Abstract

Based on Holden and Wulfsberg (2009), we explore the potential existence of downward real wage rigidity (DRWR) in Colombia. We provide a sectorial level analysis based on data from thirteen metropolitan areas over the period 2002-2014. We find that DRWR compresses the distributions of aggregate wage changes overall, as well as in specific sectors and periods. In particular we estimated a deficit of real wage cuts by 16.27%. Furthermore, we show that wage rigidity in Colombia is not connected to the wage bargaining system, in contrast to the vast empirical evidence on developed countries. On the contrary, the minimum wage and labor informality appear as the crucial drivers.

JEL Classification: E31, J38, J46 ,E24.

Keywords: Downward Real Wage Rigidity, Inflation, Minimum wages, Informality, Unemployment.

*Departament d'Economia Aplicada, Universitat Autònoma de Barcelona, Edifici B, 08193 Bellaterra, Spain; tel: +34-93.581.11.53; email: soniaalexandra.agudelo@e-campus.uab.cat.
1 Introduction

Potential adverse macroeconomic effects of the downward wage rigidity—low inflation &
high unemployment—have been the central attention of recent studies, see e.g. Holden
and Wulfsberg (2014), Stüber and Beissinger (2012), and Elsby (2009). Understanding
how an economy functions in downturns, is useful to provide arguments against or in favor
of targeting of low inflation rates undertaken for large group of economies.

Although, several micro data analysis gives support for individual downward real wage
rigidity (DRWR), see Chisrtofides and Leung (2005), there is no consensus on the aggre-
gate effects of DRWR, i.e. whether average real wage are rigid downwards, and what are
its effects on unemployment and output. According to Holden and Wulfsberg (2009), one
possible explanation for the disputable aggregate and micro effects of DRWR, may be that
the DRWR at the individual level is undone by firm behavior and market mechanisms.
Even if individual wages are rigid in real terms, firms may respond by other means, like
changing the composition of work force. And even if wage rigid some firms, jobs may be
shifted over to other firms with more flexible wages.

In line with Holden and Wulfsberg (2009), but in constrast to most of previous liter-
ature, we explore the potential existence of downward real wage rigidity using aggregate
data for the Colombian labor market. Our objective is twofold. We investigate the extent
of the DRWR and also identify what are the main driving forces. In particular, we provide
a sectorial level analysis based on data from thirteen metropolitan areas over the period
2002-2014.

One contribution of this paper is that we adapt an approach, mainly though for
developed economies, to a developing country. The crucial point, is that, wage setting
environment in Colombia differs a lot from developed world. The system of unemployment
is absent, labor unions are very weak, a modern welfare state is non-existent, and there
is a large informal or underground economy. Our empirical implementation has been
adapted taking into account these features of the Colombian labor market. In this sense
, our study might though as complementary to the increasing literature that test the
existence of DRWR.

To explore the potential existence of DRWR, we compare empirical real wage-change
distributions with constructed notional (rigid-free) distributions and look for a deficit of
real wage cuts. We estimated an average deficit, by 16.27%, it means that about 16 out
of 100 notional real wages cuts do not result in an observed wage cut due to DRWR.

Furthermore, we show that wage rigidity in Colombia is not fundamentally connected
to the wage bargaining system , in contrast to the vast empirical evidence on developed
countries, e.g. Holden and Wulfsberg (2009). On the contrary, the real minimum wage
and labor informality appear as the crucial drivers. We find a high negative effect of real minimum wage on the DRWR, in particular a 1% increase in the real minimum wage reduces the DRWR by 1.65%. As this institutional variable also captures the price wedge between consumption and industrial prices, then, the negative sign has been associated with the relative higher grow of industrial prices with respect to consumption prices. Finally, we find a unexpected positive effect of informality.

The rest of the paper is structured as follows. Section 2 discusses the theoretical background on downward real wage rigidity distinguishing the sources of the rigidity and the effects on real wage-changes distribution. Section 3 describes the empirical approach to compute the extent of the downward real wage rigidity and also presents the respective estimates. Section 4 focuses on explaining the wage rigidity. Section 5 concludes.

2 Wage rigidities and distribution of wage changes

Over the last three decades, several theoretical models have been developed to explain why firms refrain from cutting wages in economic downturns, even though wage reductions would decrease labor costs. The traditional classification distinguishes three theoretical frameworks of downward real wage rigidity (DRWR): efficiency wage theories, insider-outsider theory and contract theories. Table 1 provides a brief description of the most prominent models for each of these theories.

