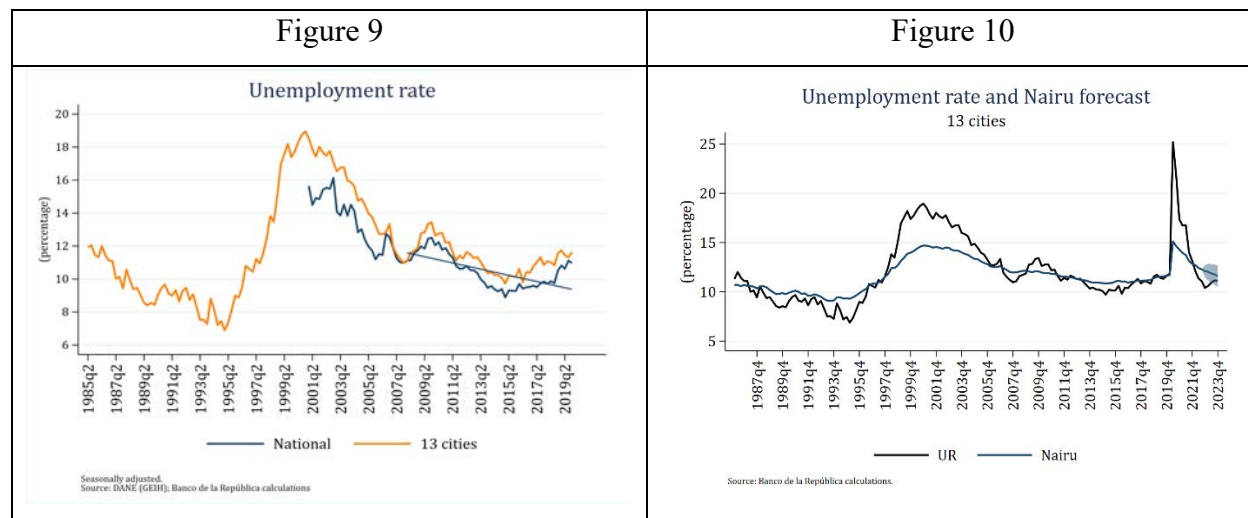


An additional structural feature of the Colombian labor market is a persistently high unemployment rate. The average unemployment rate since the 1980s has been 10.7% nationally (10.4% excluding the pandemic) and 12.1% in the urban areas (11.8% excluding the pandemic). During the last three decades, the unemployment rate has fluctuated over the business cycle, but its levels have never dropped below 8%. These levels are high relative to those of other advanced and emerging economies (Figure 8), a feature that is also consistent with the combination of a relatively high MW and large payroll surcharges in the formal sector (Arango & Florez, 2020c, and Arango et al., 2022).⁵

The unemployment rate rose sharply in the 1990s along with the hike in hiring costs (Figure 2) and the severe recession and financial crisis that the country went through at the end of the decade (Figure 9). It then came down, as the economy recovered from the crisis and the period of fast physical and human capital accumulation took place. As in the case of the informality rate, the

⁵ According to Arango & Florez (2020c) and Arango et al. (2022, p. 16), there is a negative effect of the MW on structural unemployment. However, this effect seems to have decreased recently, while other studies reported by Arango et al. (2022) do not find a statistically significant response of structural unemployment to the MW. A stylized model shown in Appendix A illustrates how increases in the MW reduce formality but have ambiguous effects on unemployment. This happens because a MW rise has two opposing impacts. On the one hand, it lowers formal labor demand and employment (increasing unemployment). On the other hand, decreasing formal employment reduces the perceived probability of getting a formal job and, thereby, diminishes the households' incentives to supply labor in the formal market (reducing unemployment). For the same reasons, formal labor productivity growth associated with expanding human or physical capital decreases informality but has ambiguous effects on unemployment.

reduction of the payroll burden may have also contributed to the downward trend of unemployment until 2015. Unemployment increased after the pronounced drop in oil prices and the terms of trade of the country in 2014-2016 and the ensuing slowdown of the economy.



The incidence of unemployment is persistently larger for women, young workers, less educated individuals, and household members other than those who receive the primary income. Further, the persistently high unemployment levels, even during periods of economic expansion, imply that structural unemployment rates usually remain at high levels. For instance, different models to compute the Non-Acelerating Unemployment Rate (NAIRU),⁶ show a NAIRU that has fluctuated between 10% and 15% during the last 30 years (Figure 10).

Finally, one of the main factors that has shaped the recent labor market trends in Colombia is the massive immigration from Venezuela that started in 2015 due to the neighboring country's economic crisis. Before the migration wave, immigrants from Venezuela as a share of the working-age population in Colombia were roughly 0.2%, and this share rose to 7% by 2022. Given the demographic profile of immigrants, mainly working-age people, the massive inflow of migrants helped to slow down the population aging process in Colombia. Further, the migratory wave, particularly since 2018, modified the decreasing trend in population growth due to the secular drop in the birth rate. Interestingly, these immigration flows were not reflected in rising rates of

⁶ These models are periodically used to estimate the NAIRU in the publication series *Reportes del Mercado Laboral*, of the Central Bank of Colombia. The current set of models is explained in GAMLA – Banco de la República (2020a).

informality between 2007 and 2019 (Figure 3). Several studies on the impact of migration from Venezuela on the Colombian labor market show relatively minor displacement effects in terms of employment for native workers, and adverse hourly wage effects concentrated on the less educated (see Tribin et al., 2020, and Lebow, 2022, for comprehensive discussions). In addition, it is also documented that Venezuelan immigrants face more frictions in the labor market, producing a more considerable extent of misallocation of this workforce across occupations (Pulido & Varón, 2020). It is estimated that by removing the additional frictions immigrants face, Colombian aggregate labor productivity could permanently increase by up to 0.4%, making the contribution of immigration to Colombian economic growth up to 13% larger.

2.2. The cyclical behavior of the labor market

We now focus on the cyclical properties of the key market labor variables (occupation, participation, unemployment and informality rates,⁷ and median labor income of both the salaried and non-salaried segment). We extract the cyclical components of the quarterly series of these indicators for the period 1984-2023 using standard Hodrick-Prescott filters. Next, we compute the cross-correlogram of each series with respect to the cyclical component of the GDP. Table 1 shows the value of the highest correlation (in absolute values) found, its sign, and the number of quarters that each series leads or lags the cyclical component of the GDP. The full correlation matrix is shown in Table B-1 in Appendix B.

Table 1

| Order | Variable | Max. Correlation | Sign | Order of lag (-) or lead (+) |
|-------|--|------------------|------|------------------------------|
| 1 | Unemployment rate (UR) | 0.85*** | - | 0 |
| 2 | Employment rate (ER) | 0.73*** | + | 0 |
| 3 | Non-salaried labor income (median) | 0.58*** | + | 1 |
| 4 | Informality rate (as non-salaried share) | 0.36*** | - | 1 |
| 5 | Labor participation rate (LPR) | 0.31*** | + | 0 |
| 6 | Salaried wage (median) | 0.25*** | + | -1 |

Notes: Significance levels: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

⁷ Given the unavailability of a long series of informality rates, we approach this indicator with the share of non-salaried workers in the total number of employees. Further, only urban series are considered.

As expected, the most synchronized labor indicator with the business cycle is the unemployment rate (maximum correlation of 0.85, significant at a 99% confidence level). The unemployment rate is countercyclical and contemporaneous to the GDP at the quarterly frequency, in contrast to the usual view that depicts unemployment responding to economic activity with a lag. Figure B-1 in Appendix B shows the levels of the unemployment rate and marks recession periods identified by a standard chronology of the business cycle in Colombia (Alfonso et al., 2013).⁸ Unemployment increases in all contractionary periods of the Colombian economy and its turning points are quite concordant with those suggested by the business cycle chronology.

The employment rate is the second most synchronized indicator with the business cycle (maximum correlation of 0.73, significant at a 99% confidence level). As expected, this rate is procyclical and contemporaneous. Figure B-1 shows that the employment rate always decreases in the identified recessions, but there are also periods in which it falls even when the economy is expanding (for instance, between 2015-2018). Regarding the formal/informal segmentation of employment, the share of informal workers is, as expected, counter-cyclical. The informality rate has a maximum correlation that is low (-0.36), although statistically significant, and responds with a one-quarter lag. Figure A-1 shows that recessions usually trigger increases in the informality rate, but the persistence of this rise is variable across the different contractionary periods.

With respect to labor income, wages in the salaried segment are almost a-cyclical, with the maximum correlation at barely 0.25 (but statistically significant), leading the GDP by 1 quarter. As we comment in section 2, this is the result of an important degree of stickiness of formal wages in Colombia, given that their adjustments occur regularly (usually once a year) and are downwardly rigid (firms usually do not make wage cuts). By contrast, the labor income in the non-salaried segment is procyclical (maximum correlation of 0.58, significant at a 99% confidence level) but lagged one quarter relative to economic activity. This points towards a larger flexibility of the informal than that of the formal labor market.

