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Moderate wage increases and flexible labour contracts to protect employment in Colombian manufacturing

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Abstract

Based on conditional and unconditional demands for labour, we exploit the variations of real minimum wage across manufacturing subsectors to present evidence that this variable affects formal employment. *The long-term elasticity of labour demand to the minimum wage is around –0.7*. Accordingly, increases in the minimum wage lead to job losses for unskilled labour, mainly in plants with fewer than 100; thus, small increases in the minimum wage are desirable to protect employment. Labour demand is highly cyclical: the output elasticity is about 1.7. Thus, some flexibility in labour contracts is desirable to reduce the link between employment and variation of plants' sales. Open-ended labour contracts might allow reductions of the nominal wage rather than inducing job losses during periods of severe slumps, as has happened during the COVID-19 pandemic.

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1. Introduction

As in many other developing countries, in Colombia the minimum wage (MW, hereafter) is a crucial policy variable. Its purpose is to protect workers from being paid unduly low wages (International Labour Organization, 2014). The International Labour Organization (ILO) further argues that its existence helps to reduce poverty and inequalities.

Although the MW is present nearly worldwide,[2] there is no agreement on whether it reaches its objectives or not. In fact, there are controversies concerning the effects of the MW on different aspects of the labour market, such as employment, unemployment, labour informality, etc., and on other dimensions of the economy, such as poverty and income distribution, fiscal balances, pensions and protection for the elderly, economic growth, and so on. By focusing on the employment effects, Neumark and Wascher (2008) show that the MW reduces employment opportunities for less-skilled workers, especially for those whose wage is close to the MW, as employers tend to replace these workers with more qualified employees when the MW increases. Neumark (2018) asserts that the MW has adverse effects on employment, a conclusion based on studies about economies as diverse as Canada, Colombia, Costa Rica, Mexico, Portugal, the United Kingdom and the United States (see also Neumark & Shirley, 2021). For developing countries, Andalón and Pagés (2008) found adverse effects of MW legislation in Kenya on formal employment as well as an increase in labour informality. Broecke, Forti, and Vandeweyer (2017) have compiled evidence on some developing countries, showing that while on average the effects on employment generally are not large, there are important negative effects for some vulnerable groups such as young people and low-skilled workers (see also Okudaira, Takizawa, & Yamanouchi, 2019; Wang, Phillips, & Su, 2019).

In contrast, Card (1992a; 1992b) and Card and Krueger (1994, 1995) presented evidence that casts doubt on the finding that increases in the MW have adverse effects on employment. In fact, they have shown that the increases have positive effects. Meta-analyses conducted by Doucouliagos and Stanley (2009) found a negligible effect of the MW on teenage employment in the United States (see also Belman & Wolfson, 2014; De Linde Leonard, Stanley, & Doucouliagos, 2014, chapter 4). More recently, Millea, Rezek, Shoup, and Pitts (2017) have shown that after the introduction of the MW in 2002 in South Africa, there were no effects on the formal employment of any demographic group covered by the law, although there are

[2] According to the ILO, more than 90 % of ILO member states have one or more MWs established through legislation or under binding collective agreements (International Labour Organization, 2016). Ghosheh (2013) states that, in 2012, '[…] less than a tenth of countries (6 %) have monthly minimum wages of less than USD 50 per month, while a slightly higher percentage (8 %) has no minimum wage. The largest group of countries comprises those that have monthly minimum wages of USD 50 to USD 149 (28 %). The rest of the countries vary between USD 1000 or more (15 %) and USD 300 to USD 999 (22 %). The majority of countries with monthly minimum wages set above USD 1000 are industrialised countries.'

effects for other workers in informal sectors covered by the legislation. Dube, Lester, and Reich (2010) used two different methodologies for cross-state neighbouring counties and nationwide – the former showed no employment effects while the latter has a labour-demand elasticity close to –1.

The Colombian labour market presents some undesirable outcomes that have been, on occasions, related to the level of the MW with respect to labour productivity of less-skilled workers or with respect to the median wage. Among such outcomes are the high structural and observed unemployment rates, the high rate of labour informality, the large regional differences in labour market outcomes, and sizeable gender gaps, etc. Thus, it seems that in Colombia there is a lot of room for policy interventions to improve the performance of the labour market.

Arango & Flórez (2020a) provide evidence that the MW has been a determinant of structural unemployment since 1984.[3] Moreover, given the low productivity of the labour force,[4] there is evidence that the MW is a key determinant of the high labour informality. In fact, according to Arango & Flórez (2020b), the high level of the MW with respect to the median wage (about 85 %) might be one source of the high labour informality rate and other symptoms of the faulty functioning of the labour market.[5] Thus, Colombia seems to be an interesting case to observe the effects of the MW policy with regards to employment.

Our aim in this paper is to verify, by using the panel structure of the Annual Manufacturing Survey (AMS) at (anonymized) establishment level, whether the MW has had adverse effects on employment in the manufacturing sector between 2000 and 2015, and then to suggest modifications in the use of this policy variable. By differentiating across the skills and contract modalities of workers and the size of plants, we estimate, within a partial equilibrium framework, the demand for labour. We focus on long-term elasticities to the MW, own-factor price, output and total factor productivity (TFP). Small plants correspond to those with 99 workers at most while large establishments have at least 100 workers. Our motivation to observe the response of small and large plants stems from the belief that the former exhibit lower labour productivity and lower TFP.[6] If this is so, increases in the MW are expected to have higher effects on employment in small plants. Because the primary source of variation is the exogenous change of the MW set annually over the whole country, which we transform into real variations across subsectors, our approach is closer to the case of a nationwide study (Dube et al., 2010).

A number of authors have previously studied the factors behind labour demand in the manufacturing sector of Colombia (Arango & Rojas, 2003; Eslava, Haltiwanger, Kugler, & Kugler, 2010; Medina, Posso, Tamayo, & Monsalve, 2013; Roberts & Skoufias, 1997; and, more recently, Arango, Castellani, & Obando, 2019). Nevertheless, only Bell (1997) explicitly analysed the effects of the MW, finding that the elasticity of employment with respect to the MW was –0.33 %. Also using the AMS panel data, Bell estimated that the elasticity of

[3] The structural unemployment in Colombia is around 10 %, one of the highest in Latin America (Ball, De Roux, & Hofstetter, 2013).

[4] While the output per worker (GDP constant 2005 US$ – ILO modelled estimates, November 2016) for Colombia was US$10,066, the average for the rest of the OECD countries was US$59.200.

