Evolving Wage Cyclicality in Latin America

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July, 2014

Abstract

A vector autoregression model with time-varying coefficients is used to examine the evolution of wage cyclicality in four Latin American economies: Brazil, Chile, Colombia and Mexico, during the period 1980–2010. Wages are highly pro-cyclical in all countries up to the mid–1990s except in Chile. Wage cyclicality declines thereafter, especially in Brazil and Colombia. This decline in wage cyclicality is in accordance with declining real–wage flexibility in a low–inflation environment. Controlling for compositional effects caused by changes in labor force participation along the business cycle does not alter these results.

Keywords: *Downward Wage Rigidity, Indexation, Real Wage Cyclicality, Vector Autoregression, Time Varying Coefficients, Bayesian Estimation*

JEL Classification: *E24.*

1 Introduction

The debate about the extent and importance of real wage rigidities has been central in developed economies. Modern DSGE models, especially those used by central banks for policy evaluation, feature different forms of wage rigidity including nominal wage stickiness and partial indexation (e.g., Christiano, Eichenbaum and Evans, 2005; Smets and Wouters, 2007). The importance of real wage rigidities is indeed fundamental to understand the trade-off between unemployment and inflation in models of the new-Keynesian tradition (Blanchard and Galí, 2007). Perhaps not surprisingly, this debate has been less important in developing countries, where other aspects of macroeconomic stabilization have been the focus of attention in the policy agenda. A natural reason for this dichotomy involves the differences in the inflation rates across the two groups of countries. High-inflation environments, which used to characterize the developing world, are associated with greater inflation volatility (Friedman, 1968). In this context, the volatility of real wages is likely to be high, too, diminishing the importance of downward wage rigidities for the macro-economy.

But developing countries have successfully brought down inflation during the past two decades. This is particularly true in Latin America, where the inflation rate declined from an average of 25 percent in the first half of the 1990s to 5 percent in 2005–2009. This process of macroeconomic stabilization most likely had a significant impact on the dynamics of wage adjustments in the region. One mechanism through which a low-inflation environment is likely to increase the degree of real wage rigidity is by increasing the likelihood that downward nominal rigidities become binding. If workers resist nominal wage cuts, firms operating in a low-inflation environment subject to a negative shock are hampered in adjusting real wages.[1] Moreover, macroeconomic stabilization may also

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[1] The literature has offered various rationales for downward wage rigidity. In the fair wage effort model, Akerlof (1980) argues that workers would perceive a wage cut as unfair, reducing their morale and effort. Hence, firms are reluctant to cut nominal wages. Manager interviews (Bewley, 1999) and surveys of wage setters (Cambell and Kamlani, 1997) in the United States provide support for this theory. In Europe efficiency wage considerations are important (DuCaju et al. 2014), but institutional constraints, most notably unions and employment protection, play a fundamental role in understanding the resistance of workers to nominal (Holden and Wulfsberg, 2008) and real (Dickens et al. 2007) wage cuts. Evidence for middle-income countries is more limited, but Messina and Sanz-de-Galdeano (2014) for the cases of Brazil and Uruguay and Castellanos, Garcia-Verdu and Kaplan (2004) for Mexico, show that downward

interact with other forms of wage rigidity, such as wage indexation, although in this case the consequences of operating in a low-inflation environment become less clear. On the one hand, indexation mechanisms might be easier to implement when inflation is low, considering that in a low-inflation environment the predictability of inflation is higher. On the other hand, indexation rules might become less necessary when inflation is under control, and the fight of central banks against indexation mechanisms are more likely to succeed.[2]

This paper attempts to shed some light on the changing importance of real wage rigidities in Latin American countries, by looking at the evolution of real wage adjustments over the business cycle. Our interest in examining *changes* in the real wage cyclicality determines the methodology we apply to the data. In contrast to the previous macro literature that examines the cyclical movements of wages,[3] we can assess the time-varying nature in the comovement of real wages and output by estimating a vector autoregression model with both, time-varying coefficients and residuals volatilities. This model has become quite a popular tool in macroeconomics over the last few years, in studies addressing questions related to the evolution of the structure of the economy and the volatility of the shocks (see Primiceri, 2005; Canova and Gambetti 2009; Galí and Gambetti 2009). Our paper is a first attempt to apply these models to assess how the cyclical behavior of wages varies over time. We focus on the four Latin American economies–Brazil, Chile, Colombia and Mexico–for which sufficiently long time-series of quarterly wage data for the manufacturing sector are available. The samples for Brazil and Mexico span from the early 1980s to 2010. In Colombia and Chile, the series are shorter, starting in 1990 and 1993, respectively.

A fundamental advantage of the approach we adopt in this paper is that it properly accounts for the dynamic properties of the underlying data series and their comovement, as well as for changes in the underlying relationship between the different variables.

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nominal and real wage rigidities are pervasive when inflation is low, i.e., during the late 1990s and 2000s.

[2]Messina and Sanz-de-Galdeano (2014) study the impact of disinflation on the extent of wage indexation in Brazil and Uruguay. While the two countries featured high indexation during the high inflation period, their responses to the disinflation of the 1990s was different. Wage indexation in Uruguay receded quite rapidly, while it was fairly persistent in Brazil.

[3]See Abraham and Haltiwanger (1995) for an excellent literature review of the empirical literature and Messina, Strozzi and Turunen (2009) for a recent application to OECD countries.

Notably, a number of authors starting with Neftçi (1978), have stressed that accounting for the dynamic properties of the data series, such as persistence over time, may matter to correctly understand real wage and employment cyclicality.[4] The dynamic properties of the data can indeed vary substantially across data series and countries, and as shown in den Haan (2000), evidence on the cyclicality of prices based on simple static measures (e.g., comovement of de-trended series) can be misleading.