According to efficiency wage hypothesis, labor productivity depends positively on the real wage paid by the firm. If wage cuts harm productivity, then cutting wages may end up raising labor costs. The insider-outsider theory, on the other hand, points out that the insiders -current workers- enjoy more favorable employment opportunities than the outsiders -the unemployed-. The reason for this disparity is that firms incur labor turnover costs when they replace insiders with outsiders. Insiders may resist competition with outsiders by refusing to cooperate with or harassing new entrants. Consequently, insiders aim more secure positions and higher wages, often by discouraging firms from hiring outsiders. Even more, in downturns and under unambiguous seniority ranking, the senior workers may insist on unchanged wages and let junior workers be laid off. If junior workers try to keep their jobs by underbidding the existing wages, the senior workers may prevent this by threats of non-cooperation and harassment.1Finally, the theory of contracts suggests that the source of the wage rigidity arises from the long-term labor

1According to Linbeck and Snower (2001), the dynamic behavior of insiders in response to macroeconomic fluctuations will depend on their preferences. Hence, other possibility is that a majority of insiders want to keep the jobs of all insiders in a downturn and that they therefore accept an overall reduction in their own real wages. This is particularly likely if there is no seniority ranking among them. Under imperfectly defined seniority rankings, some intermediate strategy may be chosen.
contracts agreed between firms and workers, in these contracts wages are set in advance and are negotiated in staggered basis, this implies that economywide average wages adjust slowly to macroeconomic conditions.

Although, the theories described so far shed light on the source of the wage rigidity, they do not provide an analytical framework which allow us to explain explicitly how downward wage rigidities affect distribution of wage changes. On this account, some theoretical models has been recently developed allowing to simulate these effects. The intertemporal model of work resistance to wage cuts of Elsby (2009) and the firm-level bargaining model of Holden and Wulfsberg (2009) make up two salient and useful examples. In both models two simulated distributions of real wage changes are compared: one distribution in which wages are assumed as flexible (i.e. free of wage rigidity) and another one where wage rigidity is likely to be bind. Both models lead to the same general prediction, the distribution of real wage changes is compressed; furthermore, the models also suggest that downward rigidity is more likely in periods of low inflation.

<table>
<thead>
<tr>
<th>Table 1. Theories of DRWR</th>
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<tr>
<td><strong>1. Efficiency wage theories</strong></td>
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<tr>
<td>Shirking model</td>
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<td>Adverse selection model</td>
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<td>Gift exchange model</td>
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<td>Turnover models</td>
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<td>Fair wage-effort hypothesis</td>
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<td><strong>2. Insider-outsider theory</strong></td>
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<td>Insider-outsider model</td>
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<td><strong>3. Contract theories</strong></td>
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<td>Long-term contract models</td>
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<tr>
<td>Implicit contract models</td>
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</tbody>
</table>

Notes: Based on Campbell and Kanis (1997)

Holden and Wulfsberg’s model (2009) sets that wage rigidity will compress wage cuts and the extent of this compression depends on economic -inflation and unemployment-
and institutional variables -employment protection and union power-. Figure 1 provides a graphical illustration of the predicted effect of DRWR on the wage-change distribution. The solid line represents the wage change distribution when DRWR binds, while the dashed line represents the wage-change distribution in the absence of rigidities. The latter is known in the literature as the notional wage-change distribution -Akerlof et al. (1996)-. Note that there is a deficit of negative real wage changes in the wage-change distribution when DRWR binds, compared to the notional distribution.

**Figure 1. Effect of DRWR on the wage-change distribution**

![Graphical illustration of wage-change distributions](image)

Note: Kernel densities of a notional distribution of real wage changes (dashed line) and a distribution of real wage changes subject to downward real wage rigidity (solid line).

Source: Holden and Wulfsberg (2009)

Furthermore, the deficit of wage cuts compared to the notional distribution is greater for large negative wage changes than for small. Finally, an important implication of this model is that DRWR has no effect on wage increases, note that the dashed and solid lines are overlaid for growth wage rates above zero. Although, most of previous literature on down wage rigidity has not taken into account a potential compression of wage increases, Elsby’s model (2009) shows that firms will compress wage increases as well as wage cuts in the presence of DRWR (i.e. downward rigidity leads to both fewer wage cuts and fewer wage increases). Elsby (2009) points out that wage cuts are compressed because labor productivity declines sharply when firms cut wages while wage increases are compressed because in an uncertain world, increasing the wage today increases the likelihood that the firm will have to cut wages, at a significant cost, in the future. The critical point is that neglecting the compression of wage increases might lead to an overestimation of the effects of DRWR on average wage growth. Although, we should deal with the potential bias in the empirical estimation of the deficit of wage cuts, we stick to the assumptions
and predictions of Holden and Wulfsberg (2009). Nevertheless, this issue will deserve a further discussion in future versions of this paper.

3 Data and empirical approach

We explore the potential existence of DRWR by comparing empirical real wage-change distributions with constructed notional (rigid-free) distributions, similarly as shown in Figure 2. In particular, we follow the empirical approach of Holden and Wulfsberg (2009), which became a useful approach for an aggregate data analysis. The critical point is that the observational unit in our data is the change in the average hourly earnings for all workers and not the change in the hourly earnings of job stayers as is common in microeconomic studies—e.g. Nickell and Quintini (2003), Elsby (2009), Stüber and Beissenguer (2012)—. There are two differences among these data sort, we have average wage over many workers and our data are affected by compositional changes because the wages of new workers differ from the wages of those who leave. One implication of these differences, is that prevalent DRWR among individual workers, apparent in micro data by a spike in the wage change distribution at zero, would not imply that the wage change is zero. Hence, we cannot test for DRWR by looking for spikes. One would expect however that prevalent DRWR at the individual level in an industry in most cases would prevent that the average wage change goes down. Hence, we are looking for a deficit of negative changes in average wages.