[5] Saracoglu (2020) shows that the growth of the economy accompanied by capital accumulation is enough to reduce the informality in Turkey. Moreover, reductions in the MW and payroll taxes are more effective at reducing the informality than enforcement and deterrence.

[6] In Colombia, firms of five workers at most, including the employer, are regarded as informal according to the Administrative Department of Statistics in Colombia (Departamento Administrativo Nacional de Estadístico, DANE). These firms are identified as hiring very low productivity workers.

employment with respect to the MW is between –0.15 % and –0.33 % in the case of unskilled workers and between –0.03 % and –0.24 % for qualified workers. Our work combines the approach of Bell (1997) with contract modalities in more fully fledged labour demand functions, both conditional and unconditional, for small and large manufacturing establishments.

As mentioned above, we exploit the variations of the real MW across subsectors. Apart from distinguishing between permanent/temporary and skilled/unskilled workers, our approach is novel in decomposing the own-factor price between the contributions of the MW and the own policy wage of the firms. This decomposition of the real wage allows us to estimate the effects of the real MW variations as well as those of the own-factor price of the individual manufacturing establishments. We find that, ceteris paribus, increases in the real MW reduce the employment mainly of unskilled workers, with both permanent and temporary contracts, in small plants. Thus, the policy of sustained large increases in the real MW since 2000 has not helped formal employment in Colombia, as we show in this paper. Instead, we recommend that increases in the MW should be as small as possible.

In the estimation of the factors behind the labour demand, we also find a large cyclicality of employment in the industrial sector; in fact, the evidence suggests that labour demand is highly dependent on the demand for the products of the manufacturing establishments. This result can be used to encourage a policy aimed at reducing the fluctuations of employment tied to the movements of output, such as the strong contraction produced by the shock of the COVID-19 pandemic. Such a policy might consider decreases in the wage rigidities of labour contracts when the economy is undergoing important slowdowns and the plant's sales are suffering a major contraction (see Elsby & Solon, 2019; Doris, O'Neill, & Sweetman, 2020). Of course, this flexibility – in particular, for wage reductions – should be bounded and qualified by the contraction of sales. For the case of Colombia, Agudelo and Sala (2017) estimate the downward real wage rigidity to be over 12 %, notoriously higher than for OECD countries. The flexibility should also consider increases of wages in the case of booms. Thus, the two policies we propose might improve the performance of the Colombian labour market.

The rest of the paper develops as follows. In Section 2 , we present the data and the empirical approach. In Section 3, we discuss the results of the estimated models and their most likely implications. Finally, we draw some conclusions and suggest policy recommendations in Section 4.

2. Data and empirical approach

Conditional on the skills of the workers, the MW can potentially affect the demand for labour; this is because it is expected that the MW affects less-skilled workers more than high-skilled workers. According to the AMS, skilled workers consist of professionals, technicians, and specialists, such as mechanical, chemical, industrial, electrical, mining, and petroleum engineers, etc. Unskilled workers are those involved in activities such as manufacturing, processing, assembly, installation, maintenance, inspection, storage, packing, loading, and unloading. Thus, one distinctive characteristic of this paper on the effects of MW on labour demand is the separation of workers into skilled and unskilled workers, and the further categorization by contract modalities.[7] That is, we also rely on the differential effects of the MW depending on the modalities of the contracts by which workers are hired by plants.

[7] Gender, geographic and subsectoral decompositions are also feasible.

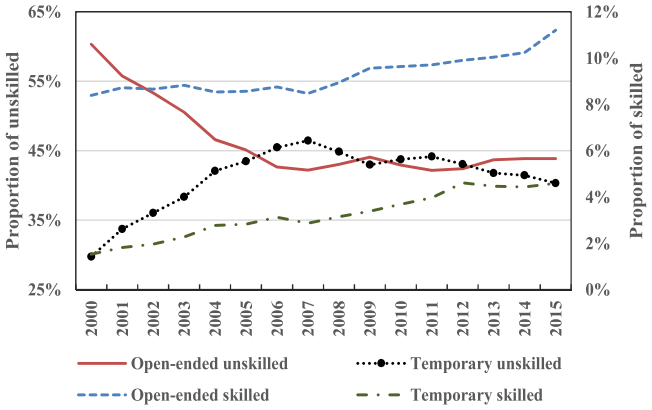

Figure 1. Composition of the labour force in the manufacturing sector, by skill and contract modalities.

Figure 1 shows the composition of the labour force involved in the production process in the manufacturing sector, by skill level and contract modalities. The share of permanent unskilled workers decreased until 2007 and then had a slight recovery. The proportion of workers with permanent contracts decreased by about 16 percentage points (pp) during the first part of the sample period. In contrast, the share of temporary unskilled workers increased up until 2007, when it reached 46 % of the total number of workers in the manufacturing sector, and then it decreased by about 6 pp. At the end of the sample period, unskilled workers, both permanent and temporary, represented 84 % of the total number of workers in the industrial sector. In 2015, skilled workers on open-ended contracts comprised about 11 % while those on temporary contracts represented 5 %.

The change in the participation of permanent workers – in total employment – over the sample period was about 14 pp; in fact, in 2000, this proportion was 69 % and, in 2015, it was 55 %. This structural change in the composition of employment was caused by the response of employers, who look for lower labour costs and more flexible contract modalities, to the behaviour of relative prices of different types of production factors and other shocks. However, this poses a challenge as a larger proportion of temporary workers might affect the plant's productivity in the long run (see Lisi & Malo, 2017; Castellani, Lotti, & Obando, 2020). Temporary contracts are associated with fewer incentives to establish solid labour relations, training, etc. (Addison & Teixeira, 2003; Alaimo, Bosch, Kaplan, Pagés, & Ripani, 2015; Pierre & Scarpetta, 2013). These decisions by employers regarding contract modalities in the composition of employment match the high downward real wage rigidity in Colombia, as documented by Agudelo and Sala (2017).

Panel A of Figure 2 shows the behaviour of the MW index during the sample period in real terms. This variable, which in nominal terms should be set in accordance with past inflation, the change in TFP and some other variables,[8] shows a trend with a positive slope deflated with both the consumer price index (CPI) for low-income individuals and with the producer price index

[8] The MW increase will also take as determinants the inflation target of the following year, the evolution of economic activity, and the contribution of wages to national income. In Colombia, the MW is determined at the end of each year by agreement of the Permanent Commission for Salaries and Labour Policies. When this is not the case, the government determines the increase (see Arango, Herrera, & Posada, 2008).