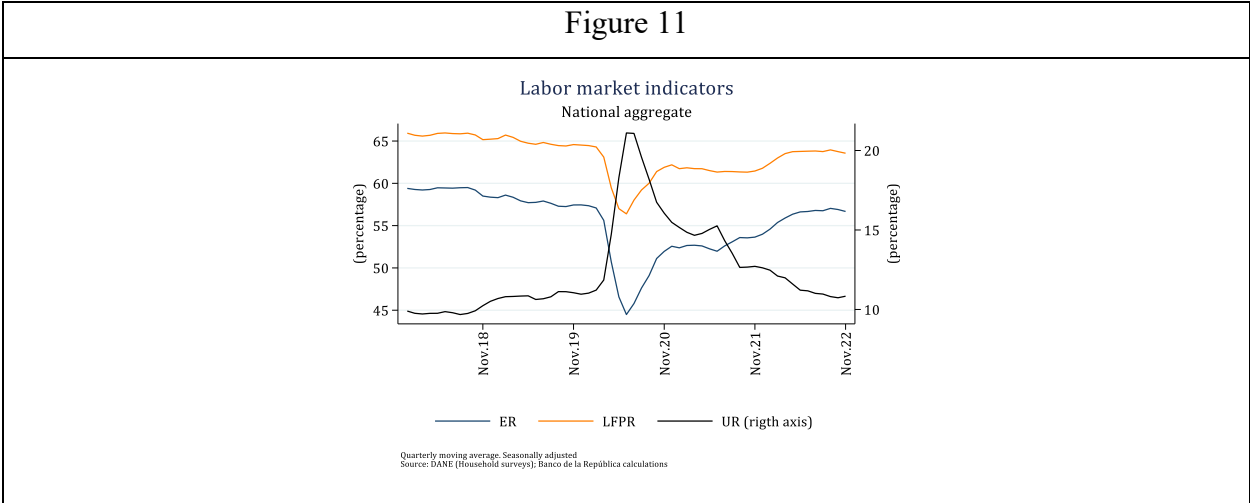
Finally, regarding labor participation, it has a maximum correlation of only 0.31, that is contemporaneous and statistically significant. The fact that this indicator has a low pro-cyclicality

⁸ We update the chronology to include the economic contraction induced by the COVID-19 pandemic.

is not at odds with economic theory, which predicts that two opposite forces influence the participation decisions over the business cycle: in recessions, there is discouragement from current jobseekers, but, at the same time, entry of additional members of the household to compensate the income-losses of the primary earner of the family. Therefore, it seems that there is not a clear force dominating the other, and the movements of the participation rate respond more to structural factors (demographic change, the entry of women into the labor force, etc.).

2.3. The labor market in the wake of the pandemic

In March 2020, as in many other countries, the Colombian Government declared the COVID-19 pandemic a public health emergency and imposed a national lockdown that excluded some essential economic activities. This had abrupt, substantial short-term impacts on the labor market. The employment rate (ER) contracted by approximately 12 pp between February and May 2020, while the labor participation rate (LFPR) went from 63,1% to 55,4% (Figure 11). Moreover, and despite the significant contraction in labor supply, unemployment peaked at 20,6% in May 2020. Following May 2020, the labor market began a gradual recovery, albeit at a slower rate than the recovery of economic activity. It was not until the end of 2022 that the key labor market indicators exhibited levels comparable to those observed before the onset of the pandemic.



The sectoral restrictions imposed by the national Government between March and August 2020 partly explain the sudden labor market deterioration. Taking advantage of the sectoral variation

implied by the excluded sectors from the restrictions, Morales et al. (2022a) estimate that the effect of the sectoral restrictions on employment accounted for approximately a quarter of the job losses. Other aggregate factors explain the rest of the fall, such as the general lockdown or the contraction of aggregate demand. Moreover, it is also documented that in the short term, the most significant job losses occurred in small and medium-sized companies belonging to sectors with fewer teleworking possibilities and more physical proximity between workers (GAMLA-Banco de la República, 2020b; Morales et al., 2022b). Likewise, firm-level estimates based on administrative records show that the pandemic led to the exit of numerous small and medium-sized firms. While there were few bankruptcies among large companies, significant payroll cuts were observed in this segment. These staff cuts were substantial in companies with lower productivity, liquidity, and profit margins before the pandemic (GAMLA-Banco de la República, 2021c).

On the labor supply side, the drop in labor participation was considerably more prominent for women and low-skill workers. Remarkably, the differential effect on women was mainly driven by those belonging to households with children (GAMLA-Banco de la República, 2021a). The latter findings reflect that women were particularly affected by the school closures, which were considerably prolonged in Colombia. With the reopening of schools by the beginning of 2022, the labor force participation rate significantly recovered. However, even in 2022, there was still a non-negligible difference in participation by gender relative to the pre-pandemic period. The gender gap in participation at the end of 2022 was around 0.8 pp higher than before the pandemic.

Interestingly, the informality rate did not significantly increase during the pandemic (Figure B-1 in Appendix B), in contrast with the empirical regularity reported previously regarding its countercyclical nature. This could be the result of the mobility restrictions and social distancing measures adopted to prevent contagion and that discouraged informal activities that tend to be contact-intensive. Afterwards, the strong recovery of the economy pushed formal labor demand and reinforced the declining trend of the informality rate.

Another effect of the pandemic that has been documented by the literature is the differential behavior of labor demand across occupations. For example, once the lockdowns were eased, a faster growth was observed in vacancies in occupations with high skills and low potential for

automation (such as professionals and technical workers) compared to those more prone to automation (such as elementary occupations, clerical support, and sales works, among others) (Bonilla et al., 2022). This could be a structural shift in the labor demand in a country with high informality and unemployment and could imply the rise of structural mismatches between the current workers' skills and those required by the labor market, with potential effects on long-term informality and unemployment rates, and the location of the Beveridge curve (GAMLA-Banco de la República, 2021b).

Finally, there is evidence that the policy measures designed to reduce job losses and compensate for income reductions due to the pandemic had mixed impacts on the labor market outcomes. On the supply side, the Government notably increased the coverage and the number of direct subsidies granted to the most vulnerable households: Subsidies grew from 0.3% of GDP in 2019 to 1.3% in 2021. The available literature found that there were no persistent changes in labor participation in the groups most likely to receive additional subsidies during the pandemic (GAMLA-Banco de la República, 2022; Gallego et al., 2021) and that there were positive (albeit modest) effects on measures of households' well-being such as food access or financial inclusion (Londoño-Velez & Querubin, 2022; Gallego et al., 2021). On the demand side, the Government introduced a program for employment protection with different payroll subsidies to the most affected firms during the pandemic. Recent impact assessments show positive, sizable, and persistent effects in eligible firms for the subsidy compared to the non-eligible ones (GAMLA-Banco de la República, 2023; Bonilla et al. 2023). The average effect for eligible firms was an increase in employment of 4 pp. with respect to non-eligible ones.⁹

3. The contribution of wages in the recent inflationary surge

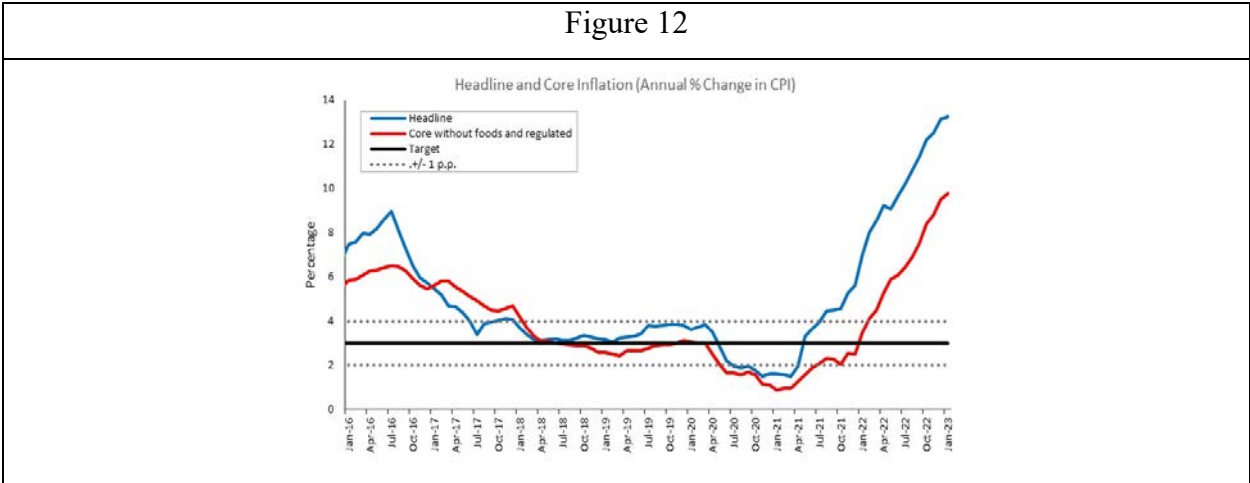
In this section, we focus on the wage-setting process in Colombia and the role of wages in the recent inflationary escalation. We first summarize the main drivers of inflation in the aftermath of the pandemic. Next, we describe the major features of the wage-setting process in Colombia, highlighting the critical incidence of the MW both in the distribution of wages and in its annual adjustments. Finally, we estimate the long-run relationship between wages, prices, and

⁹ To achieve this impact, the policy had a cost of COP 715 billion, equivalent to 0.1% of the GDP.

productivity. This exercise allows us to gauge the current and prospective inflationary pressures stemming from the labor market.