An important remark, is that, even if there is significant DRWR at the individual level, average wage growth at the industry level might be negative if workers with high wages quit—e.g. older workers who retire—. On the other hand, average wage changes might be large positive, if other workers receive large wage increases. Another key issue is that a deficit of negative changes in average industry wages might also be caused by other mechanisms than DRWR, e.g. systematic cyclical compositional changes, as the share of low-skilled workers may decrease in recessions, pushing up average wages when they are most likely to fall.

On this account, if we find statistical evidence of DRWR, it would imples that the wage rigidity found in microdata is not totally offset by compositional and other changes.

Regarding data issues, we use an unbalance panel of sector level data for the annual percentage growth of hourly wages for all workers in thirteen metropolitan areas covering the period 2002-2014. The areas included are: 1) Bogotá; 2) Medellín and Valle de Aburrá; 3) Cali and Yumbo; 4) Barranquilla and Soledad; 5) Cartagena; 6) Manizales and Villamaría; 7) Montería; 8) Villavicencio; 9) Pasto; 10) Cúcuta, Villa del Rosario, Los Patios and El Zulia; 11) Pereira, Dosquebradas and La Virginia; 12) Bucaramanga, Florida
Blanca, Giron and Piedecuesta; and 13) Ibagué. The sectors have been classified according to two-digits ISIC covering nine aggregate sectors: 1) Agriculture, Cattle Ranch, Forestry, Hunting and Fishing; 2) Mine and Quarry Exploitation; 3) Manufacturing Industry; 4) Electricity, Gas and Water; 5) Construction; 6) Commerce, Repairing, Restaurants and Hotels; 7) Transport, Storage and Communication; 8) Financial and Insurance; and 9) Social, Communal and Personal Services. In total, there are 8137 observations distributed across 59 industries, 767 sector-year samples. The data is taken from two household surveys, the Continuous Household Survey (Encuesta Continua de Hogares -ECH-) for the period 2002-2006 and the Household Integrated Survey (Gran Encuesta Integrada de Hogares -GEIH-) for 2007-2014.

Given the characteristics of our panel data, it allows us to estimate the extent of DRWR by comparing empirical and notional sector-year specific wage change distributions. Thus, we can construct sector-year specific estimates of the extent of DRWR by looking for a deficit of wage cuts in the observed wage changes. The notional distributions are derived from sector-year samples with high median nominal and real wage growth, which are assumed to be unaffected by DRWR. We assume that in the absence of any DRWR, the notional real wage growth in area $j$ in sector $i$ in year $t$, is stochastic with an unknown distribution $G$, which is parametrized by the median real wage growth, $\mu_{it}^N$, and the dispersion, $\sigma_{it}^N; G(\mu_{it}, \sigma_{it})$. Thus, we allow the location and dispersion of the notional urban wage growth to vary across sectors and years. Our hypothesis is that there is a larger variation across sectors than across areas with respect to inflation and wage setting (institutional variables).

### 3.1 Constructing the notional distribution

The notional distributions are constructed in two steps. First, we construct an underlying distribution of wage changes based on a subset of the sample, with $S^H = 209$ observations which were selected according to a twofold criteria: first, the median nominal and the median real wage growth must above the 75th percentile over all sector-years; second the level of inflation in sector $i$ is above the 75th percentile sector-years $^2$. The underlying distribution, thus, is constructed by normalizing the 209 empirical observations from the high-wage growth samples in high inflation years as follows:

$$\Delta w^u_s \equiv \frac{(\Delta w_{jit} - \mu_{it})}{(P_{75it} - P_{35it})}, \quad j, i, t \in H \quad \text{and} \quad s = 1, \ldots, S^H$$

$^2$The use of sector-years samples with median high-wage growth in upper quartiles and high inflation years is clearly arbitrary, therefore, we must modify the assumptions to check whether the results are robust.
where $\Delta w_{jit}$ is the observed wage growth in the city $j$, sector $i$, year $t$; $\mu_{it}$ is the corresponding observed sector-year specific median; and $(P75_{it} - P35_{it})$ is the inter-percentile range between the 75th and 35th percentiles which is used as a measure of dispersion. The subscript $s$ runs over $j$, $i$ and $t$ in 767 sector years. The calculated $\Delta w_{us}^s$ should thus be thought as observations from the standardized underlying two-parametric distribution $W \sim G(0, 1)$. Figure 2 compares the underlying distribution of wages (solid line) with the standard normal distribution (dashed line); note that the underlying distribution is slightly skewed left, the skewness coefficient of -0.02 confirms this small asymmetry.