We find that wages have been highly procyclical in three of the countries studied: Brazil, Colombia and Mexico. The exception is Chile, which exhibits mostly acyclical real wages in the manufacturing sector. In Brazil and Colombia there are clear signs of declining wage cyclicality over the sample period. The evidence in Mexico goes in the same direction, but differences over time are not as marked. These developments go in line with the emergence of downward real wage rigidities in the region during the macroeconomic stabilization of the late 1990s and 2000s. Although our main focus is on the study of the cyclicality of real wages, we also investigate the parallel developments of employment adjustment over the business cycle. Interestingly, declining wage cyclicality is not accompanied in all cases by an increase in the employment cyclicality, suggesting a more important role of alternative adjustment channels (e.g. hours or other labor costs) during the past decade.

An important limitation of studying the cyclical behavior of real wages with aggregated data is that we cannot control for systematic changes in the composition of employment, which are likely to occur at business cycle frequencies (Bils, 1985). Low-earning workers typically enter the labor force during upswings and exit during downturns, biasing downwardly the reaction of wages to the cycle evaluated at the macro level. Following Solon, Barsky and Parker (1994), a number of studies using micro data for developed countries have confirmed the importance of such bias. We tackle this issue in our context by looking at the Brazilian case in more detail, exploiting available micro data from the "Pesquisa Mensal de Emprego", one of the few labor force surveys

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[4]Abraham and Haltiwanger (1995) discuss at length the different approaches taken up in the literature to measure the cyclical behavior of wages. An application using the correlation between de-trended compensation per employee and GDP in a large number of Latin American countries is Aguilera and Martínez (2009).

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in the developing world reporting long series (since 1984) of individual wage data on a monthly basis. Interestingly, we find that controlling for observable characteristics of the employed population over the business cycle makes little difference to the estimates of real wage cyclicality.

The Brazilian data also allow us to examine real wage adjustments for the whole economy and to contrast them with those found in the manufacturing sector. The declining cyclicality found in the manufacturing sector is broadly consistent with what we find for the whole economy, suggesting that our results are likely to extend to the rest of the economy.

The rest of the paper is organized as follows: Section 2 describes the data and econometric strategy. Section 3 summarizes the main results. Section 4 assesses the robustness of the results with respect to both changes in the composition of the labor force over the business cycle and differences in the cyclical behavior of wages across sectors. Section 5 concludes.

2 Data and Econometric Approach

2.1 Data

We use quarterly data for Brazil, Chile, Colombia and Mexico. The key variables are: real consumer wages; employment index industry; volume of industrial production index. All these variables are obtained from national sources, as described in Appendix 1. The indicator of real wage is the average hourly wage in the manufacturing sector deflated by the consumer price index (CPI). As Abraham and Haltiwanger (1995) and Messina, Strozzi and Turunen (2009) have shown, the choice of the deflator is not innocuous. Consumer wages (those deflated with the CPI) tend to be more pro-cyclical than producer wages (those deflated with producer price indices). We focus on consumer wages since this is the best measure to approximate worker's welfare. Naturally, the employment measure we use is the number of employees in the manufacturing sector. This leaves out from the analysis the intensive margin of labor market adjustment, since long series of hours worked for LAC countries are not available. All the variables are
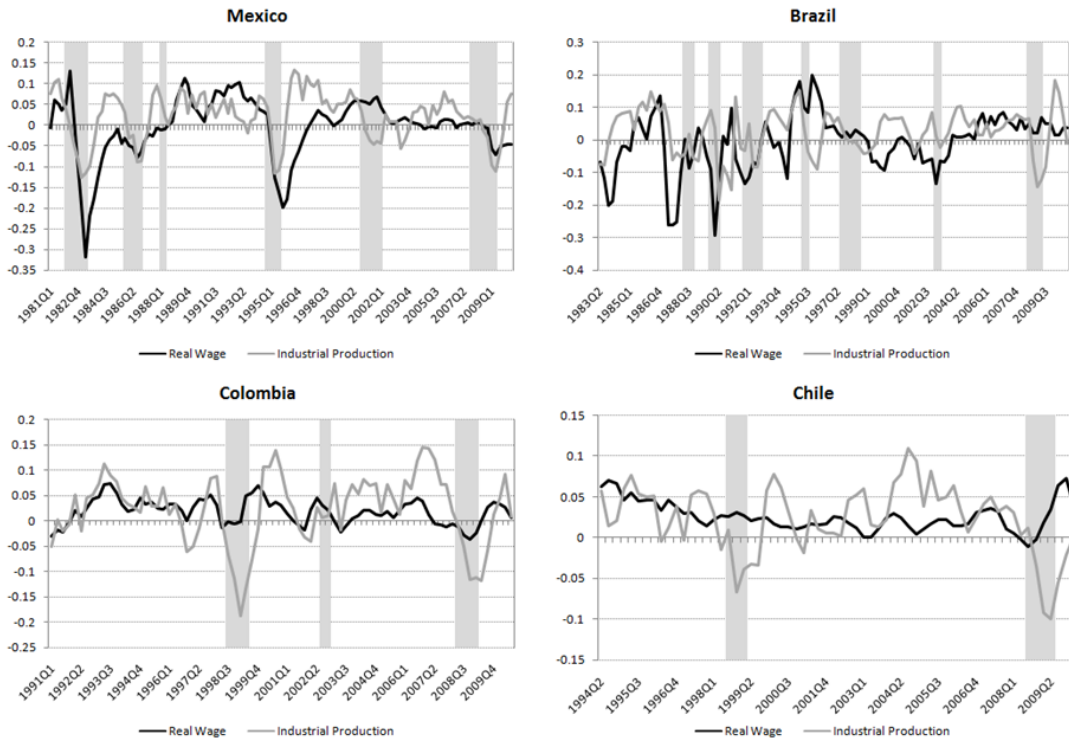
Figure 1: Growth of Real Hourly Wages and Industrial Production during Expansions and Recessions

seasonally adjusted using the X12 methodology. Considering the rapid swings in the series that characterize these emerging economies we take annualize growth rates rather than changes in the log series, which are customary in most of the literature.