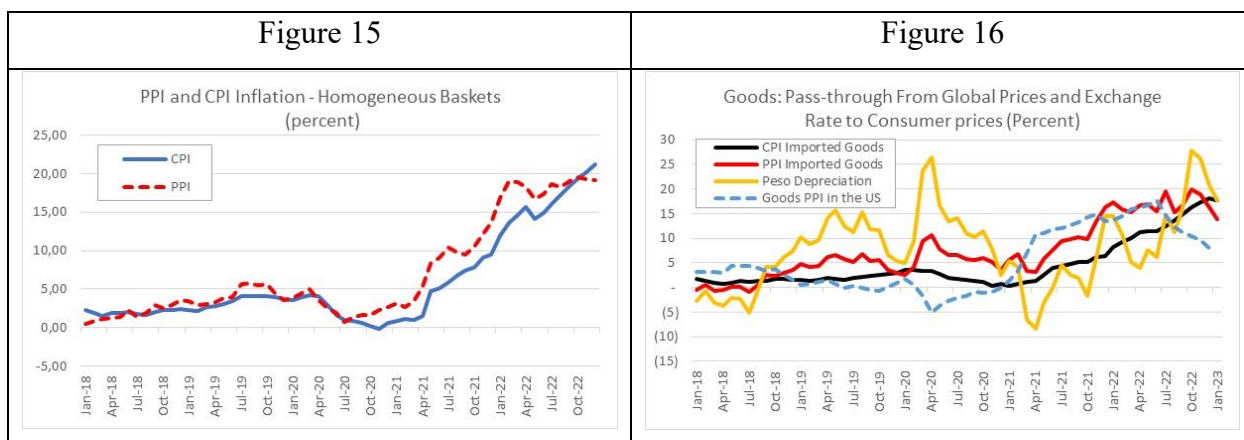
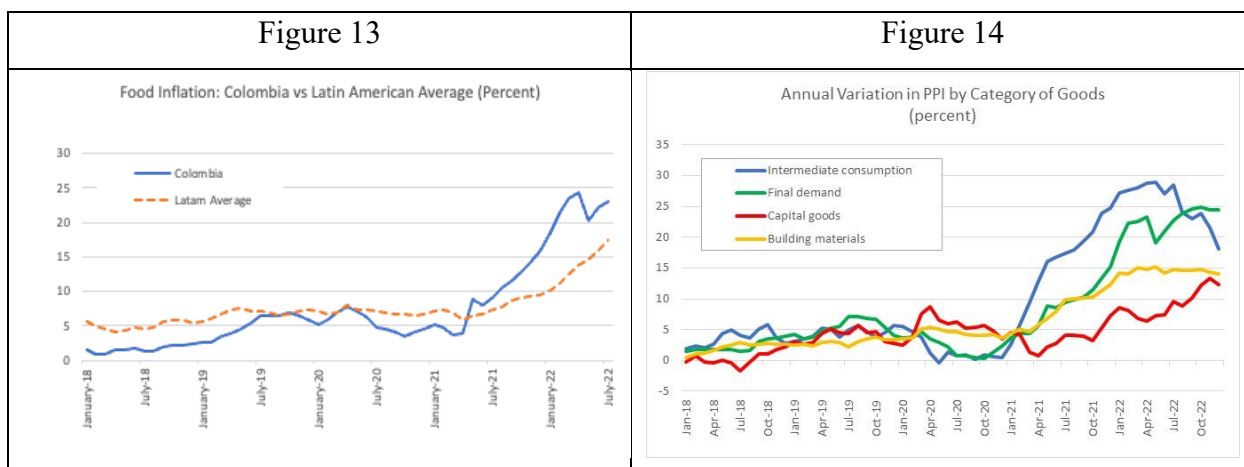
3.1. Main drivers of the current inflation escalation

Inflation in Colombia fell below the 3% target during the pandemic in 2020 and 2021, and it bottomed out at 1,51% in March 2021, its second lowest level in history. In the second quarter of 2021 inflation started to increase and in January 2023 both headline and core inflation reached their highest point (13.1% and 9,8%, respectively) since 1999, and, unlike in other countries, they have not peaked (Figure 12).



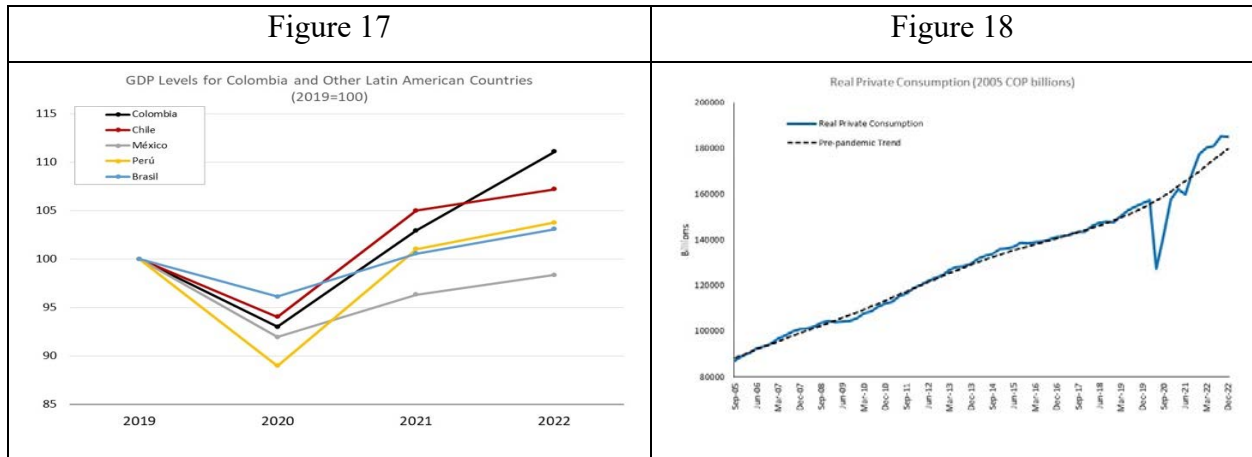
There are multiple factors and shocks that explain the behavior of inflation. First, several relief measures during the pandemic were implemented through prices. These measures included temporary reductions in prices of public utilities, persistent decreases in the prices of fuels, and temporary elimination of VAT and consumption taxes in mobile phone plans, hygiene products, restaurants, and hotels. The timing of the reversion of these measures has been spread over time and continues to affect measured inflation as price levels recover. Second, the increase in inflation has been led by food and good prices. On the one hand, food prices started increasing sharply in May 2021, as road blockades amid two months of social unrest protests affected the production cycle and the productive capacity of several products. A year later, food inflation in Colombia was higher than in most countries in Latin America with the blockades explaining about 9pp of the

difference (Figure 13). This shock was followed by other negative supply shocks, including the Russian invasion of Ukraine that affected input prices (e.g., fertilizers) and excess rain over the last two years, as well as a sustained local currency depreciation that affects mainly processed foods. With all this, food inflation finished 2022 at 28%. In the case of goods, initially the supply chain disruptions that affected production and trade globally were behind the surge. Cost increases have been widespread (Figure 14) and have been passed through prices (Figure 15). More recently, the sustained and relatively high depreciation of the currency (see Figure B-2 in Appendix B) has been also passed through to good and food prices (Figure 16), which have kept rising despite the fall in transport and logistics costs, and the reduction in the growth of these prices globally.

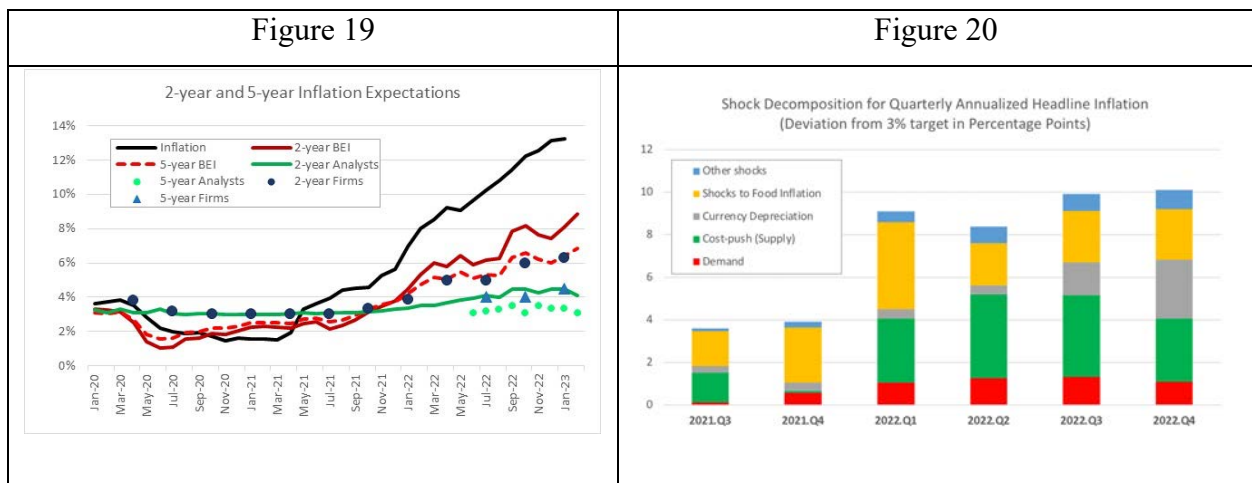


Demand factors have also played a role. The recovery of the Colombian economy after the pandemic has been remarkable (Figure 17) with GDP reaching levels above pre-pandemic trends, led by private consumption (Figure 18) supported by a fall in savings, credit growth and the

recovery of the labor market, but also against the backdrop of sustained fiscal deficits (7.2% of GDP in 2020, 7.1% in 2021 and 6.4% in 2022 for the General Government).