\[
\Delta w_{us}^s \equiv \Delta w_{us}^s(P75_{it} - P35_{it}) + \mu_{it}, \quad i, t \in H \quad \text{and} \quad s = 1, \ldots, S^H
\]

Therefore, we have constructed, 767 notional sector-year distributions $\Delta \tilde{w}_{us}^s \sim G(\mu_{it}, P75_{it} - P35_{it})$, each consisting of $S = 209$ wage-change observations. Note that, these notional distributions have by construction the same shapes or structural across all notional sector-years, but their median and inter-percentile range are the same as their empirical sector year counterparts.
3.2 Measuring the extent of DRWR

As we have constructed the sector-year specific distributions, we can proceed to explore the extent of DRWR by comparing the notional and empirical distributions. In particular, we compare the incidence rate of notional wage changes \( \bar{q}(k)_{it} \), below a specific floor, \( k = 0 \), with the corresponding empirical incidence rate, \( q(k)_{it} \). Thus, for all sector-years samples, the notional incidence rate is defined as

\[
\bar{q}(k)_{it} = \frac{\# \Delta w_{it}^{s} < k}{S_{it}}, \quad s = 1, \ldots, 209
\]

Likewise, the empirical incidence rate is

\[
q(k)_{it} = \frac{\# \Delta w_{it}^{j} < k}{S_{it}}, \quad j
\]

where \( S_{it} \) is the number of observed areas in sector-year \( it \). The deficit of observed wage changes below floor \( k \) relative to the notional distribution (i.e., the fraction of wage changes prevented, \( FWCP(k) \)) is calculated as

\[
FWCP(k)_{it} = 1 - \frac{q(k)_{it}}{\bar{q}(k)_{it}}
\]

The estimates of \( FWCP \) in single sector-years will be imprecise, because the small number of areas in each sector-year sample, thirteen or less. Thus, we present estimates of the average \( FWCP \) for aggregate industries and periods, which are likely to be more precise.\(^3\)

3.3 Estimates

Table 2 presents estimates of the notional incidence rate, \( \bar{q} \), and the fraction of wage changes prevented, \( FWCP \). It also reports the empirical incidence rate, \( q \). The data corresponds to sectorial, temporary and overall average.

For the full sample, the estimated \( FWCP \) is 16.27%. Thus, about 16 out of 100 notional real wages cuts in the overall sample do not result in an observed wage cut due to DRWR. A more surprising result is that about 30% of observed wage changes are negative. Hence, our results suggest that in a free wage rigidity system the rate of real wage cuts would be much higher.

At sectorial level, the extent of the DRWR is much larger in two economic activities: mining and agriculture, the fraction of wage changes prevented is 40.15% and 37.31%, on

\(^{3}\)In next stages of this research, we will use the simulation method of Holden and Wulfsberg (2009) to test the statistical significance of our estimates of DRWR. Their method is considered very powerful for detecting a possible difference between the empirical and notional wage change distribution.
average. Two common features of these sectors are the high union density, 42.88% and 72.48%; and the high level of unemployment, 13.17% and 15.40% (see Table 4). These results are consistent with the standard theoretical prediction. On the other hand, real wages from commerce and electricity sectors appear as flexible, with a FWCP of 1.34% and 3.70%. As shown in Table 4, both industries share similar levels of unemployment, by 11% on average, a low rate compared to 15.40% of the agriculture sector. Finally, the wage rigidity for the manufacturing industry and the financial service sector is roughly 11%, two percentage points under the overall mean.

Distinguishing among time periods, the DRWR becomes stronger in 2002, 2007 and 2014. The early 2000s make up a post-financial crisis period, in which consumption and production prices sharply drop leading to single-digit inflation rates in contrast to two-digit inflation rates of the nineties. On the other hand, 2007 is a low inflation year pre-great recession, for example the mining activity reached a zero inflation rate. Regarding 2014, it is economic expansion year in which most of sectors experienced a slight fall in prices. Overell, these results provide empirical evidence that wage rigidity is more likely to be bind in periods of low inflation.