We start the discussion of the data in Figure 1, which shows the evolution of the growth rate of real wages and the index of industrial production in the four countries considered for the analysis. Gray areas indicate recessions, which are dated following Hardin and Pagan (2002).The first aspect that stands out from the data is that wages in Mexico and Brazi7l appear to be more volatile than output during the first half of the sample. This is particularly evident during the recessions. Real wages fell rapidly during the debt crisis (1982) and the Tequila crisis (1995) in Mexico. In Brazil, the recessions of the 1990s are also characterized by rapid falls in real wages. This wage adjustment contrasts sharply with the adjustment of real wages during the great recession of 2008-

2009. In the case of Mexico, real wages fall, but to a lesser extent that the fall in real output. In Brazil, the rapid downward adjustment in production is not matched by a downward adjustment in real wages. In Colombia wages also appear to be less sensitive to output in the second half of the sample, but the real wage does not decline during the recessions throughout the sample period. In contrast, manufacturing wages in Chile appear to be highly insensitive to the cycle throughout the period.

2.2 Econometric Approach

The model is a vector autoregression with time-varying coefficients and stochastic volatility. Let $y_t = (w_t, e_t, y_t)'$, where w_t is the real wage, e_t is employment and y_t is industrial production. y_t satisfies

$$y_t = A_{0,t} + A_{1,t}y_{t-1} + ... + A_{p,t}y_{t-p} + \varepsilon_t \tag{1}$$

where $A_{i,t}$ are matrices of time-varying coefficients, $i = 1, ..., p$, ε_t is a Gaussian vector white noise and $A_{0,t}$ is a vector of time-varying intercepts.

Let $vec(\cdot)$ be the stacking column operator. We define $A_t = [A_{0,t}, A_{1,t}..., A_{p,t}]$, and $\theta_t = vec(A_t')$, and we assume

$$\theta_t = \theta_{t-1} + \omega_t \tag{2}$$

where ω_t is a Gaussian vector white noise with variance Ω.

We decompose the variance of the innovation in (1), Σ_t, as follows: $\Sigma_t = F_t D_t F_t'$, where D_t a diagonal matrix and F_t is a lower triangular matrix with ones on the main diagonal. Let $\phi_{i,t}$, $i = 1, ..., n-1$ the column vector formed by the first i elements of the $(i+1)$-th row of F_t^{-1} and σ_t to be the vector of the diagonal elements of $D_t^{1/2}$. We assume that the parameters evolve as

$$\log \sigma_t = \log \sigma_{t-1} + \xi_t \tag{3}$$

$$\phi_{i,t} = \phi_{i,t-1} + \psi_{i,t} \tag{4}$$

where ξ_t and $\psi_{i,t}$ are Gaussian vectors white with covariance Ξ and Ψ_i. Finally we

assume that ξ_t, ψ_t, ω_t, ε_t are uncorrelated and that also the elements of $\psi_{i,t}$ and $\psi_{j,t}$ are uncorrelated for $j \neq i$. Details of the estimation can be found in the Appendix.

To investigate variances and correlation let us consider the approximated MA representation

$$y_t = \mu_t + \sum_{k=1}^{\infty} C_{k,t} \varepsilon_{t-k} \tag{5}$$

where $\mu_t = \sum_{k=0}^{\infty} C_{k,t} A_{0t}$, $C_{0,t} = I$, $C_{k,t} = \mathcal{S}_{n,n}(\mathbf{A}_t^k)$, $\mathbf{A}_t = \begin{pmatrix} I_{n(p-1)} & A_t \\ & 0_{n(p-1),n} \end{pmatrix}$, and $\mathcal{S}_{n,n}(X)$ is a function selecting the first n rows and n columns of the matrix X.

The approximated variance of y_t is given by

$$V_t(y_t) = \sum_{k=0}^{\infty} C_{k,t} \Sigma_t C'_{k,t}.$$

The time-varying correlation between the first and second variable is given by

$$Corr_{t,12} = \frac{V_{t,12}}{\sqrt{V_{t,11} V_{t,22}}}$$

Once the estimates of model parameters are available, we draw a realization of A_t and Σ_t and compute the implied realization of V_t and $Corr_t$.