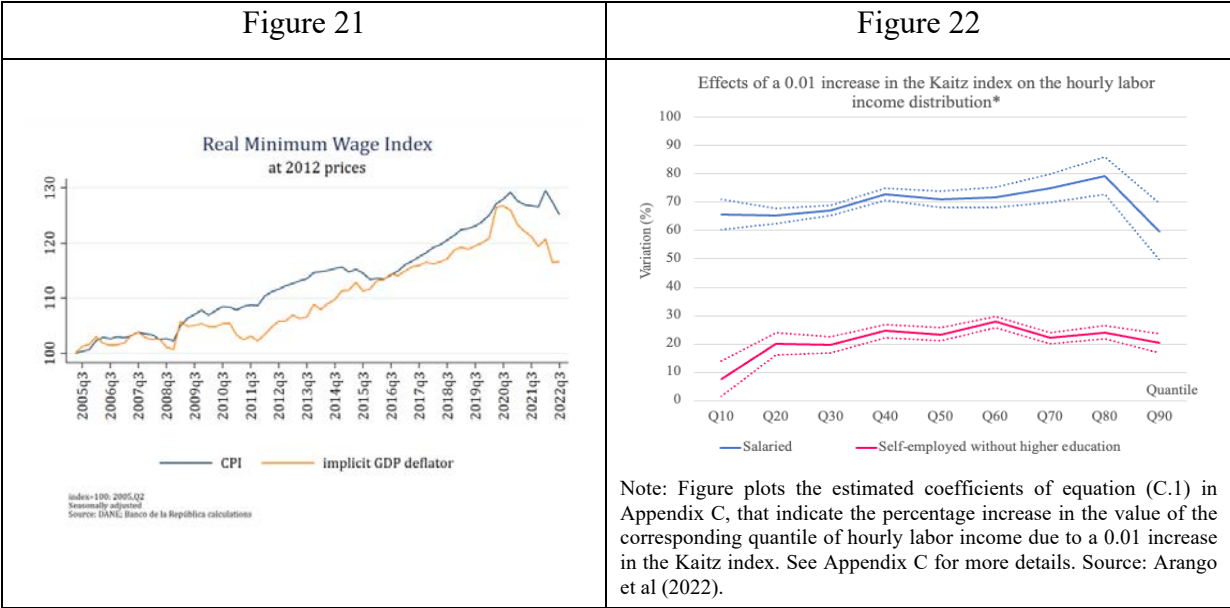
More recently two other factors are playing a role in inflation dynamics, imprinting persistence in inflation, which might make the disinflationary process longer and more costly. First, as price increases well above the inflation target have become widespread, inflation expectations have risen (Figure 19), with all expectation measures lying well above target at all horizons. This may be a factor behind generalized and relatively large price increases. Second, as inflation has risen, indexation mechanisms are playing a bigger role and the risk of a higher degree of indexation in the economy has become more prominent. These indexation mechanisms affect some important prices, such as those of public utilities and rents, and even the MW, as we will explain below.



All the factors mentioned above have been important in the behavior of inflation. Using a semi-structural model for monetary policy, we decompose inflation to gauge the contribution of different shocks to inflation (Figure 20). Cost push shocks, that were the main driver of inflation at the end of 2021 and the first half of 2022, have started to vanish. Nevertheless, as of the end of 2022 they still accounted for about 30% of inflation. Shocks to food prices that at the beginning of 2022 accounted for about half inflation now account for about 25%, whereas shocks that affected the exchange rate contributed little at the beginning of 2022, but now account for about 30%. Finally, aggregate demand shocks contribute to explain about 10% of inflation and gained importance in absolute terms as 2022 progressed. A similar picture emerges from the shock decomposition of core inflation, but with a bigger contribution from aggregate demand shocks, which explain 15% of the surge, and also a larger contribution (40%) from the depreciation of the Colombian Peso (see Figure B-3 in Appendix B)

3.2. The wage-setting process in Colombia and the macroeconomic impacts of the MW

One of the main features of the wage-setting process in Colombia is the critical influence that the mandatory legal MW has both on the observed distribution of wages and on the adjustments of other wages and prices (indexation mechanism). As mentioned above, the ratio of the MW to the median wage in Colombia is high with respect to other advanced and emerging economies (Figure 1). The current pervasiveness of the MW in the distribution of wages in Colombia is the result of initially high values and the accumulation of significant positive annual real increases experienced in the last two decades. Figure 21 shows two real MW indices from 2005 to 2023. The MW deflated by the CPI has grown around 27.4% between June 2005 and June 2022; the same rate is 16.5% using the implicit GDP deflator. These dynamics are supported by a constitutional court ruling that prevents the MW annual increases to be lower than past CPI inflation. It is worth noting that in the aftermath of the pandemic, in 2022 and 2023, the real minimum wage growth rate reached its highest levels of 4.5% and 2.8%, respectively, when deflated by the past year CPI. These growth rates have been higher than different measures of labor productivity, possibly contributing to the recent rise in inflation, an issue that we explore in the next subsection.



The MW influence is evident not only in the high share of workers earning it, but also in how the MW hikes could affect other salary increases in the market. Rises in the Kaitz index (the ratio of the MW to the 70th percentile of the wage distribution) of the Colombian cities were associated with increases in virtually all quantiles of the earnings distribution, controlling for fixed time effects and individual and city characteristics (see Figure 25, and for more details, Appendix C). Moreover, the impacts of rises in the Kaitz index are substantially stronger in the distribution of the earnings of the salaried workers than in the distribution of labor income for the non-salaried segment. These observations suggest a possible impact of the MW in the determination of other salaries in the formal sector.

A comprehensive study on the macroeconomic effects of the MW in Colombia (Arango et al., 2022) was recently published by the Central Bank of Colombia. Given the prominent influence that the MW has on the labor market, the observed distribution of wages and on the indexation of other salaries and prices, in what follows we briefly summarize some of its findings. We focus our summary on the effects on three dimensions: inflation, employment (informality and formal employment) and the adjustment of macroeconomic variables to changes in the MW.

First, regarding inflation, the study uses different methodologies to assess the impact of MW hikes on prices, exploiting both aggregate and micro-level data. With aggregate data, two methodologies

(an IV approach that uses variation over time and an accounting exercise that uses an input-output matrix and the distribution of value added across factors remunerations) find similar results: a rise of 10 pp in the MW causes an increase of up to 1,4 pp in the total CPI inflation and up to 1 pp in the core inflation. It should be noted, however, that these estimates only cover a period characterized by low inflation (2010 - 2019) and that the input-output analysis finds variable impacts depending on the year evaluated. Regarding the exercise with microdata, the results suggest a considerable heterogeneity of the pass-through of the MW to prices across different price baskets, with food and food away from home showing the greatest transmissions. Excluding regulated goods and services, the median rise in prices following an increase of 10 pp in the MW is 1,6 pp, a transmission that occurs mainly during the four months after the MW hike.

Regarding employment, the study begins by summarizing the literature on the effects of the MW on the informality rate in Colombia. The tested mechanism in most of those studies is well-known: when the rise in the MW is higher than the increase in labor productivity, hiring slows down, and job seekers are pushed to informality. This mechanism is particularly relevant in Colombia, where productivity growth is heterogeneous across different regions or labor market segments, but there is a single national MW. For instance, by exploiting regional variation, Arango & Florez (2020a) find that a rise of 10 pp in the MW relative to the wage in the 70th percentile of the wage distribution increases the informality rate by 1.4 pp on average in the main cities. However, there are noticeable heterogeneous effects across cities, with the largest impact for a given city being 6.2 pp. Using variation across demographic groups instead, Arango et al. (2020b) find that the same rise in the relative MW increases the informality rate by 2.1 pp on average. The effect is larger for young, female, and less skilled workers. These results confirm the impacts estimated previously in the literature for Colombia, in which rises in the Kaitz index led to higher probabilities of being informal (Mondragón et al., 2013; Mora & Muro, 2014).

The study also estimates the impact of the MW on formal employment by considering the effects on formal job creation and destruction separately. The results suggest that a 1% increase in the real MW reduces formal employment by 1%. The drop in formal employment is accounted for by an increase of 44 basis points (bp) in formal job destruction and a decrease of 56 bp in formal job creation. It is worth saying that the destruction of formal employment does not necessarily imply

a direct impact on informality, since workers could move not only towards informality but also to unemployment or inactivity.

Finally, the study includes an analysis of the adjustments of some macroeconomic variables to unanticipated shocks to the MW through the lenses of two DSGE models. The first model assumes flexible prices, incomplete financial markets and a segmented labor market between formal and informal sectors. The second model adds price rigidities and a central bank acting to stabilize prices. Regarding the adjustments within the flexible price model, an unanticipated increase of 1% of the MW reduces the share of formal employment by 1% due to the larger threshold formal firms face to hire skilled workers. Also, it reduces the capital-labor ratio by 0.78% and aggregate consumption by 0.37%. These effects are due to lower precautionary savings resulting from the insurance provided by the MW, lower savings by the workers displaced from formal to informal jobs, and to the decrease in the marginal product of capital stemming from the reduced formal employment. Regarding the adjustments with sticky prices, the same increase in the MW generates a similar re-composition towards informality and a reduction in GDP, investment, and consumption, especially of unskilled workers. The reduction of the GDP is more prominent in the short run (0.12%) than in the long run (0.08%) and generates a negative output gap with respect the output under flexible prices. With respect to prices, the cost-push shock induced by the MW hike dominates the impact on the output gap and thus headline inflation rises (8pb). Finally, given that the monetary authority reacts to both the output gap and inflation, the calibrated policy rule suggests that the response of monetary policy is mild.