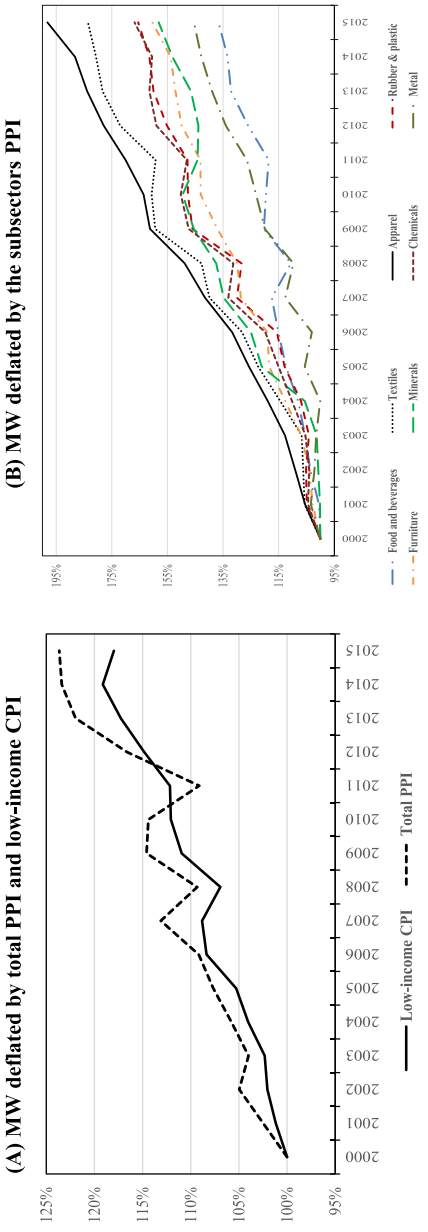

Fig 2. Real minimum wage indexes.

(PPI). For the CPI, the increase was 18 pp during the sample period while for the PPI the increase was 23.7 pp. This means that the real MW of less-skilled workers grew annually by between 1.2 % and 1.58 %, which did not have positive effects on labour informality, as documented by Arango & Flórez (2020b) and Arango, Flórez, and Guerrero (2020), among others. Panel B of Figure 2 shows the heterogeneity of the MW in real terms across manufacturing subsectors; this variable is obtained by deflating the nominal MW by the subsectoral PPI (two-digit SIC PPI). The differences in the evolution of the real MW can be seen from the point of view of the plants: not all plants in the different subsectors face the same real MW and this variation supports our strategy for identifying the effects of the MW on labour demand. The differences among subsectors are sizeable and depend enterely on the PPI.[9] Subsectors such as apparel and textiles have faced the highest real MW, while food and beverages together with metal have faced the lowest.

According to theory, within a static competitive framework and a multifactor production function (Cahuc & Zylberberg, 2004), the conditional labour demand is obtained by minimizing the cost function conditional on a production level. It depends on product demand, productivity and relative factor prices, $l\,(1/w,\ r,\ y/A;\alpha)$, where w, r, y, A and α correspond, respectively, to real wage, capital price, output, technology and the parameters of the production function. The labour demand can also be obtained by maximizing the profit function; the resulting unconditional labour demand will depend on the same variables, except for the firm's product level, $l\,(1/w,\ 1/r,\ A;\alpha)$.

Although the static framework is a useful guide for the inclusion of variables in empirical specifications of labour demand, it neglects the presence of adjustment costs in a dynamic context where there is also uncertainty about factor prices, final good prices, taxes, new profit opportunities and productivity (Hamermesh, 1993). By assuming that the firm has rational expectations and that all available information at period t is used to form the expectations about future labour demand, the empirical model is given by (see Hamermesh, 1993, chapter 7)

$$l_{k,i,t} = \lambda_k l_{k,i,t-1} + \sum_{m=1}^{M} \sum_{j=0}^{J_m} \mu_{m,k,j} X_{m,k,i,t-j} + \omega_{k,i,t}, \tag{1}$$

where $l_{k,i,t}$ is the logarithm of the number of workers of type k (total, skilled, unskilled, permanent, and temporary workers) at plant i in period (year) t. The model includes just one autoregressive term, as in Arango et al. (2019), which allows us to recover information about the adjustment costs, hysteresis and other sluggish reactions related to the labour market. The index m in $X_{m,k,i,t-j}$ corresponds to the M different factors behind labour demand, which in the empirical model include the real MW, the real own-factor price (the average real wage paid by the plant), the TFP indicator, the real interest rate, the value added of the firm in real terms, the price of energy purchased by the plant, also in real terms, etc.[10] Thus, $\mu_{m,k,j}$ is the vector of parameters to be estimated while $\omega_{k,i,t}$ is a residual term. Additional controls are also included in the regression, such as the depreciation rate and a lagged value of the labour participation rate

[9] The PPI is an indicator of the evolution of producer sales prices, corresponding to the primary channel of commercialization or distribution of goods traded in the economy. The CPI, however, mirrors the fact that a good can be commercialized or distributed by different intermediaries who will modify the sale price until it reaches the final consumer. Thus, the PPI measures the average change over time in prices from the first level of commercialization for a basket of products; in the case of Colombia, this excludes services.

[10] Variables are all in real terms unless otherwise stated.

in the city where the plant is located. The latter variable has the purpose of controlling for some elements of labour supply that interplay with the demand for labour within cities.

Given the difficulty in analysing the short-run coefficients within a dynamic framework, we compute long-term elasticities, which can be thought of as the complete adjustment process after the shock. Based on expression (1), this corresponds to $\partial l_{k,i}/\partial X_{m,k,i} = (\mu_{m,k,0} + \mu_{m,k,1})/(1 - \lambda_k)$ (see Hamermesh, 1993, chapter 7; Blundell & Bond, 1998).

The labour demand corresponds to the number of workers of type k reported by each manufacturing plant. Thus, this variable can be split depending on the group(s) in which the researcher is interested. We focus on skills and contract modalities. In addition, the output corresponds to the total value added in each plant, computed as the difference between gross production and intermediate consumption, while the price of energy is computed as the total value of electric energy purchased by the plant divided by the total kilowatt-hours purchased by the plant. The capital rental price has been split into two components: the real depreciation rate and the real interest rate. The former is computed as the annual value established as a replacement for the use or obsolescence of fixed assets adjusted for inflation during their useful life as a proportion of total assets. The latter corresponds to the ordinary and preferential annual interest rates[11]; this is because a real interest rate at plant level is not available in the AMS.

Three variables deserve special attention: the real MW, the own-factor price (real wage) and the TFP. The real MW is obtained by dividing the nominal MW – set yearly – by the two-digit SIC PPI corresponding to the plant; thus, we obtain a subsectoral variation of the real MW, as shown in panel B of Fig. 2, which we exploit in the following paragraphs. With respect to the own-factor price, because the AMS does not provide information about real wages of the establishments for each worker or type of worker, this variable is computed by dividing first the respective payroll for each type of worker (total, skilled, unskilled, permanent, and temporary workers) by the two-digit SIC PPI. Then, the real payroll of each type of workers is divided by the number of such type of workers.