3 Results

3.1 The Cyclicality of Real Wages and Employment

Figure 2 shows the time-varying evolution of the standard deviation of wages, employment and industrial production (IP) in the four countries studied. The first aspect worth noting is the tremendous volatility of wages and employment in the two countries that experienced three-digit inflation rates during the 1980s and first half of the 1990s: Brazil and Mexico. The volatility of employment and wages is about three to four orders of magnitude larger in this period relative to the other two countries as well as to their own experiences during the 2000s. In contrast, the variance of wages in Chile and Colombia remain low and fairly stable throughout the sample period. The variances of employment spike in these two countries only at the end of the 1990s.
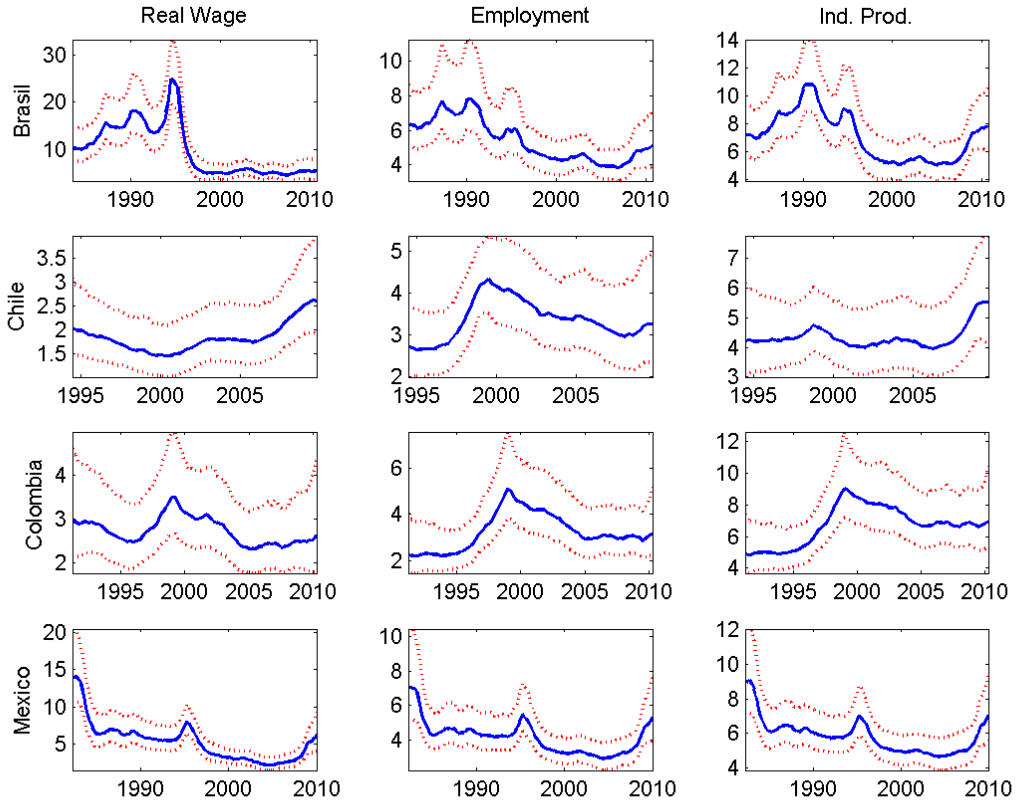
Figure 2: The Evolution of the Standard Deviation of Wages, Employment and Output

How about the response of these three macro aggregates during the Great Recession? In Brazil, Chile and Colombia, we do not observe substantial changes, with the possible exception of an increase in the variance of IP in Chile. In contrast, and consistently with the sharp economic downturn suffered by Mexico because of the collapse of trade with the US (Eaton et al., 2011), the variance of wages, employment and output in this country increases rapidly during the last two years of the sample.

The relative volatility of the real wage with respect to output declines with inflation, particularly in those countries that experienced two- or three- digit inflation rates during the 1980s and early 1990s. Li (2011) shows that a stylized fact of real wages in emerging countries is that they tend to be more volatile than output (30–70 percent more volatile), while in the developed economies, wages instead fluctuate less than output (on average,

30 percent less). Figure 3 shows the ratio of the variance of the real wage and employment with respect to IP in the four countries studied. In Brazil and Mexico, the variance of real wages is higher than the variance of output during the high-inflation years, declining rapidly thereafter. Interestingly, the relative volatility of wages spikes in Brazil right at the time of *Plan Real* stabilization plan, which successfully reduced inflation in the years following 1994. Once inflation is under control, the relative variance of wages moves from 1.5 to below 1.0, and it continues declining until 2010. In Mexico, the stabilization of real wages is slow-moving but even more impressive. Starting with a relative volatility with respect to output close to 1.5 it reaches 0.5 by 2005, spiking again during the Great Recession. In contrast, the relative volatility of wages in Chile and Colombia is always below the volatility of output, and much more in line with that reported by Li (2011) for high-income countries.

Declines in the volatility of wages are coupled with reductions in the employment volatility with respect to output, suggesting progressive stabilization in the four labor markets as time evolves. The sole exception is observed in Mexico during the Great Recession, which displays a spike in the volatility of employment associated with the rapid increase in unemployment.

Figure 4 presents the time-varying cyclicality of wages and employment in the four LAC countries studied. Each row presents a country and two columns to show an estimated pairwise measure of comovement: wages and output (column 1) and employment and output (column 2). The first aspect worth stressing is that, with the exception of Chile, wages appear to be fairly procyclical in the first years of the sample. Concentrating on the comovement between wages and output, the average of the median posterior cyclicality up to the year 1995 in Brazil is around 0.4, close to 0.7 in Colombia, and 0.3 in Mexico.