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Years</th>
<th>( \bar{q}_t )</th>
<th>( q_t )</th>
<th>( FWCP_t )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture &amp; Fishing</td>
<td>2001-02</td>
<td>47.20</td>
<td>36.70</td>
<td>21.98</td>
</tr>
<tr>
<td>Mine &amp; Quarry Exploitation</td>
<td>2002-03</td>
<td>60.16</td>
<td>49.08</td>
<td>15.57</td>
</tr>
<tr>
<td>Manufacturing Industry</td>
<td>2003-04</td>
<td>50.30</td>
<td>43.61</td>
<td>13.53</td>
</tr>
<tr>
<td>Electricity, Gas &amp; Water</td>
<td>2004-05</td>
<td>40.37</td>
<td>40.08</td>
<td>14.88</td>
</tr>
<tr>
<td>Construction</td>
<td>2005-06</td>
<td>49.96</td>
<td>47.94</td>
<td>9.43</td>
</tr>
<tr>
<td>Commerce &amp; Hotels</td>
<td>2006-07</td>
<td>40.63</td>
<td>30.72</td>
<td>28.69</td>
</tr>
<tr>
<td>Transport &amp; Communication</td>
<td>2007-08</td>
<td>49.34</td>
<td>44.64</td>
<td>14.90</td>
</tr>
<tr>
<td>Financial &amp; Insurance</td>
<td>2008-09</td>
<td>54.80</td>
<td>48.84</td>
<td>14.42</td>
</tr>
<tr>
<td>Social Services</td>
<td>2009-10</td>
<td>47.13</td>
<td>40.39</td>
<td>17.73</td>
</tr>
<tr>
<td></td>
<td>2010-11</td>
<td>44.26</td>
<td>40.39</td>
<td>13.14</td>
</tr>
<tr>
<td>All observations</td>
<td>2011-12</td>
<td>48.21</td>
<td>46.14</td>
<td>13.76</td>
</tr>
<tr>
<td>( \bar{q} )</td>
<td>2014-13</td>
<td>50.78</td>
<td>42.91</td>
<td>14.22</td>
</tr>
<tr>
<td>( q )</td>
<td>2013-14</td>
<td>43.53</td>
<td>35.26</td>
<td>19.07</td>
</tr>
</tbody>
</table>

Notes: Data in percentages
4 Explaining Downward Real Wage Rigidities

The theoretical model of Holden and Wulfsberg (2009) described in section 2, points out that the prevalence of DRWR depends on institutional and economic variables such as the strictness of employment protection legislation (i.e. regulation about hiring and firing)\(^4\). The union bargaining strength in whatever form (e.g. measures of trade union density, number of strikes, or days lost due to labor conflicts). The unemployment rate and the inflation with a potential no-linear effect.

Although, vast empirical evidence on developed countries (e.g. Kahn (1997), Chis-rtofides and Leung (2003) and Fehr and Gote (2005)) has found that all this explanatory variables are, indeed related to wage rigidity. The wage setting environment in Colombia differs from developed countries. The system of unemployment is absent, labor unions are very weak, a modern welfare state is non-existent, and there is a large informal or underground economy. We must, therefore, take into account these features of the Colombian labor market in our empirical implementation. Additionnally, variables related to employment protection are not included due to data is not available. \(^5\) On this account, our empirical specification test five potential drivers of the DRWR: inflation, unemployment, union power (measured as trade union density and union affiliation), informality and real minimum wage.

The theoretical effect of minimum wage on wage changes is well-known. The minimum wage operates as a sort of reservation or floor wage, that exerts an upward pressure on wages. This, in turn, has been interpreted as a source of the downward wage rigidity. Although, initially one would expect a positive relationship between the fraction of wage cuts prevented and the minimum wage. There are some key empirical issues which lead us to expected an opposite relationship (a negative sign) in the Colombian case. First, nominal minimum wage is indexed on a yearly basis following the previous year CPI inflation rate. Its growth cannot be inferior to this rate,\(^6\) and is the same irrespective of the economic sector (see Hofstetter, 2005, for details). Second, as shown in Iregui et al. (2012), most of firms adjust nominal wages annually at rates that are roughly equivalent to the observed rate of CPI inflation. Hence, if the nominal minimum wage is deflated by GDP deflator, it simply captures the wedge between consumption and production prices.

\(^4\)The first type of regulation includes: rules favouring disadvantaged groups, conditions for using temporary or fixed-term contracts, training requirements. The second type refers to redundancy procedures, mandated prenotification periods and severance payments, special requirements for collective dismissals and short-time work schemes.

\(^5\)As we have available a microdata base, which contains a large number of variables, we may construct some indicators.

\(^6\)This was started by judgment C-815 of the Constitution Court in 1999 as a consequence of the loss of purchasing power of the minimum wage in the eighties and early nineties.
Our hypothesis is that, if industrial prices tend to grow more than consumption prices (reflecting a lower real minimum wage), we would expect a lower fraction of real wage prevented and a greater empirical incidence of real wage cuts. On contrary, if industrial prices tend to grow less than consumption prices, following the same intuitive idea, we expect a positive effect exerted by the real minimum wage (or alternatively by the price wedge) on the DRWR.

Regarding the link between DRWR and informality, some recent theoretical and empirical studies, e.g Ahmed et al. (2014) and Batini and Levine (2010), highlight that wages in informal sectors are flexible or at least they are significantly more flexible that those from formal sectors. Indeed, Batini and Levine (2010) set that the benefit of informality derives from its wage flexibility. In a macroeconomic context, using average wage growth as observation unit, this flexibility would reduce the extent of DRWR. However, it is not clear, whether the wage flexibility in informal sector may extert a negative or positive effect on DRWR of the formal sector. Ahmed et al. (2014) found that informal economy is a key determinant of wage stickiness (measure as the frequency of wage changes) in Pakistan. Indeed, they show that, firms who hire informal labor force, tend to be more flexible to changes in wages.\footnote{This issue requires further research.}

4.1 Data

We construct a panel database with a cross-section dimension of \( N = 9 \) sectors and a time dimension of \( T = 12 \) years covering the period 2002-2014. Table 3 presents the variables and the corresponding sources.