However, the own-factor price and the MW might exhibit some simultaneity (i.e., share some information) in the sense that the internal (idiosyncratic) wage policy of the plants might overlap, to some extent, with the national wage policy represented by the annual variation of the MW. In other words, the annual variation and the level of the MW may affect the annual variation and the level of the wage paid by the plants to theirs workers.[12] Thus, instead of using the two wages (own-factor price and the MW) in the empirical specifications of labour demand used below, we split the real wage into two components: the information it contains about the MW and the residual, which would represent the internal wage policy of the plants. Thus, we estimate seven different panels: one for the wage of total workers and six for each type of worker defined by skill and contract modalities (i.e., wages for total workers, skilled, unskilled, open-ended skilled, temporary skilled, open-ended unskilled, and temporary unskilled). The specification of the panel is given by

[11] These interest rates are obtained from the Financial Superintendent of Colombia and included in the estimation under the assumption that large and very large firms obtain a preferential interest rate, while the rest of plants can only access ordinary interest rates.

[12] We refer to this as the signalling introduced by the increases of the MW or, in other words, the way in which the MW affects the whole salary structure of firms.

Table 1
Effect of minimum wage on own-factor price (real wage) in the balanced panel: fixed effects (2000–2015).

Variables	Total workers	Skilled	Unskilled	Open-ended skilled	Temporary skilled	Open-ended unskilled	Temporary unskilled
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
MW	0.830 ***	0.383 ***	0.844 ***	0.552 ***	0.628 ***	1.022 ***	0.883 ***
	(0.007)	(0.026)	(0.010)	(0.027)	(0.087)	(0.015)	(0.026)
Constant	5.729 ***	12.288 ***	5.436 ***	10.230 ***	8.382 ***	3.350 ***	4.623 ***
	(0.089)	(0.334)	(0.136)	(0.357)	(1.137)	(0.196)	(0.340)
Observations	32,418	20,735	32,068	18,367	7709	26,537	19,387
Plants	2043	1709	2042	1616	1145	1945	1736
R^2	0.327	0.012	0.181	0.024	0.008	0.160	0.061

Notes: ***, ** and * denote significance at the 1 %, 5 % and 10 % levels, respectively. Source: DANE-AMS, and authors' calculations.

$$ln(wp_{k,i,t}) = \delta_k^{const} + \delta_k \ln(mw_t) + \epsilon_{k,i,t} \quad k = skilled, \quad unskilled, \quad etc., \tag{2}$$

where $wp_{k,i,t}$ represents the real wage paid to workers of type k by plant i in time t, mw_t is the nation-wide MW deflated by the two-digit SIC PPI, and $\epsilon_{k,i,t}$ stands for the residual term which together with the constant, δ_k^{const}, represent the individual wage policy of the plants. The results of these estimations appear in Table 1.

All models suggest that the MW is mirrored in the own-factor price paid by the plant to the workers, where the highest coefficient corresponds, as expected, to unskilled workers (as we can observe in columns 3, 6 and 7 of Table 1). By contrast, the coefficients associated with the wages of skilled workers are lower. To generate the MW used in the regressions of labour demand presented below, we use the second element of the right-hand side of equation (2), $\delta_k ln(mw_t)$, while the own-factor price will correspond to $\delta_k^{const} + \epsilon_{k,i,t}$. Because these two elements reflect the own-factor price policy of each plant in the AMS, we do not expect it to be free of some autocorrelation or any other structure linked to the innovation processes. Thus, we do not carry out any further tests and corrections in this sense.

The construction of the TFP also calls for some attention as this unobserved variable could be biased by the selection of firms over time, by the endogeneity between inputs and production, and by the unobservable heterogeneity of firms. TFP is computed by means of the algorithm of Levinsohn and Petrin (2003), which uses the energy paid by the plants as the intermediate input[13] as well as the total cost of all materials used by the plants in the production function. Thus, the TFP shocks can be expressed as a function of intermediate inputs and capital that are approximated in the production function by polynomials. Finally, it is important to mention that, except for the real interest rate, the depreciation rate and labour participation, all variables are expressed in logarithms.

[13] This is different from the approach of Olley and Pakes (1996), who use the firm's capital investment decision as an identification strategy.

3. Determinants of labour demand

Having defined the variables and the empirical model, we split the labour demand between skilled and unskilled, and further by contract modalities. The latter categorization of workers relies upon the segmentation hypothesis of the labour force in the industrial sector set forth by Castellani, Lotti and Obando (2017) (see also Arango et al., 2019). According to them, the optimal responses of employers to shocks depend on the type of workers they have, or could have, in their plants.[14]

Given the bias of coefficients induced by potential endogeneity of some variables, an accurate estimation of the parameters of interest should consider the source of variation grouped in the residual term of expression (1), $\omega_{k,i,t}$, which, in our view, might include four elements: $\omega_{k,i,t} = \eta_{k,i} + \gamma_{k,t} + \upsilon_{k,i,t} + \varepsilon_{k,i,t}$. The first element, $\eta_{k,i}$, comprises the unobserved heterogeneity of plants related to characteristics such as the properties of the output, managerial efficiency, and technical knowledge, as set forth by Roberts and Skoufias (1997). These specific characteristics will most likely lead to differences in dimensions such as output, factor demands, prices, etc. Disregarding such components would result in biased coefficients. Time-varying shocks, such as changes in labour or competition regulations announced within the year, might affect the relative prices of different types of labour used by some plants in the manufacturing industry; these types of shocks, denoted by $\gamma_{k,t}$, might also affect decisions related to the level or composition of output. Idiosyncratic time-varying shocks to plants, such as equipment breakdowns, strikes, unforeseen fluctuations in demand, factor supplies, changing financial environment and reporting errors, are linked to the third error source, $\upsilon_{k,i,t}$. Finally, the fourth source of error, $\varepsilon_{k,i,t}$, is a well-behaved zero-mean shock varying across time and plants. Thus, our identification strategy also considers that real wages [$\delta_k^{const} + \epsilon_{k,i,t}$, in the notation of expression (2)] and output are also potentially endogenous. We assume that the MW [$\delta_k ln\,(mw_t)$, in the notation of expression (2)], the Levinsohn–Pretin-type TFP and interest rates are exogenous.