These numbers are on the upper range of the estimated cyclicality of wages in OECD countries, a fact also highlighted by Li (2011). Using two dynamic approaches for 18 OECD countries, Messina, Strozzi and Turunen (2009) found that the cyclicality of wages ranges from -0.38 in New Zealand to 0.41 in Japan. In the United States, wages are mildly procyclical, at 0.28.
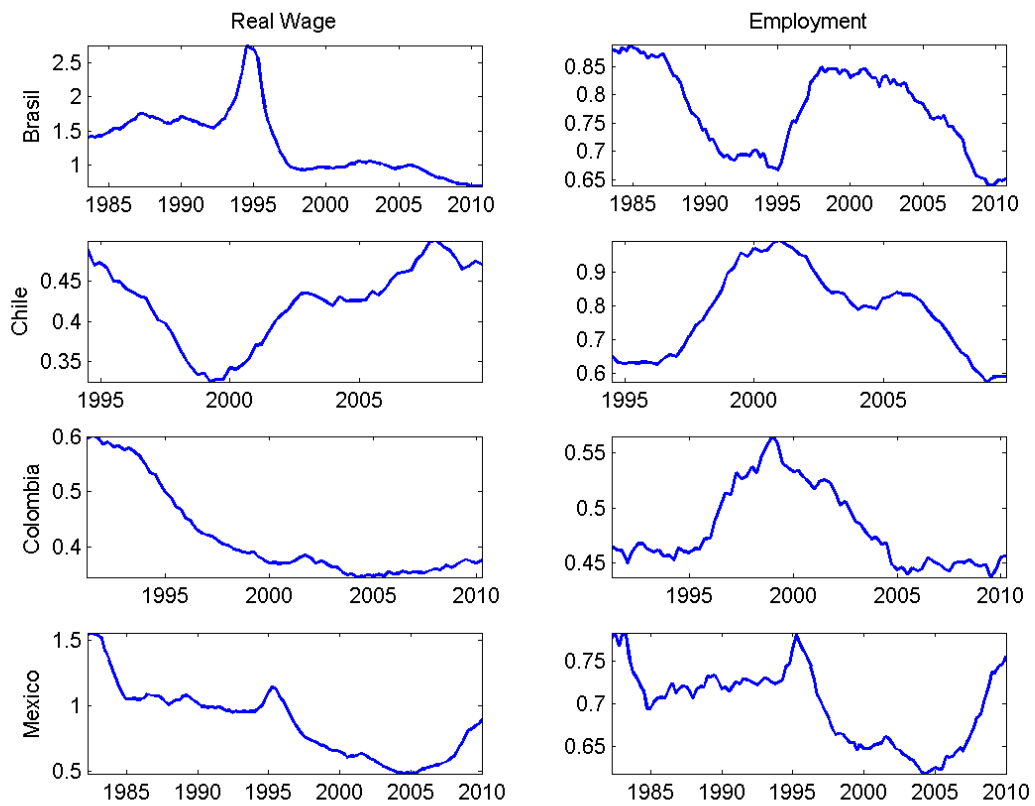
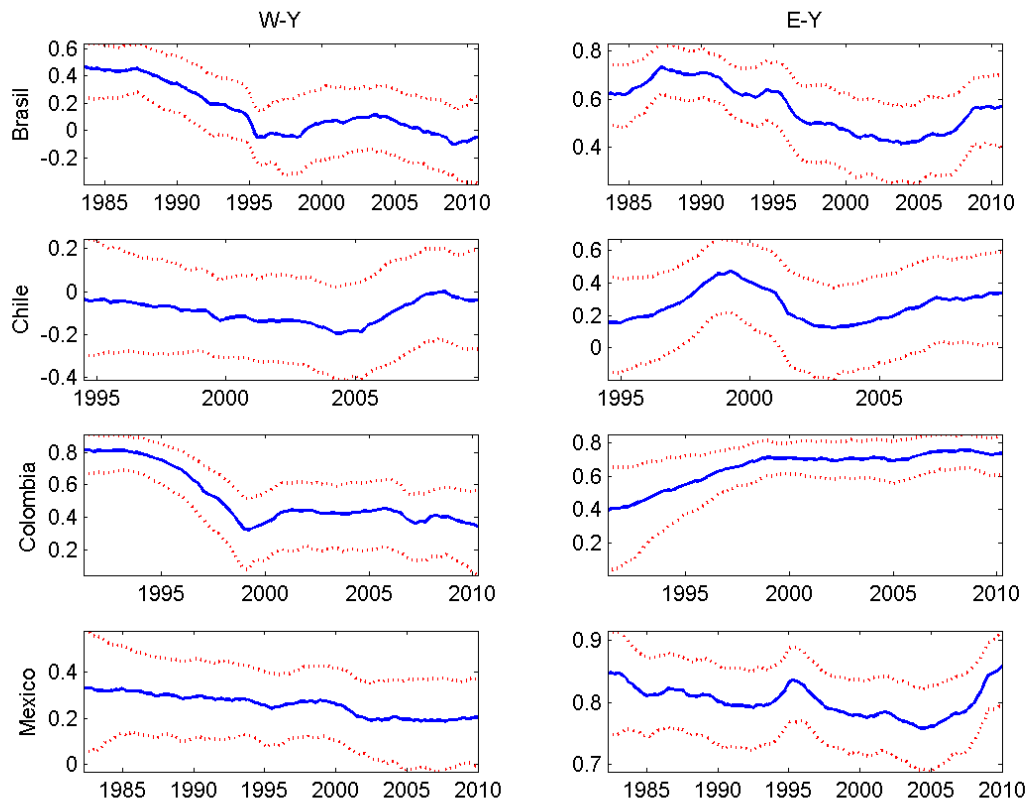Figure 3: The relative variance of wages and employment with respect to output

Figure 4: The Evolving Cyclicality of Real Wages and Employment

There are signs of a declining cyclicality over time in Colombia and Brazil, and to a lesser extent in Mexico. In Colombia, the probability that the correlation between real wages and output in the first year of the sample is larger than the correlation of the same variables in the last year of the sample exceeds 95 percent. Similarly, the probability of a larger cyclicality of real wages at the beginning of the sample than at the end of the sample is 86 percent in Brazil. (Interestingly, the decline in the cyclicality of wages in this country is observed during the 1990s, coinciding with the *Plano Real* stabilization plan.) The corresponding probability of a reduction in the cyclicality of wages in Mexico is 60 percent. In sharp contrast, wages appear to be relatively acyclical in Chile, with no clear pattern over the short period of time for which data are available (1993–2010).

There is not necessarily a one–to–one correspondence between the evolution of the wage and employment cyclicality. As we saw earlier, the macro stabilization associated with the dessinflation process broguth about a reduction of both, the volatility of wages and employment. In Brazil and Mexico, the two countries that displayed higher turbulance of wages and employment during 1980s and early 1990s, the employment cyclicality remained fairly stable throughout the study period. In contrast, the reduction of Colombia's wage cyclicality is associated with an increase in the comovement between employment and output, although in this case the estimated probability of an increase is 88 percent.