Sectorial inflation is calculated base on GDP deflator, which is taken from the National Administrative Department of Statistics (Departamento Administrativo Nacional de Estadística, DANE). Unemployment and informal employment rates are computed base on micro data, which are taken from the Continuous Household Survey (Encuesta Continua de Hogares, ECH) for 2002-2006 and the Household Integrated Survey (Gran Encuesta Integrada de Hogares, GEIH) for 2007-2014. As, there are not series available for sectorial unemployment rates, they have been approximated as follows: the number of unemployed in sector \( i \), taking as reference the sector of the last job; over the number of employees in that sector. Regarding informal rate (i.e. informal employment over total employment), it has been computed following informal employment definition of DANE and International Labour Organization (OIT). In particular, it is considered informal employment:

- Private employees and workers who work in establishments, businesses or enterprises employing up to five persons in all its branches and agencies, including the employer
and/or partner.

- Family workers with out remuneration.
- Domestic workers.
- Laborers in enterprises or activities employing up to five persons.
- Own-account workers who work in establishments, businesses or enterprises employing up to five persons, except independent professionals.
- Employers and employees in enterprises employing up to five persons.

The union affiliation data (i.e. the number of affiliates per union) is obtained from the national trade union institution (Escuela Sindical Nacional, ENS), in turn, trade union density rate is approximated with the number of unionized workers reported by ENS and the total employment from ECH-GEIH. Finally, data on nominal minimum wages is collected from the Colombian Central Bank (Banco de la República) and they are deflated by the GDP deflator.

Table 3. Definitions of variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Sources</th>
<th>Subindices</th>
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<tbody>
<tr>
<td>$FWCPF_{it}$</td>
<td>Fraction of wage changes prevented</td>
<td>(1) $i = 1, ..., 9$ sectors</td>
</tr>
<tr>
<td>$p_{it}$</td>
<td>GDP deflator</td>
<td>(2) $t = 1, ..., 13$ years</td>
</tr>
<tr>
<td>$\Delta p_{it}$</td>
<td>Inflation</td>
<td>(2)</td>
</tr>
<tr>
<td>$U_{it}$</td>
<td>Unemployed</td>
<td>(3)</td>
</tr>
<tr>
<td>$N_{it}$</td>
<td>Total employment</td>
<td>(3)</td>
</tr>
<tr>
<td>$N_{it}^{in}$</td>
<td>Informal employment</td>
<td>(3)</td>
</tr>
<tr>
<td>$u_{it}$</td>
<td>Unemployment rate $\frac{U_{it}}{N_{it}}$</td>
<td>(3)</td>
</tr>
<tr>
<td>$\iota_{it}$</td>
<td>Informal employment rate $\frac{N_{it}^{in}}{N_{it}}$</td>
<td>(3)</td>
</tr>
<tr>
<td>$\vartheta_{it}$</td>
<td>Trade union affiliation</td>
<td>(4)</td>
</tr>
<tr>
<td>$\theta_{it}$</td>
<td>Trade union density</td>
<td>(1-4)</td>
</tr>
<tr>
<td>$w_{it}^{min}$</td>
<td>Minimum real wage</td>
<td>(5)</td>
</tr>
</tbody>
</table>

Notes: All nominal variables are deflated by the GDP deflator (base: december 2005). (1) Own estimates; (2) DANE; (3) Own calculations base on ECH-GEIH ; , (4) ENS; (5) Banco de la República

4.2 Stylized facts

Table 2 provides descriptive information on some crucial macroeconomic variables of interest. Subscript $i$ denotes information corresponding to the average rates in each of the
9 sectors in which the Colombian industry has been disaggregated. This information give us further insights about which factors could explain the large differences on wage rigidity across sectors.

First of all, we observe some general and remarkable issues. There is a low union density rate, which goes in parallel with a general fall in union affiliation. The size of the informal activity is extensive, except for the electricity, gas and water sector whose rate is only 2.42% on average. Finally, given the indexation of nominal minimum wage to CPI index, the falls in the minimum real wage in mining and construction sector reflect that GDP inflation is larger to the CPI inflation.

Second, we observed that real wages in commercial sector and social services are highly flexible. The performance of the commercial sector is quite consistent with the theoretical predictions. The wage flexibility goes together with the insignificant trade union density, 2.87%; the extensive size of informal employment, 68.64%; and unemployment rates over the mean, by 11%.

Finally, as mentioned in previous sections, the extent of the DRWR is much larger in mining and agriculture activities. Although, both activities have the greatest union densities and high unemployment rates, the size of the informal employment in mining sector is relatively low.