Addressing the aforementioned sources of bias, as well as any potential reverse relationship of both real wage and value added with labour demand, we use an instrumental variables approach along with some moment conditions. Thus, we follow the generalized method of moments (GMM) estimation procedure of Blundell and Bond (1998) that combines, within a panel framework, both lagged levels and lagged first differences of variables as instruments to improve the efficiency of the estimator. Additionally, we also implement the correction of Windmeijer (2005) to address the downward bias of the two-step GMM standard deviation estimator shown in Arellano and Bond (1991).

Output and real wage endogeneity can be addressed by using lagged values of these variables, as well as labour demand and the nominal MW, taking advantage of the instrument matrix structure. In addition, lagged first differences of the instruments are also used, as these can improve efficiency when the lagged levels are weak instruments. This happens, for instance, when λ_k is close to one or when the variance of the fixed effects (σ_η^2) is higher than the variance of the time-varying idiosyncratic shocks (σ_γ^2, σ_υ^2). Thus, lagged levels and lagged first

[14] Between 2000 and 2015, the balanced AMS panel accounted for 2025 plants. This sample is composed of plants that survive the whole sample period, have a value added greater than zero in each period, and have sensible total (production and non-production) labour shares, although we admit it was 1.5 at most for just one period. Because this situation is not common in the AMS, we retained those observations.

Table 2
Long-term labour demand elasticities without substitutes: balanced panel GMM estimates (2000–2015).

Variables	Conditional demand for labour						Unconditional demand for labour					
	Skilled	Unskilled	Open-ended		Temporary		Skilled	Unskilled	Open-ended		Temporary	
			Skilled	Unskilled	Skilled	Unskilled			Skilled	Unskilled	Skilled	Unskilled
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Autoregressive	0.470 * **	0.582 ***	0.471 * **	0.751 ***	0.344 ***	0.521 ***	0.305 ***	0.378 ***	0.449 **	0.506 ***	0.227 * **	0.361 ***
	(0.055)	(0.064)	(0.053)	(0.059)	(0.055)	(0.047)	(0.093)	(0.093)	(0.205)	(0.160)	(0.083)	(0.062)
MW	0.220	–0.860 ***	–0.099	–0.983 *	0.469	–0.278	0.174	–0.191	0.510	–0.510	0.164	–0.761
	(0.701)	(0.207)	(0.414)	(0.558)	(0.820)	(0.396)	(0.810)	(0.242)	(0.613)	(0.423)	(1.281)	(0.674)
Own-factor price	–0.331 * *	–0.378 *	–0.254 *	–0.955 ***	–0.288 * *	–0.049	–0.528 *	–0.397 *	–0.367	–1.021 * **	–0.367 *	0.207
	(0.132)	(0.213)	(0.144)	(0.308)	(0.133)	(0.212)	(0.302)	(0.217)	(0.371)	(0.185)	(0.210)	(0.277)
TFP	–1.899 * **	–1.250 **	–1.682 * **	–1.639	–0.723	–0.077	0.701	0.579 *	0.899	1.131 *	–0.710	1.378 ***
	(0.517)	(0.579)	(0.516)	(1.073)	(0.648)	(0.649)	(0.434)	(0.336)	(0.650)	(0.590)	(0.539)	(0.485)
Value added	1.858 * **	1.475 ***	1.686 ***	2.656 **	0.471	0.555						
	(0.554)	(0.537)	(0.555)	(1.035)	(0.601)	(0.621)						
Observations	15,712	24,715	13,755	19,985	5112	14,425	15,712	24,715	13,755	19,985	5112	14,425
Number of plants	1577	2016	1471	1858	881	1570	1577	2016	1471	1858	881	1570
Hansen *p*-value	0.111	0.00838	0.0257	0.161	0.353	0.0527	0.00407	0.000489	0.00528	0.687	0.424	8.87e–06
Ar(2) *p*-value	0.486	0.404	0.387	0.740	0.849	0.440	0.863	0.782	0.948	0.654	0.941	0.145

Notes: ***, ** and * denote significance at the 1 %, 5 % and 10 % levels, respectively. All models include time and SIC fixed effects. Source: DANE-AMS, and authors' calculations.

differences of labour demand, output, wages and the nominal MW[15] are used as instruments in the conditional specification, and lagged levels and first differences of labour demand, real wages and the MW are used in the unconditional specifications of labour demand.

Table 2 shows the initial GMM estimates of the total labour demand based on the balanced panel. Apart from the autoregressive component of labour demand, it also includes the MW, own-factor price (real wage), TFP and value-added long-term elasticities. The models in Table 2 and subsequent tables include contemporary and lagged values of most variables, including the interest rate and, as stated earlier, the lagged price of energy, the depreciation rate and other intermediate inputs, as well as lagged realizations of the labour participation rate in the city where each plant is located, as a way to control for some labour supply movements (these coefficients are not shown for space reasons). All models of Table 2 include time fixed effects and also SIC fixed effects, with the aim, among other things, of controlling for mark-up movements in unconditional specifications of labour demands. Notice that these fixed-effect controls do not overlap with the subsectoral real MW since the latter are included both contemporary and lagged.

The estimates in Columns 2 and 4 of Table 2 suggest that increases in the MW reduce the employment of unskilled workers. According to the elasticities, the demand for unskilled permanent workers is more responsive (–0.983) than for unskilled temporary workers, for which the estimate of –0.278 is not significant. Interestingly, in the former case, the own-factor price elasticity (–0.955) remains significant and has the expected sign. The elasticity with respect to the MW of total unskilled workers is –0.860.

The magnitude of MW elasticities (less than 1 in absolute value) suggests an increase of earnings for less-skilled workers who remain in the job (stayers) following an increase in the MW. However, this labour market outcome might not be fully satisfactory given the loss of jobs that, accordingly, takes place in response to the increases in the MW. In the conditional specification, the demand for skilled workers is completely inelastic to the MW but not to the own-factor price, as we can observe in Columns 1, 3 and 5.

The evidence of the adverse effects of increases in the real MW on the demand for unskilled workers is clearer in the case of conditional demand than for unconditional demand, where, regardless of having the expected sign, no coefficient is statistically significant (see Columns 7–12). In this sense, the null hypothesis (i.e., the demand for labour is inelastic with respect to the MW) cannot be rejected. Except for unskilled temporary workers under both conditional and unconditional specifications and skilled workers on open-ended contracts in the unconditional specification, we can assert that the demand for labour is responsive to changes in the real wage.

The autoregressive, TFP and value-added long-run elasticities are statistically significant and have the expected signs. Table 2 also shows another important result: the high cyclicality of the employment in the industrial sector linked to the elasticity of labour demand with respect to output. From now on, we shall emphasize this finding to suggest a second policy measure apart from the one related to the MW.