The changing wage cyclicality patterns can also be seen through differences in the impulse-response functions over time. We have cut the sample in 2000, which balances observations before and after in Chile and Colombia, but also marks the beginning of an unprecedented period of sustained growth and low inflation in the Latin American region (de la Torre et al. 2010) and show impulse reposes of wages to a one standard deviation negative output shock before and after in the first two columns of Figure 5. The last column of Figure 5 shows the impulse-response of wages during the Great Recession, which is dated following Harding and Pagan (2002) business cycle dating algorithm. The declines in wage cyclicality are evident in Brazil and Mexico. For example, the response of wages in Brazil reaches a trough during the third quarter after the shock at −0.7 in the pre-2000 sample, while the corresponding figure is −0.45 after 2000.
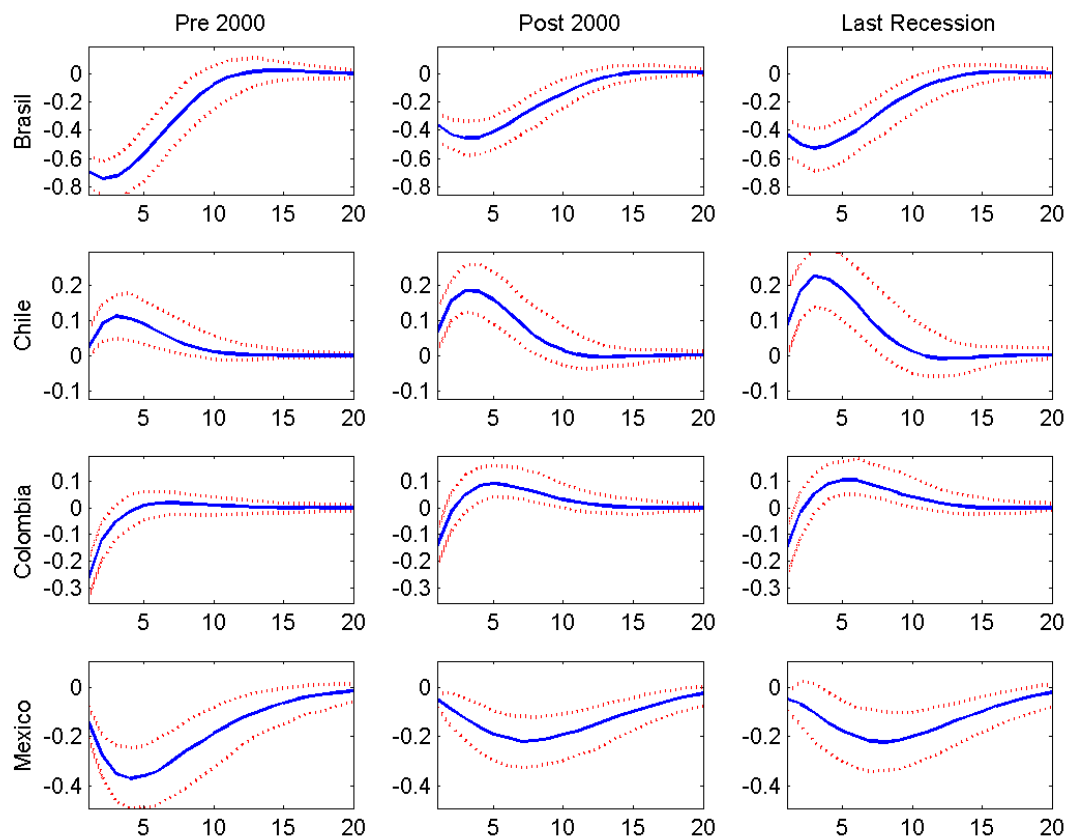
Figure 5: Impulse-response functions of real wages to a negative output shock

3.2 Business Cycle Asymmetries: Excess Cyclicality during Expansions?

To further examine the potential asymmetries in the response of wages and employment to output, we calculate the difference in the cyclicality of each variable between expansions and recessions.[5] If downward nominal wage rigidities are important, we may expect excess cyclicality of wages during expansions.

Specifically let $\rho_t^{j,y}$ be the correlation between variable j (which is either employment (l) or wages (w)) and output (y). Define the differential cyclicality between expansions and recessions $\left(DC^{j,y} \right)$ as

$$DC^{j,y} = 1/T_1 \sum_{t_1 \in boom} \rho_{t_1}^{j,y} - 1/T_2 \sum_{t_2 \in recession} \rho_{t_2}^{j,y} \quad \text{for } j = w, l, \tag{6}$$

where T_1 is the number of quarters of expansion and T_2 the number of periods of recession.

Table 1 displays the median and the 68 percent confidence interval for the difference between the average correlation coefficient in booms and recessions. $DC^{w,y}$ refers to the comovement of real wages and output and $DC^{l,y}$ to the comovement of employment and output.

Perhaps not surprisingly, wages tend to be more responsive to output during expansions in the three countries that exhibit highly procyclical wages. The median excess procyclicality of wages (difference in the cyclicality between expansions and recessions) is 0.13 in Brazil, 0.09 in Mexico, and 0.27 in Colombia. This is indicative of asymmetries in wage setting, whereby wage gains during expansions are more easily obtained than real wage cuts during recessions. As for employment, we find a mild excess of procyclicality during expansions in all countries except Chile. Interestingly, in all countries, the excess procyclicality of wages during expansions exceeds that of employment, suggesting again a role for downward real wage rigidities during recessions.

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[5]The turning points to date expansions and recessions are obtained from the series of industrial production with the Bry–Boschan Quarterly (BBQ) algorithm (Hardin and Pagan, 2002).