Beyond the critical importance of the MW, the literature has explored some microeconomic features of the wage-setting process in Colombia using different firms' surveys. For example, Iregui et al. (2012) document that firms adjust wages less frequently than prices, that time-dependent wage adjustments are more common than time-dependent price changes, and that firms usually do not cut wages (suggesting downward wage rigidity). This latter fact is explained by the observed Colombian practice of adjusting wages in line either with the previous year's inflation rate or with the increase in the MW. This result, coupled with the low frequency of wage changes, provides evidence of noticeable wage stickiness in the formal labor market.

Finally, there is evidence of considerable heterogeneity of the pass-through from wages to prices across industries. Iregui et al. (2012) find that, when asked about the importance of past wage increases for price changes, 37% of the firms responded that they were not important at all, whereas 20% considered them to be very important. Part of the variation in the answers is explained by the industry to which the firms belong. So, although the relationship between wage and price changes does not generally seem to be exceptionally strong, the pass-through of wages to prices is particularly high in some sectors, especially in those in which the labor cost share is high.¹⁰ The evidence also indicates that the pass-through is mediated by industry-level dimensions, such as the sectoral aggregate labor productivity (Iregui et al., 2012) or market concentration (Heise et al, 2021).

3.3. Assessing the inflationary pressures from the labor market

In order to gauge the current and prospective inflationary pressures stemming from wages, a long-run relationship between prices, wages, and labor productivity is estimated for Colombia. More specifically, we aim to answer these questions: (i) Are wages significantly above their long-term relationship with productivity and prices, thereby contributing to the observed inflation rise (e.g., through increasing unit labor costs or high inflation expectations)? and (ii) do their expected dynamics imply serious inflationary risks in the future? A simple framework to address these questions acknowledges that consumer prices in a small open economy are made up by domestic and imported components,¹¹ so that the following relationship is posited:

$$w_t = \beta_0 + \beta_1 p_t + \beta_2 lp_t + \beta_3 p_t^* + \beta_4 e_t + \varepsilon_t \quad (\text{Eq. 1})$$

In which w_t are nominal wages, p_t is the CPI, lp_t is output per worker, p_t^* are foreign consumption good prices and e_t is the nominal exchange rate (all in logarithms). We estimate Eq.

¹⁰ For example, wage increases are very important in setting prices for around 60% of the firms surveyed in the education and health sector, and in other services.

¹¹ Let P be the CPI. Then $P = (P^D)^a (P^M)^{1-a}$ where P^D and P^M are the domestic and imported components of consumer prices, respectively. P^M can be approximated by the product of foreign prices (P^*) and the exchange rate (E): $P^M = P^*E$. Further, P^D is driven by nominal wages (W) and the marginal product of labor (MPL): $P^D = W/MPL$. Therefore, we obtain $P = (W/MPL)^a (P^*E)^{1-a}$ that in logs corresponds to Eq. 1. The five series (in logs) have unit roots (Table B-2 in Appendix B), so that a cointegration relationship is estimated using Johansen's method.

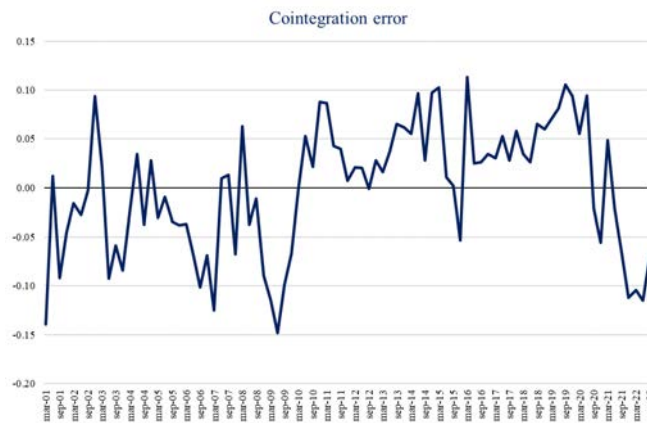
1 using a Johansen cointegration methodology. The estimated Johansen’s VEC long-run and short-term error-correction coefficients are presented in Table 2, and the cointegration error is shown in Figure 23.¹² The latter indicates that wages in 2022 were *below* their long-term level, given the values of the other macro variables included in the system. This is consistent with the documented formal wage rigidity in the midst of the inflationary and exchange rate shocks mentioned above. Hence, up until the third quarter of 2022, there is no evidence of wage growth in excess of labor productivity significantly contributing to the sharp increase of inflation.

Table 2

| | β | α |
|-------|----------------|---------------------|
| | LT coefficient | ST error correction |
| w | 1 | -0.39*** |
| p | 0.94*** | -0.032** |
| lp | 1.36*** | 0.028 |
| p^* | 0.30 | -0.027 |
| e | 0.09 | 0.310*** |

Notes: The table shows the estimated coefficients of the cointegrating vector (Eq. 1) and the short-term adjustment mechanism of a VECM model with three lags and one cointegrating equation. Significance levels *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Figure 23



Source: Authors’ calculations.

¹² The Johansen trace test shown in Table B-3 in Appendix B indicates that there is only one cointegration vector for this system in the 2000Q1-2022Q3 sample.

Going forward, however, the evolution of wages do represent a risk for convergence of inflation toward the 3% target. Starting from levels below their long-term “equilibrium” level, a correction of the current deviation would imply large upward adjustments of wages, *ceteris paribus*. As implied by the significant and relatively large value of the short-term error correction coefficient (α) in Table 2, wages have typically been one of the main ways in which the long-run equilibrium is restored in the estimated system (the other being the exchange rate movements). Indexation of formal wages is a mechanism through which such an adjustment takes place¹³. Hence, if the inflationary shocks persist for a protracted period, demand pressures remain, or the currency depreciates further, wage increases would likely be large and could delay convergence of inflation to target, requiring a tighter stance of monetary policy¹⁴.

4. Conclusions

This paper provides an overview of the main structural features of the labor market in Colombia and analyzes the role of wages in the post-pandemic inflationary surge. For this, we depict the performance of the key labor market indicators over the past few decades and link it to the main findings of the recent literature on topics such as the impacts of the COVID-19 pandemic, the roots of informality and the macroeconomic effects of the MW, among others. We document a highly segmented labor market with a significant incidence of informality and unemployment, although with improvements in both indicators in the decade before the pandemic. Regarding labor income, while we observe procyclical informal labor earnings, salaries in the formal sector are sticky and heavily influenced by the MW. The bindingness of the MW in Colombia is high relative to other economies, and there is evidence that further increases in the real MW relative to productivity have adverse macroeconomic impacts. The pass-through of wages to prices is not very strong, but there are noticeable heterogeneities of the transmission across sectors.

¹³ Suppose, for example, the following “error correction” mechanism for wages: $\Delta w_t = (p_{t-1} - w_{t-1} - lp)$, with constant labor productivity, lp . Then, $\Delta w_{t+1} = (p_t - w_t - lp) = (p_{t-1} + \Delta p_t - w_{t-1} - \Delta w_t - lp) = \Delta p_t$, which corresponds to a case of complete backward indexation of wages.

¹⁴ Based on a sample of advanced economies, Alvarez et al. (2022) find that episodes with macro features similar to those of the post-COVID-19 (accelerating inflation, declining real wages and tight labor markets) are followed by nominal wage rises to catch-up with prices, supported by low unemployment.

Finally, we estimate the long-run relationship between aggregate prices, wages, and labor productivity, to explore whether the dynamics of nominal wages and their expected adjustments to catch up with prices have fueled the post-pandemic inflationary escalation. We conclude that, up until the third quarter of 2022, wages were below their “long-term” level, given the shocks to prices and the exchange rate. Therefore, wage increases above labor productivity growth were not among the main drivers of the observed inflation escalation. However, their adjustment toward their long-term “equilibrium level” (possibly through indexation) could imply risks for convergence of inflation to target, especially if inflationary shocks persist, aggregate demand remains strong, or the currency depreciates further.

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APPENDIX A: A stylized model of the labor market under a real minimum wage

Main assumptions:

Consider a closed economy with one good and flexible prices in a static setting. The good is produced by a formal competitive firm that uses a constant returns to scale (CRS) technology that employs formal labor and capital, and is subject to a binding real minimum wage regulation. The good can also be produced with a less productive technology, in which workers use their informal labor input only. The workers earn the totality of the output produced in the informal sector.

The workers are made up by households that do not own capital and decide how much labor to supply in the formal market and how much labor to use in the informal production. There are N worker-households of this type. The stock of capital is pre-determined and owned by a capitalist household, who does not work and inelastically supplies capital, earning a competitive rental price.

The assumption of a binding real minimum wage is a reasonable approximation to the MW regulation in Colombia, which establishes that the nominal MW growth cannot be lower than past inflation.