One element of the labour-demand functions that we consider next is the potential (imperfect) substitution among different types of labour. This is because some types of work can be substituted by others, depending on the technical conditions of the production process and the relative prices of the different types of labour we are considering. For example, in some cases, temporary skilled workers can be used instead of other permanent workers in the production process, or vice versa. To account for the potential substitutability among workers, we use the

[15] Average real wage, MW, value added starting at lag three and year dummies are used as instruments.

levels (stocks) of other workers employed in the production process. The argument for including substitution in this way is that not only the wage of the potential substitutes (also used below) might be relevant, but also the real interest rate and the compatibility with TFP movements, etc. Thus, we take all these variables into account by using the stocks of other labour force in the plant as potential substitutes.

Accordingly, the results of the specifications in Table 3 include the levels of other workers used in the production process. These levels of potential substitutes are endogenous variables, so the specifications in Table 3 instrument these as well as the other endogenous variables, adding their past realizations to the set of instruments.

First, in Columns 1–6, we observe that the adverse effects of changes in the MW are statistically significant only for unskilled workers, with the highest elasticity corresponding to temporary unskilled workers (–0.715) and the lowest to total unskilled workers (–0.618). The own-factor price elasticities are also significant and negative, except for temporary workers, both skilled and unskilled, although the size of the coefficients – when these are significant – agree with those found in similar studies (see Hamermesh, 1993, chapter 7). Again, the high elasticities with respect to output (between 1.118 and 1.898) are evidence of the cyclicality of industrial employment. This finding, which is different from the findings of Roberts and Skoufias (1997) and Bell (1997) but similar to those of Medina et al. (2013) and Arango et al. (2019),[16] allows us to suggest a policy such that, to avoid strong employment fluctuations introduced by demand (output or value added) shocks, some flexibility in the wage component of permanent contracts could be introduced in Colombia.

Such flexibility might consist of reducing the downward rigidity of nominal wages by allowing for some wage decreases[17] when the economy is in a slowdown phase and firms' sales are suffering a major contraction. This policy recommendation would be aimed[18] at limiting job losses when the demand for firms' products decreases persistently and the decrease is sizeable. A good example of this situation is provided by the recent COVID-19 pandemic when the contraction of GDP in Colombia for 2020 was sizeable (–7 %); the possibility of reducing wages would have helped save hundreds of thousands of jobs with much less pressure on the public finances of the government.

Of course, the possibility of having nominal wage reductions should be bounded and qualified by the contraction of sales. It would also require an important complement with programmes of financial education and information provided by firms and the economic authorities to workers. Evidence of nominal wage adjustments during recessions and downturns can be found in Doris et al. (2020) for the case of Ireland, and in Elsby and Solon (2019) for the United Kingdom, the United States and some other countries (see also Lazear & Shaw, 2009; Elsby, Shin, & Solon, 2016). Using data from a survey to firms, Iregui, Melo, and Ramírez (2011) presented evidence that suggests that there is downward rigidity of nominal wages in Colombia. The measure we are proposing points to nominal wages with obvious consequences in real wages. Agudelo and Sala (2017) also documented a downward real wage rigidity in Colombia

[16] Arango, Castellani y Obando (2019, Table 1) estimated long-term output elasticities as high as 1.12 and 1.05 for skilled and unskilled workers, respectively.

[17] Of course, the introduction of such measures in Colombia would need changes of some norms of the Substantive Labour Code, such as Article 59.

[18] Another way of introducing flexibility aimed at reducing job loss when the demand for the firms' products decreases persistently is by means of work divisibility and hourly wages (divisibility of working hours). In these cases, if there is a slowdown, the number of hours might be reduced instead of firing workers.

Table 3
Long-term labour demand elasticities with stocks of potential substitutes: balanced panel GMM estimates (2000–2015).

Variables	Conditional demand for labour						Unconditional demand for labour					
	Skilled	Unskilled	Open-ended		Temporary		Skilled	Unskilled	Open-ended		Temporary	
			Skilled	Unskilled	Skilled	Unskilled			Skilled	Unskilled	Skilled	Unskilled
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Autoregressive	0.552 * **	0.714 * **	0.583 * **	0.747 * **	0.524 * **	0.635 * **	0.435 * **	0.638 * **	0.533 * **	0.755 ***	0.428 ***	0.575 ***
	(0.036)	(0.040)	(0.040)	(0.039)	(0.041)	(0.037)	(0.039)	(0.046)	(0.041)	(0.045)	(0.046)	(0.045)
MW	0.050	–0.618 ***	–0.202	–0.678 * **	0.249	–0.715 * **	–0.115	–1.101 * **	–0.468	–0.874 ***	0.501	–1.045 ***
	(0.369)	(0.122)	(0.280)	(0.165)	(0.515)	(0.222)	(0.411)	(0.191)	(0.313)	(0.223)	(0.498)	(0.263)
Own-factor price	–0.379 * **	–0.358 * *	–0.427 * **	–0.718 * **	–0.061	–0.082	–0.413 * **	–0.647 * **	–0.477 * **	–0.685 * **	–0.092	0.056
	(0.094)	(0.155)	(0.096)	(0.214)	(0.074)	(0.127)	(0.122)	(0.200)	(0.103)	(0.233)	(0.079)	(0.152)
TFP	–1.922 * **	–1.520 * **	–1.842 * **	–0.735	–1.132 * *	–1.856 * **	0.565 * *	0.539 * **	0.635 * **	0.607 * *	0.107	0.532 **
	(0.259)	(0.289)	(0.316)	(0.463)	(0.534)	(0.450)	(0.238)	(0.199)	(0.175)	(0.279)	(0.182)	(0.235)
Value added	1.831 * **	1.793 ***	1.848 * **	1.272 * **	1.118 * *	1.898 * **						
	(0.231)	(0.254)	(0.286)	(0.415)	(0.490)	(0.418)						
Observations	15,712	24,715	13,755	19,985	5112	14,425	15,712	24,715	13,755	19,985	5112	14,425
Number of plants	1577	2016	1471	1858	881	1570	1577	2016	1471	1858	881	1570
Hansen *p*-value	0.593	0.00617	0.233	0.204	0.261	0.00980	0.346	0.000228	0.171	0.687	0.366	5.57e-05
Ar(2) *p*-value	0.696	0.585	0.225	0.224	0.0586	0.479	0.0654	0.105	0.471	0.844	0.0274	0.445

Notes: ***, ** and * denote significance at the 1 %, 5 % and 10 % levels, respectively. All models include time and SIC fixed effects. Source: DANE-AMS, and authors' calculations.

that does not help to damp employment fluctuations during slumps. Making labour contracts more flexible will reduce both the incidence and prevalence of temporary employment as well as the cyclical unemployment. It will also reduce the search costs in the economy with beneficial consequences in structural unemployment (see Arango & Flórez, 2020a), as well as having positive effects on the firms' productivity (see Castellani, Lotti and Obando, 2017; Lissi and Malo, 2017), and strengthening the ties between firms and workers.