Table 1: The Cyclicality of Wages and Employment: Differences between Booms and Recessions

Percentiles:	16th	50th	84th
Brazil			
$DC^{w,y}$	0.0177	0.1277	0.2293
$DC^{l,y}$	0.1666	0.1913	0.2187
Chile			
$DC^{w,y}$	-0.1597	-0.0612	0.0403
$DC^{l,y}$	-0.0062	0.1117	0.2108
Colombia			
$DC^{w,y}$	0.2118	0.2747	0.3349
$DC^{l,y}$	0.2723	0.3291	0.3794
Mexico			
$DC^{w,y}$	0.0414	0.0881	0.1375
$DC^{l,y}$	0.2613	0.2819	0.2992

4   Extensions: Compositional Effects and Differences across Sectors

Workers are heterogeneous, and those who exit and enter the labor market along the business cycle are not a representative sample of the labor force. In particular, low-earning workers and those with less attachment to the labor market tend to enter the labor force during expansions and exit during recessions. Solon, Barsky and Parker (1994) show that such composition bias is important, and that failing to control for the time-varying characteristics of the labor force in the employed population introduces a downward bias in estimates of the cyclicality of wages in the United States. Similar conclusions are reached for other developed countries (e.g., Carneiro, Guimaraes and Portugal, 2012).

The literature has largely ignored the potential importance of compositional effects in wage cyclicality estimates in developing countries. This may be a concern, although there are reasons to think that the aforementioned compositional bias in the estimated elasticities may be more limited in developing countries. Large informal sectors in developing countries typically act as a buffer, expanding in recessions and contracting in expansions, thus avoiding rapid increases in unemployment and inactivity (Bosch and

Maloney, 2010). Hence, changes in the composition of the employed labor force over the business cycle might be more limited.

To assess the importance of compositional effects in estimates of wage cyclicality we exploit micro data from the Brazilian labor force survey, the *Pesquisa Mensal de Emprego* (PME), which enables us to derive a quarterly series of wages for the manufacturing sector over a fairly large period; in this case, 1984–2010.[6]

We proceed in two steps. First, we exploit the individual worker data in the PME to purge the wage series from changes in observable worker characteristics over the business cycle. This is obtained by estimating a standard Mincer regression

$$w_{it} = \alpha + \beta X_{it} + \tau_t + \epsilon_{it}, \tag{7}$$

where w_{it} denotes the hourly wage of worker i at time t, X_{it} is a matrix that includes quadratic terms on education and age, and τ_t are quarterly dummies.[7] In a second step, we recover the coefficients of the quarterly dummies, and use their projection $(\hat{\tau}_t)$ as our main wage variable in the vector autoregression analysis. This projection is naturally the average quarterly wage once changes in the education and experience of the employed population have been purged.

Figure 6 shows the evolution of the cyclicality of real wages in Brazil before and after controlling for compositional effects. The graphs in the left-hand panels reproduce our previous estimates, which do not take into account changes in the composition of the employed population over the cycle. The right-hand panels show the impact of controlling for observable worker characteristics on the cyclicality and volatility of all variables. We find that changes in the composition of the work force do not have a major impact on the comovement of wages and output. As before, we observe a decline in the elasticity throughout the sample period.

Our analysis so far has been confined to the manufacturing sector. We can also exploit the PME, which is representative of all sectors in urban areas in Brazil, to

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[6]See Appendix A for data details.