Equilibrium:

The labor supply decision is based on an intra-temporal optimization problem in which households know that, due to the binding real minimum wage, there is unemployment in equilibrium. Thus, they maximize an expected utility function that is computed on the basis of the probability of getting a formal job. The possibility of being unemployed prompts households to allocate time to informal production.

In equilibrium, the rental price of capital clears the capital market, formal labor is determined on the demand side by the binding real MW, formal labor supply may be greater than demand (there may be equilibrium unemployment), informal production is positive and the subjective probability of finding a formal employment coincides with the ratio of formal labor demand to total formal labor supply.

Workers' decision problem:

All households are identical ex-ante. They estimate a subjective probability of formal employment equal to p . They solve the following problem:

$$\begin{aligned} & \text{Max} \quad p U(c_L^f, l^f + l^i) + (1 - p) U(c_L^i, l^f + l^i) \\ & c_L^f, c_L^i, l^f, l^i \\ & \text{Subject to} \\ & c_L^f = w^{\min} l^f + G(l^i) \quad (\text{A1}) \\ & c_L^i = G(l^i) \quad (\text{A2}) \end{aligned}$$

$\bar{l}^f, \bar{l}^i, c_L^f, c_L^i$ and $G(l^i)$ are formal labor supply, informal labor supply, household consumption when formal, household consumption when informal and the informal production function, respectively. The FONC for this optimization problem imply:

$$w^{min} = -\frac{E[U_l(\cdot)]}{p U_c(c_L^f, l^f + l^i)} \quad (A3)$$

$$G'(l^i) = -\frac{E[U_l(\cdot)]}{E[U_c(\cdot)]} \quad (A4)$$

Formal firm's decision problem:

$$\begin{aligned} \text{Max } & F(L^f, K) - w^{min} L^f - r K \\ & L^f, K \end{aligned}$$

$F(\cdot), L^f, K$ and r are the formal firm's technology, demand for labor, demand for capital and the rental price of capital, respectively. FONCs are conventional in this case:

$$F_L(L^f, K) = w^{min} \quad (A5)$$

$$F_K(L^f, K) = r \quad (A6)$$

Capital owner's decision:

Capital owners inelastically supply of a pre-determined capital stock and consume the proceeds from its rent:

$$K = \bar{K} \quad (A7)$$

$$c_K = r \bar{K} \quad (A8)$$

Competitive equilibrium:

Equilibrium values for $c_L^f, c_L^i, c_K, \bar{l}^f, \bar{l}^i, L^f, K$ and r satisfy equations (A1) through (A8) and ensure that the subjective probability of formal employment equals the actual ratio of formal labor demand to formal labor supply:

$$p = \frac{L^f}{N l^f} \quad (A9)$$

Thus, formal labor demand will be determined by the fixed stock of capital and the minimum wage and can be lower than formal labor supply, i.e. there may be unemployment in equilibrium. Good market equilibrium holds by Walras Law, since the capital market clears, informal output is totally consumed by workers, formal employment is determined as previously described and there is a CRS technology in the formal sector (there are no economic profits).

Comparative statics:

The model above is used to explore the effects of changes to the MW on unemployment and informality. It is also used to study the impact of rising physical and human capital, which, as stated in this note, may be behind the declining trend of informality observed in Colombia, despite high MW and formal payroll surcharges.

Preferences and technology are specified as follows:

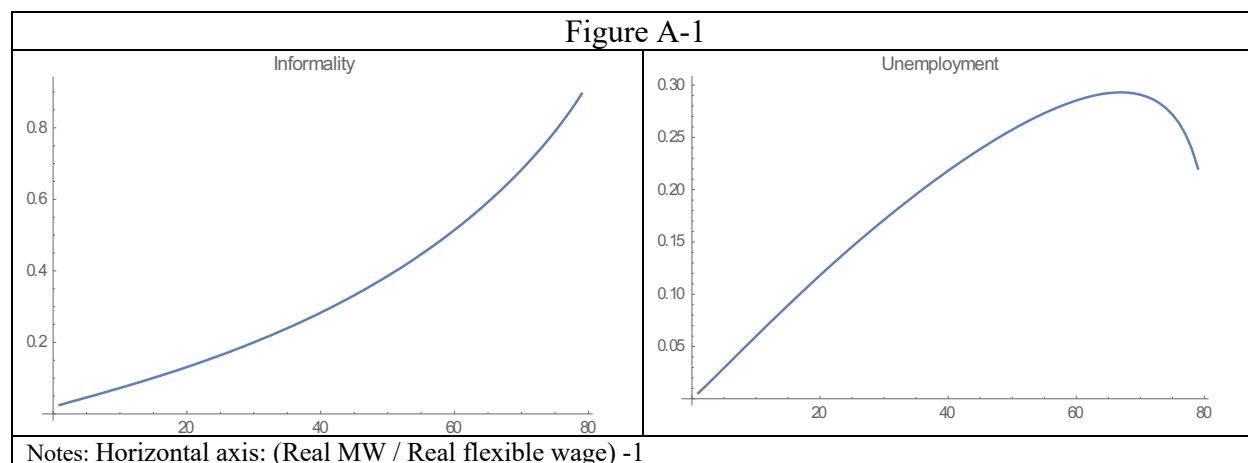
$$U(c, l^f + l^i) = \ln(c) - \frac{(l^f + l^i)^{1+\varphi}}{1 + \varphi}$$
$$F(K, L^f) = A (\alpha K^\rho + (1 - \alpha) L^{f\rho})^{1/\rho}$$
$$G(l^i) = B l^{i\gamma}$$

Given the nature of the model and the specification of preferences and technology, closed form solutions of equilibrium are difficult to obtain. Thus, numerical simulations are performed with the following parameterization:

$$\varphi = 0.4, \rho = -1.35, \alpha = 0.3, \gamma = 0.5, A = 1, B = 0.2 A, N = 1$$

Effects of changes in the real MW on informality and unemployment

As the binding real MW increases, formal labor demand diminishes, reducing the probability of finding a formal job. Workers respond by raising informal labor to sustain consumption, thereby increasing informality (defined as the ratio of informal employment to total employment). Unemployment, on the other hand, may rise or fall following a higher real MW (Figure A-1)¹⁵.



¹⁵ The horizontal axes in Diagram 1 represent the percentage deviation of the real MW from the real wage that would prevail in the absence of minimum wage regulation.