The results of the unconditional demand for labour also show that the MW has important effects on the demand for unskilled workers. Moreover, the respective elasticities are higher with respect to the conditional specifications, between –0.874 and –1.101. Except for unskilled permanent workers (–0.685), the coefficients linked to the own-factor price are higher than those of columns 1–4, as predicted by the theory, although the demand for temporary workers remains inelastic with respect to the real wage. Importantly, the TFP elasticities are positive and mostly significant. Thus, TFP appears to be a complement of labour force in the production process.

Apart from distinguishing between permanent/temporary and skilled/unskilled workers in the industrial sector, we also observe differential responses of labour demand to changes in the MW and the other variables from the point of view of the size of plants. The motivation for separating the plants in this way is the expected lower productivity of workers in small plants. Thus, we divide the panel into large (those with 100 workers or more dedicated to production duties) and small (with up to 99 workers) plants.

In the analysis of plants by size, we continue to consider potential substitution among different types of labour, because, given the expected labour productivity of workers, the optimal responses might be different. The specifications in upper panel of Table 4 include information on potential substitutes as measured by stocks of each type of potential substitute. Yet, another way of introducing information about potential substitutes is to consider the real wage paid to other workers in the production process. However, not all plants demand all types of labour and, therefore, the missing wages of potential substitutes would reduce the number of observations available for the estimations. To address this issue, we replace the missing wages by the average wages in the industry of each worker's classification and we estimate the corresponding specification of the substitute wages. That is, when a plant is not demanding one type of workers (i.e., it has zero of one type of worker), then the substitution is considered by including the average wage paid by the subsector (two-digit SIC) assuming that the plant is prevented from having such workers because of the relative wage or for technological reasons, or both. This gives place to the second estimate with potential substitutes of the labour force, in this case, by including the average wage of workers paid by the industry (see lower panel of Table 4).

Here we focus on the elasticities with respect to the MW, own-factor price and value added. According to these results, with the two ways of measuring potential substitution, the effects of the MW occur only in unskilled workers hired by small plants. These workers, who are supposed to have a lower labour productivity, hired by firms also of lower productivity, are the most affected by increases in the MW. Thus, to avoid job losses in the manufacturing sector in Colombia, increases in the MW should be moderate.[19] At the same time, the labour forces of small plants have, in general, negative responses to increases in own-factor prices.

[19] The evidence we have provided shows the adverse effects of increases in the MW on the demand for labour, which has mostly occurred for unskilled workers hired by small plants. However, these results might be incomplete in the sense that we are unable to account for those plants that have been deterred from hiring new skilled and unskilled workers because of the increases in the MW when, ceteris paribus, such increases are well above the increases in the labour productivity of unskilled workers.

Table 4
Long-term labour demand elasticities with potential substitutes: balanced panel (2000–2015).

Variables	Conditional demand for labour						Unconditional demand for labour					
	Skilled	Unskilled	Open-ended		Temporary		Skilled	Unskilled	Open-ended		Temporary	
			Skilled	Unskilled	Skilled	Unskilled			Skilled	Unskilled	Skilled	Unskilled
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Levels of potential labour substitutes												
Large plants												
MW	1.112	–0.274	–0.232	–0.277	0.400	–0.168	1.938	–0.516	0.068	–0.453	0.741	–0.036
	(0.759)	(0.286)	(0.504)	(0.515)	(0.682)	(0.462)	(1.212)	(0.474)	(0.707)	(0.639)	(0.813)	(0.589)
Own-factor price	–0.245	0.144	–0.774 * **	–0.567 *	0.006	0.334	–0.551 **	–0.056	–1.022 ***	–0.342	–0.046	0.331
	(0.156)	(0.205)	(0.100)	(0.312)	(0.087)	(0.218)	(0.244)	(0.330)	(0.135)	(0.424)	(0.094)	(0.274)
Value added	2.252 ***	1.333 ***	2.016 ***	1.963 ***	0.802 *	1.726 ***						
	(0.395)	(0.504)	(0.362)	(0.663)	(0.481)	(0.596)						
Hansen *p*-value	0.199	0.130	0.455	0.261	0.571	0.207	0.503	0.0189	0.183	0.412	0.412	0.108
Number of plants	514	534	492	499	389	497	514	534	492	499	499	497
Small plants												
MW	–0.458	–0.909 ***	–0.291	–1.024 ***	0.392	–0.611 * **	–0.222	–1.127 ***	–0.278	–1.059 * **	–0.141	–0.791 ***
	(0.409)	(0.193)	(0.295)	(0.196)	(0.590)	(0.215)	(0.507)	(0.221)	(0.352)	(0.263)	(0.634)	(0.273)
Own-factor price	–0.267 ***	–0.755 ***	–0.273 * **	–1.280 * **	–0.121	–0.340**	–0.402 * **	–1.053 ***	–0.327 ***	–1.145 * **	–0.177 *	–0.221
	(0.087)	(0.230)	(0.077)	(0.201)	(0.078)	(0.173)	(0.102)	(0.225)	(0.096)	(0.227)	(0.090)	(0.172)

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Table 4 (*continued*)