<table>
<thead>
<tr>
<th>Table 4. Macro developments in the Colombian industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector</td>
</tr>
<tr>
<td>Agriculture &amp; Fishing</td>
</tr>
<tr>
<td>Mine &amp; Quarry Exploitation</td>
</tr>
<tr>
<td>Manufacturing Industry</td>
</tr>
<tr>
<td>Electricity, Gas &amp; Water</td>
</tr>
<tr>
<td>Construction</td>
</tr>
<tr>
<td>Commerce &amp; Hotels</td>
</tr>
<tr>
<td>Transport &amp; Communication</td>
</tr>
<tr>
<td>Financial &amp; Insurance</td>
</tr>
<tr>
<td>Social Services</td>
</tr>
</tbody>
</table>

4.3 Econometric methodology

We undertake Poisson regressions where the number of observed wage changes below floor $k = 0$ in each sector-year sample, $Y(k)_{it}$, depends on the average number of simulated wage cuts for each sector-year sample, $\hat{Y}(k)_{it}$, and the explanatory variables mentioned above, $X_{it}$. A Poisson regression becomes appropriate, because $Y(k)_{it}$ is the number of
times we observe an event. The conditional density of the number of observed wage cuts in country-year $i,t$ in the Poisson model is

$$f \left[ Y(k)_{it} = y(k)_{it} \mid \hat{Y}(k)_{it}, X_{it} \right] = \frac{e^{-\lambda_{it} Y(k)_{it}} Y(k)_{it}^{y(k)_{it}}}{y(k)_{it}!},$$

where the Poisson parameter, $\lambda_{it}$, is given by

$$\lambda_{it} = \hat{Y}(k)_{it} e^{x_{it} \beta}, \quad \text{if } \hat{Y}(k)_{it} > 0,$$

where $\beta$ is the parameter vector we want to estimate. Using the definition of the FWCP and given that $\hat{Y}(k)_{it} = E[\hat{Y}(k)_{it} \mid \hat{Y}(k)_{it}, x_{it}]$, we obtain

$$[1 - FWCP(k)] = \frac{Y(k)_{it}^{Y(k)_{it}}}{Y(k)_{it}^{x_{it} \beta + \varepsilon_{it}}}, \quad \text{if } \hat{Y}(k)_{it} > 0,$$

where $\varepsilon_{it}$ is an error term. Recall that $[1 - FWCP(k)]$ captures the fraction of real wage cuts realized.

### 4.4 Results

Table 5 displays estimates from Poisson regressions in two blocks, the one on the left-hand-side corresponding to the estimation where FWCP is used as the dependent variable; and the one on the right-hand-side to the estimation, where $[1 - FWCP(k)]$ is used as the dependent variable. Both estimations are shown as a robustness check. Take into account, that the corresponding coefficients must have an opposite sign across blocks.

All specifications, columns 1-8, were computed using the Maximum Log-Likelihood estimator including fixed effects across sectors. The reported robust standard errors are clustered by sectors. Although, there are potential econometric problems associated to Poisson regression, e.g. overdispersion and zero inflation; we do not deal with them because, first of all, we should improve the DRWR estimates and perform a lot of robustness checks. Thus, the following results represent an initial point of reference.

In any case, the eight sets of estimates provide a similar picture, we find statistical evidence that inflation, the real minimum wage, and the informal employment, have significant effects on DRWR. On contrary, the unemployment rate, the union density and the union affiliation appear as non-relevant. An important remark, is that the magnitude of the coefficients are quite robust across specifications, the only exception is the minimum wage. Note that, the magnitude of the coefficients go down when $\Delta p_{it}^2$ is dropped.

Inflation is found to have a low negative effect on the fraction of real wage cuts prevented, by 0.01%, it means that an increase of 1 percentage point in the inflation rate reduces in 100 bps the FWCP. The negative sign is consistent with the standard
theoretical predictions. On the other hand, the estimates on columns 6 and 8 report a statistical positive effect of inflation on the fraction of real wage cuts realized, nevertheless, its magnitude becomes non-relevant, meaning that positive inflation shocks (at sectorial level) do not exert a strong downward pressure on real wages. Also, note that inflation does not have a quadratic effect.