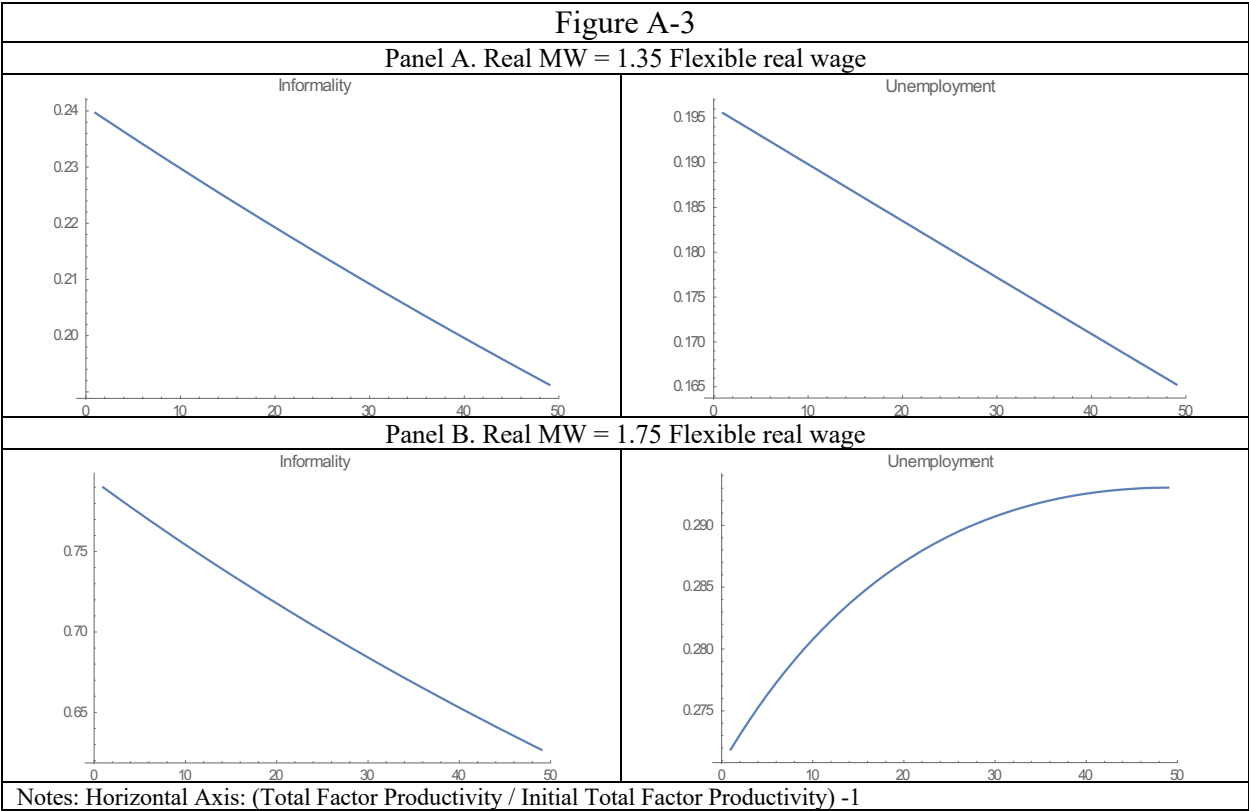
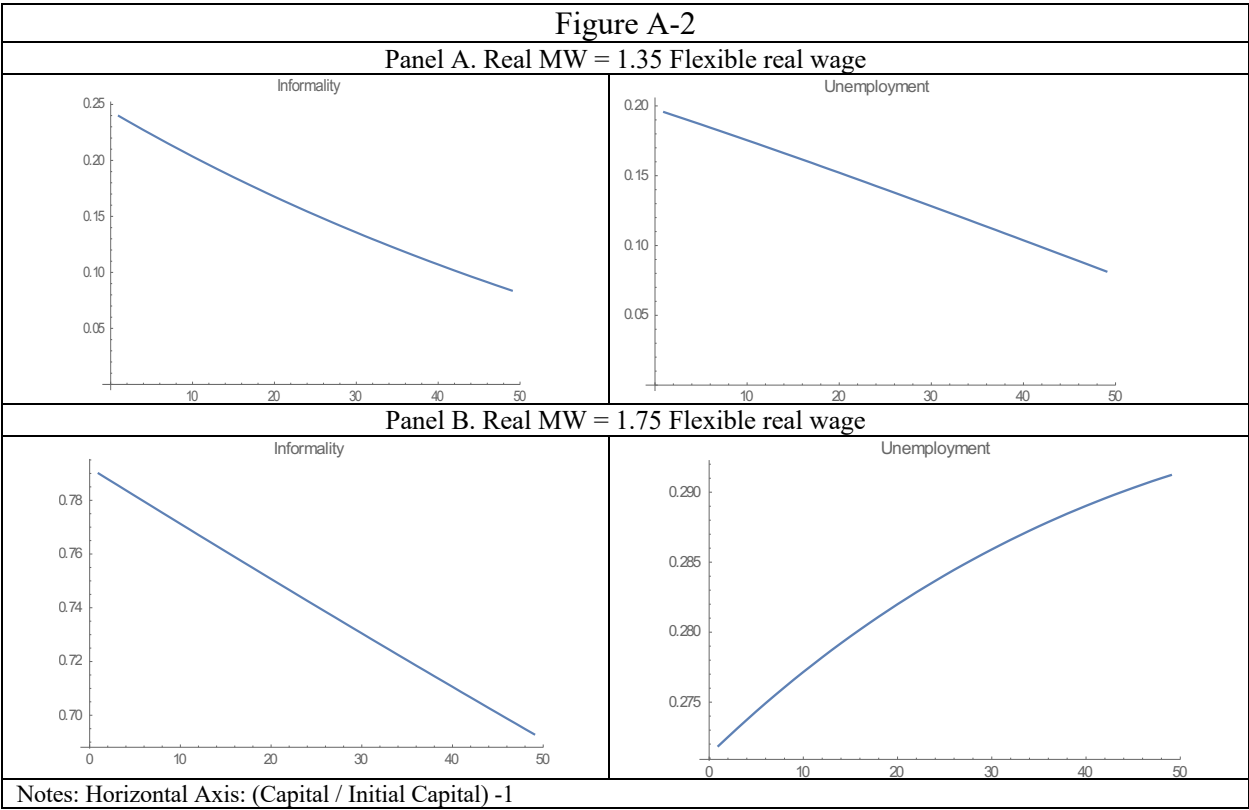
This happens because the rise in the MW decreases formal labor demand, but also discourages formal labor supply. The latter effect is the result of a decreasing ex ante perceived probability of finding a formal job. Thus, for not too high real minimum wages, a relatively high probability of finding formal work implies a small drop in labor supply with respect to the fall in labor demand. However, as the effects of higher real MW on formal employment accumulate, the probability of finding a formal job reaches low levels and formal labor supply drops become larger, while, at the same time, formal marginal labor productivity rises, dampening the impact of higher wages on formal labor demand. Consequently, a smaller unemployment rate is obtained in equilibrium.

Effects of changes in the capital stock on informality and unemployment

When the MW is relatively small (e.g. 1.35 times the real wage with no MW regulation), the probability of finding a formal job is high, so that increases in capital raise formal labor demand, but not so much formal labor supply (Panel A of Figure A-2). By contrast, when the MW is relatively large (e.g. 1.75 times the real wage with no MW regulation), the probability of finding a formal job is low. Increases in capital raise formal employment and significantly upgrade the perceived probability of formal employment. As a result, formal labor supply jumps and unemployment rises. In all cases, informality drops (Panel B of Figure A-2).

Effects of changes in total factor productivity on informality and unemployment:

As total productivity rises, informality generally drops, following an increase in formal employment and a decrease in the informal one (Panel A of Figure A-3). Regarding unemployment, as in the exercises above, the effect is ambiguous and depends on the level of the MW. For a low MW (1.35 times the real wage with no MW regulation), the initial probability of finding a formal job is high and, as consequence, total factor productivity increases raises formal labor demand by more than formal labor supply, thus reducing unemployment. For a higher MW (e.g. 1.75 times the real wage with no MW regulation), the productivity gains increase the probability of finding a formal job from low initial levels, raising labor supply relative to labor demand. Consequently, unemployment goes up (Panel B of Figure A-3).



APPENDIX B: Additional Tables and Figures

1. Additional Tables

Table B-1
Full correlation matrix of the key market labor indicators with respect to the GDP

| Variables | Lags and leads with respect to the GDP | | | | | | | | | | | | |
|------------------------------------|--|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|----------|----------|-----------|-----------|
| | -6 | -5 | -4 | -3 | -2 | -1 | 0 | +1 | +2 | +3 | +4 | +5 | +6 |
| Employment rate | -0.232*** | -0.212*** | -0.095 | -0.058 | 0.092 | 0.388*** | 0.732*** | 0.456*** | 0.195** | 0.027 | -0.12 | -0.217*** | -0.247*** |
| Unemployment rate | 0.197** | 0.140* | -0.019 | -0.116 | -0.272*** | -0.527*** | -0.851*** | -0.644*** | -0.377*** | -0.189** | 0.048 | 0.182** | 0.201** |
| Labor force participation rate | -0.174** | -0.202** | -0.174** | -0.227*** | -0.152* | 0.063 | 0.308*** | 0.039 | -0.114 | -0.189** | -0.162** | -0.173** | -0.201** |
| Informality rate | -0.143* | -0.211*** | -0.274*** | -0.286*** | -0.358*** | -0.330*** | -0.349*** | -0.360*** | -0.350*** | -0.093 | -0.074 | -0.108 | -0.053 |
| Salaried wage (median) | -0.102 | -0.079 | 0.007 | 0.101 | 0.202** | 0.252*** | 0.224*** | 0.183** | 0.095 | 0.059 | 0.081 | 0.135* | 0.208** |
| Non-salaried labor income (median) | -0.017 | -0.031 | 0.057 | 0.155* | 0.176** | 0.284*** | 0.440*** | 0.578*** | 0.400*** | 0.272*** | 0.098 | 0.03 | 0.098 |

Notes: Significance levels: * p<0.10, ** p<0.05, *** p<0.01.

Table B-2
Dickey-Fuller tests for unit root presence

| | Test statistic | Dickey-Fuller critical value (at 1%) |
|--|----------------|--------------------------------------|
| Log. wage | -1.29 | -4.02 |
| Log wage (first difference) | -17.28 | -4.02 |
| Log. labor productivity | -1.65 | -4.02 |
| Log. labor productivity (first difference) | -15.59 | -4.02 |
| Log. CPI | -3.32 | -4.02 |
| Log CPI (first difference) | -8.26 | -4.02 |
| Log. consumer goods price index | -1.53 | -4.02 |
| Log. consumer goods price index (first difference) | -6.93 | -4.02 |
| Log. Exchange rate USD/COP | -1.58 | -4.02 |
| Log. Exchange rate USD/COP (first difference) | -7.91 | -4.02 |

Trend included.