Variables	Conditional demand for labour						Unconditional demand for labour					
	Skilled	Unskilled	Open-ended		Temporary		Skilled	Unskilled	Open-ended		Temporary	
			Skilled	Unskilled	Skilled	Unskilled			Skilled	Unskilled	Skilled	Unskilled
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Levels of potential labour substitutes												
Value added	2.107 ***	0.841 **	1.581 * **	0.773	0.386	1.676 ***						
	(0.272)	(0.339)	(0.257)	(0.490)	(0.500)	(0.463)						
Hansen *p*-value	0.385	0.0904	0.640	0.669	0.384	0.491	0.204	0.00106	0.561	0.304	0.416	0.149
Number of plants	1063	1482	979	1359	492	1073	1063	1482	979	1359	492	1073
Average wages of potential labour substitutes												
Large plants												
MW	1.666	–0.418	1.075	–1.025	0.476	–0.553	2.574	0.548	3.374	–0.025	0.857	0.024
	(1.259)	(0.343)	(1.230)	(0.921)	(1.134)	(0.876)	(1.951)	(2.322)	(2.638)	(1.700)	(1.190)	(0.878)
Own-factor price	–0.137	–0.066	–0.519 * **	–0.599 * *	–0.026	0.247	–0.065	3.763	–0.393	–0.479	–0.078	0.319
	(0.151)	(0.182)	(0.158)	(0.268)	(0.099)	(0.451)	(0.300)	(4.940)	(0.411)	(0.545)	(0.134)	(0.370)
Value added	2.653 * **	1.981 * **	2.732 * **	3.483 * **	1.735 ***	1.193						
	(0.511)	(0.452)	(0.544)	(1.048)	(0.618)	(1.020)						
Hansen *p*-value	0.419	0.674	0.322	0.615	0.235	0.428	0.636	0.0235	0.153	0.505	0.102	0.242
Number of plants	518	533	501	505	437	510	518	533	501	505	437	510
Small plants												
MW	–0.177	–0.612 ***	0.305	–1.236 ***	–0.563	–1.523 ***	–0.273	–0.552 **	–0.200	–1.190 ***	–0.035	–1.698 ***
	(0.795)	(0.148)	(0.547)	(0.255)	(0.686)	(0.339)	(0.818)	(0.249)	(0.578)	(0.304)	(0.723)	(0.399)

(*continued on next page*)

Table 4 (*continued*)

Variables	Conditional demand for labour						Unconditional demand for labour					
	Skilled	Unskilled	Open-ended		Temporary		Skilled	Unskilled	Open-ended		Temporary	
			Skilled	Unskilled	Skilled	Unskilled			Skilled	Unskilled	Skilled	Unskilled
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Levels of potential labour substitutes												
Own-factor price	–0.192 **	–0.365 **	–0.332 * *	–1.268 * **	–0.350 * *	–0.460 **	–0.334 *	–0.410 *	–0.417 ***	–1.176 ***	–0.468 **	–0.402 *
	(0.091)	(0.185)	(0.136)	(0.191)	(0.174)	(0.219)	(0.196)	(0.245)	(0.148)	(0.230)	(0.207)	(0.226)
Value added	2.471 ***	1.371 ***	1.955 ***	1.165 * **	1.348 ***	1.867 ***						
	(0.451)	(0.261)	(0.314)	(0.329)	(0.306)	(0.507)						
Hansen *p*-value	0.0322	0.213	0.0212	0.0490	0.178	7.96e–05	0.000104	0.000241	6.43e–05	0.0161	0.139	2.71e–05
Number of plants	1135	1486	1052	1392	645	1166	1135	1486	1052	1392	645	1166

Notes: ***, ** and * denote significance at the 1 %, 5 % and 10 % levels, respectively. All models include time and SIC fixed effects. Source: DANE-AMS, and authors' calculations.

It is also important to emphasize that the output elasticity is lower for small-sized plants than for large plants. However, for establishments with fewer than 100 workers, labour demand for unskilled workers is more responsive for temporary workers than for permanent workers. Nevertheless, the policy recommendation of introducing some wage flexibility to contracts should be considered for all permanent workers in all firms. The results in Table 4 support the partition of labour demand not only by skills and contract modalities but also by the size of plants.

4. Conclusions and policy recommendations

In this paper, we use the AMS between 2000 and 2015 to present estimates of conditional and unconditional functions of demand for labour. We focus on the long-term elasticities, which comprise contemporary and lagged responses of the aggregate labour demand, as well as labour demands specific to skills and types of contract, to variations of the MW, output, own-factor price wage and TFP shocks, controlling for the autoregressive coefficients. In most cases, the estimated elasticities have the signs predicted by the theory. To arrive to these results, it was fundamental to obtain the subsectoral real MW and to break down the real wage paid by plants into national wage policy (MW) and the wage policies of individual firms; it was also important to consider the potential substitutability among the different labour types, and the size of plants.

Our first finding is that increases in the real MW destroy formal employment mainly of unskilled workers, on both permanent and temporary contracts. According to the elasticities of Table 3, without taking into account the size of plants, an increase of 1 % in the real MW, ceteris paribus, reduces employment between 0.618 % and 0.715 %, within a period of between one and two years.

Once the size of plants is considered, we find that the effects of changes in the MW are concentrated on unskilled workers in small plants; in fact, the elasticities with respect to the MW fluctuate between –0.55 and –1.69. This is indirect evidence that the labour productivity of workers in small plants is lower than that of workers in large plants, and very close to the previous (before the increase) real MW.

The above numbers are not negligible. Thus, the policy of sustained large increases in the real MW carried out since 2000 in Colombia (see Panel A of Fig. 2) has not been used appropriately and it has not helped to generate formal employment, but instead to reduce it; it has contributed to the poor outcomes of the labour market. It is probable that subsectors such as apparel and textiles have been most affected by the increases in the MW, as seen in panel B of Fig. 2. The policy lesson to be learnt from this is that in order to avoid the loss of less-skilled jobs in small plants, increases in the MW should be as small as possible in Colombia, a country where the ratio of the MW to the median wage (85 %) is far greater than the average in OECD countries (about 50 %). The policy measure we recommend must, obviously, be accompanied by an intense job training programme aimed at increasing labour productivity, as proposed by Arango & Flórez (2020b), in such a way that the median wage increases at a suitable rate and, consequently, the ratio of the MW to the median wage reaches the level of that in OECD countries.

Our second finding concerns the size of the elasticity of labour demand with respect to output, which is around 1.7. That is, the level of employment depends heavily on the demand for the output of the plant, and when the economy is in a slump, the adjustment probably results in job losses. One way of avoiding such an outcome would be to allow reductions in the nominal wages of permanent contracts by some percentage, in order to limit the loss of this type of employment when the demand for the product of the firms decreases abruptly and persistently, as has happened

during the COVID-19 pandemic.[20] This flexibility of labour contracts should also include increases of wages when there is a persistent boom in sales for industrial plants. Making labour contracts more flexible will reduce both the incidence and prevalence of temporary employment, will make labor demand more vigorous and reduce the cyclical unemployment since the adjustment in the labour market after a shock will take place via prices rather quantities. It will also reduce the search costs in the economy with beneficial consequences in structural unemployment (see Arango & Flórez, 2020a) as well as having positive effects on the firms' productivity, and strengthening the ties between firms and workers. Nevertheless, it is important to emphasize that the implementation of this policy must be complemented by programmes of financial education and information for workers, provided by firms and different government levels (national and subnational). Making labour contracts more flexible in the way we are suggesting will reduce the rigidity of wages in Colombia found by Agudelo and Sala (2017).

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