Table 5. Estimated equations

<table>
<thead>
<tr>
<th></th>
<th>$FWCP_{it}$</th>
<th></th>
<th>$[1 - FWCP_{it}]$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FE</td>
<td>FE</td>
<td>FE</td>
</tr>
<tr>
<td>$\Delta p_{it}$</td>
<td>0.00</td>
<td>-0.01***</td>
<td>-0.01***</td>
</tr>
<tr>
<td></td>
<td>[3.00]</td>
<td>[3.19]</td>
<td>[3.19]</td>
</tr>
<tr>
<td>$\Delta p_{it}^2$</td>
<td>-0.00***</td>
<td>-0.00***</td>
<td>0.00***</td>
</tr>
<tr>
<td></td>
<td>[-3.54]</td>
<td>[-4.19]</td>
<td>[3.90]</td>
</tr>
<tr>
<td>$u_{it}$</td>
<td>-0.01</td>
<td>-0.02</td>
<td>-0.02</td>
</tr>
<tr>
<td></td>
<td>[-0.56]</td>
<td>[-0.62]</td>
<td>[-0.62]</td>
</tr>
<tr>
<td>$\theta_{it}$</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>[0.93]</td>
<td>[0.74]</td>
<td>[0.92]</td>
</tr>
<tr>
<td>$\vartheta_{it}$</td>
<td>-0.56</td>
<td>-0.99</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>[-2.55]</td>
<td>[-2.15]</td>
<td>[0.49]</td>
</tr>
<tr>
<td>$\tau_{it}$</td>
<td>0.03***</td>
<td>0.04***</td>
<td>0.03***</td>
</tr>
<tr>
<td></td>
<td>[3.07]</td>
<td>[3.60]</td>
<td>[3.32]</td>
</tr>
<tr>
<td>$w_{it}^{\text{min}}$</td>
<td>-1.65**</td>
<td>-1.44***</td>
<td>-1.65**</td>
</tr>
<tr>
<td></td>
<td>[-2.55]</td>
<td>[-2.15]</td>
<td>[-2.48]</td>
</tr>
<tr>
<td>Obvs.</td>
<td>117</td>
<td>117</td>
<td>117</td>
</tr>
<tr>
<td>$LL$</td>
<td>-26.11</td>
<td>-26.16</td>
<td>-26.11</td>
</tr>
</tbody>
</table>


Regarding informality, we find a significant effect on the $FWCP$ and the counterpart, $[1 - FWCP]$. But in both sets of regressions, we obtained an unexpected sign. In particular, the results suggest that a 1% increase in the informal employment rate causes the downward real wage rigidity to strengthen by 0.03%. As the informal employment have not been excluded from the sample; we thing that this positive effect, might capture a kind of spillover effect arising from the wage flexibility in the informal economy. Nevertheless, we have not been identified a potential mechanism capable to explain the relationship between informality and DRWR of the formal employment.

On the other hand, the real minimum wage exerts a high negative effect on the DRWR. As explained formerly, given that in Colombia the nominal minimum wage is highly tied to the cost of living, the corresponding coefficients capture the impact exerted by the wedge between consumption and industrial prices on DRWR. In turn, the sign of the
coefficient will depend on the relative evolution of prices. Thus, a effect of -1.65%, are reflecting that GDP inflation for some sectors (mining and construction) tend to grow more than consumption prices, therefore a 1% in the price wedge reduces the DRWR by 1.65%.

5 Conclusions and further research

We have explored the potential existence of downward nominal wage rigidity (DRWR) in Colombia. The analysis is provided at sectorial level, based on data from thirteen metropolitan areas over the period 2002-2014. We estimated a deficit of real wage cuts by 16.27%, it means that about 16 out of 100 notional real wages cuts do not result in an observed wage cut due to DRWR. At the sectorial level, we find marked differences. On one extreme, we have the mining and agriculture sectors, where more than 40% of the real wage cuts are prevented. On the other extreme, we have the commercial sector, with a rate, by 1.34%. In addition, the manufacturing industry and the transport service have intermediate level of DRWR, reporting rates about the overall mean.

Although, the large differences in the DRWR may be associated to large differences on trade union densities across sectors. We show that wage rigidity in Colombia is not fundamentally connected to the wage bargaining system, in contrast to the vast empirical evidence on developed countries, e.g. Holden and Wulfsberg (2009).

On the contrary, the real minimum wage and labor informality appear as the crucial drivers. We find a high negative effect of real minimum wage on the DRWR, in particular a 1% increase in the real minimum wage reduces the DRWR by 1.65%. As this institutional variable also captures the price wedge between consumption and industrial prices, then, the negative sign has been associated with the relative higher grow of industrial prices with respect to consumption prices. On this account, the indexation of nominal wages have not enhance the DRWR, at least for those sector whose relative price follow the same trend described formerly.

Regarding informality, we find a significant effect labor informality, but we obtained an unexpected positive sign. As we work with total employment, we thing that it can disturb the truth effect of informal economy on DRWR.

Our analysis can be improved and extended in a variety of directions. Regarding the notional distribution, we must conduct different robustness checks. To construct the underlying distribution, different dispersion measures must be undertaken. The empirical and notional incidence rate should be calculated for different wage changes floors. Moreover, we must test the significane of DRWR, usinf for explame the simulation method of Holden and Wulfsberg (2009).
Further research should control for types of employment (either formal-informal or low-high skilled) because the extent of DRWR may exert different effects on real wage changes distribution depending on the type of worker. Even more, some of the drivers discussed in this study may become more or less powerful after controlling by type of worker. For example, regarding informality, international evidence suggests that wages in informal sectors are significantly more flexible than those from formal sectors.

Another research avenue is to construct another explanatory variables related to non-wage cost, type contracts, different measures of informality.

References