Table B-3
Johanssen test for cointegration relations

| Maximum Rank | Eigenvalue | Trace statistic | Critical value (5%) |
|--------------|------------|-----------------|---------------------|
| 0 | . | 76.5043 | 68.52 |
| 1 | 0.30461 | 43.4459* | 47.21 |
| 2 | 0.23476 | 19.0974 | 29.68 |
| 3 | 0.10857 | 8.6389 | 15.41 |
| 4 | 0.08808 | 0.2488 | 3.76 |
| 5 | 0.00273 | . | . |

Number of lags in VAR: 4

2. Additional Figures

Figure B-1

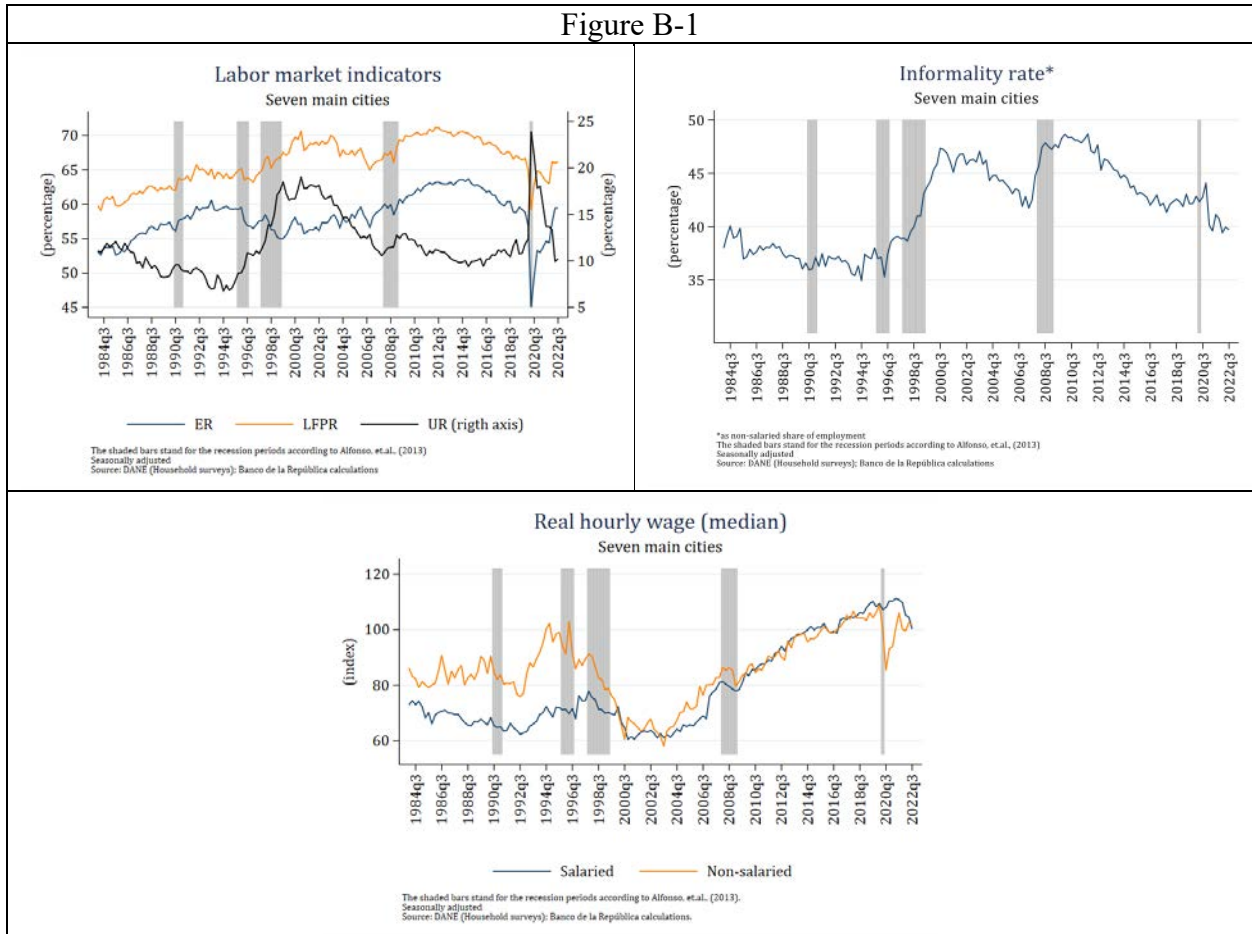


Figure B-2

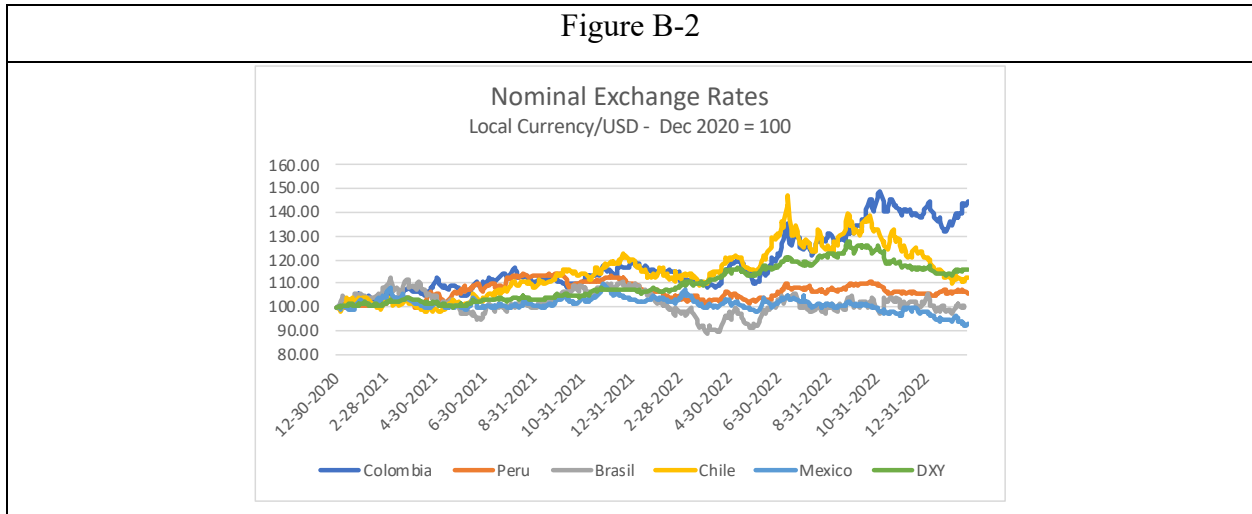
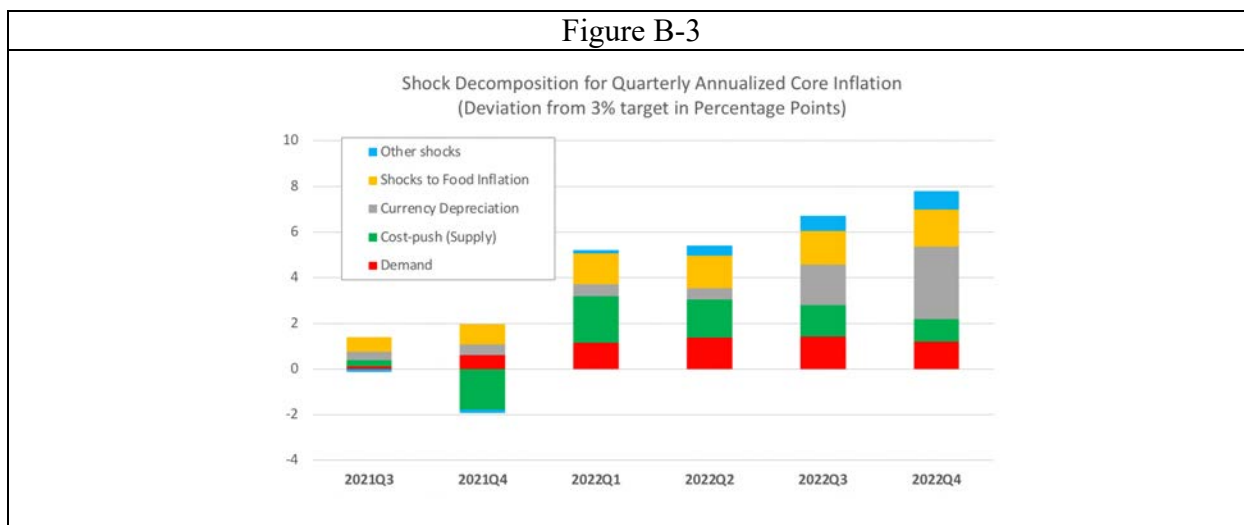


Figure B-3



APPENDIX C: Effects of an Increase in the Kaitz Index in the Earnings Distribution

In this Appendix we reproduce the methodology of Arango et al. (2022) to assess the effects of changes in the Kaitz index (KI) on the distribution of earnings of salaried workers and self-employed workers with no higher education (as a proxy of informal workers) that are displayed in Figure 22. Specifically, Figure 22 plots the estimated coefficients of a regression that quantifies how the quantiles of the earnings distribution of each group of interest, from the 10th to the 90th percentile, change due to increases in the KI of the city c where the person belongs. The method used is that of Firpo, Fortin, and Lemieux (2009), which allows to estimate the impact of changes in the distribution of the explanatory variable X on the distribution statistic $v(Y)$ of the outcome variable Y . In this case, the distribution statistic is the recentered influence function (RIF)¹⁶ of the quantile τ of the logarithm of hourly labor income for each year t between 2008 and 2019. The estimated equation is thus:

$$RIF_{\tau}(y_{ict}) = \beta_{0,\tau} + \beta_{1,\tau}KI_{ct} + \beta_{2,\tau}KI_{ct-4} + X_{ict}B_{3,t} + Z_{ct}B_{4,t} + \partial_{c,\tau} + \partial_{t,\tau} + \varepsilon_{ijt,\tau} \text{ (Eq. C.1)}$$

where i represents an individual, X_{ict} contains usual individual characteristics, Z_{ct} contains city-level characteristics, and ∂_c and ∂_t are city- and time- fixed effects respectively. The coefficients displayed in Figure 22 correspond to the sum of the estimated coefficients $\hat{\beta}_{1,\tau}$ and $\hat{\beta}_{2,\tau}$. For more details see Arango et al. (2022).

Additional reference:

Firpo, S., Fortin, N. and T. Lemieux (2009). Unconditional Quantile Regressions. *Econometrica* 77(3): 953-973.

¹⁶ Influence functions measure the influence of a single observation on the statistics of a distribution (in this case the quantile τ). The recentered influence function is the statistic plus its influence function.