[7]The regression is conducted after trimming the observations in the bottom 1 percent and top 99 percent of the distribution of hourly wages, and excludes public sector workers.
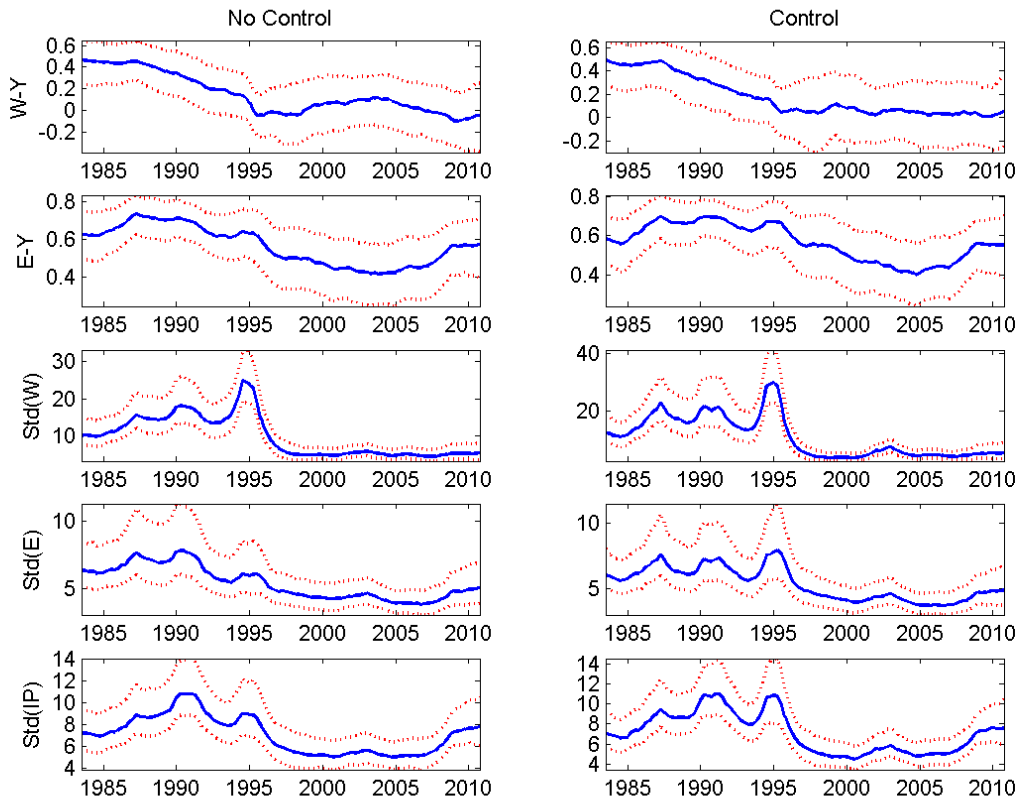
Figure 6: The Role of Compositional Effects. Real Wage and Employment Cyclicality in Brazil Controlling for Over-Time Changes in Human Capital
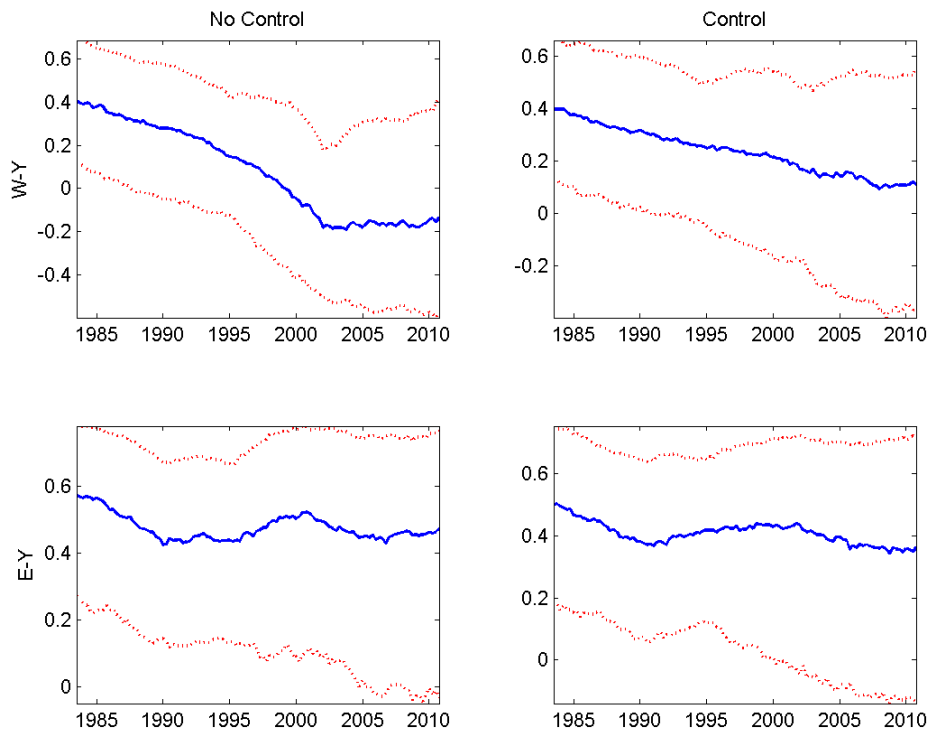
Figure 7: The Evolving Cyclicality of Real Wages and Employment in the Whole Brazilian Economy

examine possible differences in the cyclical behavior of real wages across sectors. Because we are interested in the comovement between wages and output, aggregate GDP is the output indicator we consider when we evaluate the cyclicality of real wages for the whole economy.

Figure 7 shows the evolution of the cyclical behavior of real wages for the whole Brazilian economy. The graphs in the left-hand side show the cyclicality of wages and employment when the row series of real wages are considered. In the right-hand side we show instead the cyclicalities of employment and wages obtained with the series of wages that control for observable worker characteristics.

The broad patterns described earlier remain unchanged when all sectors of the economy are considered. The correlation of wages and output starts at 0.4 in 1984, falling gradually to become acyclical during the 2000s. The pattern in the time evolution of

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the correlations is similar in the case of the wage series that nets out changes in the composition of the labor force, although the fall in the real wage cyclicality is more gradual.

5   Conclusions

This paper studies changes in the cyclicality of real wages in four Latin American countries during the past three decades. Our empirical approach relies on a vector autoregression model with both, time-varying coefficients and residuals volatilities, which properly accounts for the dynamic properties of the underlying data series and their comovement, as well as for changes in the underlying relationship between the different variables.

We find that real wages were highly procyclical during the 1980s and early 1990s in most of the countries studied, but the responses of wages to business cycle fluctuations declined in the second half of the 1990s and 2000s. This decline coincided with the disinflation process in Latin America, suggesting a new role for downward wage rigidities in the region. Consistent with the existence of downward wage rigidities, we find in most cases an excess cyclicality of wages: the response of the real wage to output was stronger in expansions than in recessions.

Our results are primarily based on aggregated data for the manufacturing sector, and hence present certain limitations: First, compositional effects due to ins and outs of workers with different characteristics along the business cycle have been shown to bias downward estimates wage cyclicality in developed economies. Second, higher volatility of manufacturing output than GDP may also offer a misleading picture of the behavior of the real wage in the whole economy.

We have assessed the importance of these two potential concerns using micro data in the case of Brazil. Perhaps surprisingly, we find that wages holding the composition of the labor force constant over the cycle behave very similarly to aggregate wages. This stands in contrast with previous findings for high-income countries.

One possible reason for the lack of important compositional effects in these countries is the role of informality as a buffer. To the extent that the relevant adjustment margin

in emerging economies lies in the frontier between formal and informal employment, and not between employment and unemployment, compositional effects may be less severe. However, we certainly cannot rule different results in the other countries studied, and hence this issue deserves further research. Lastly, we find no major differences between manufacturing sectors and other sectors of the economy in the cyclical behavior of real wages.

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Appendices

A Data

Brazil: Quantity of industrial production indexes are the "Produção industrial da indústria geral" from IGBE (the series can be found at http://www.ipeadata.gov.br) while GDP for the whole economy is obtained from Datastream. Nominal hourly wages and employment in the private sector, both for the manufacturing and whole economy, are obtained from the micro data of "Pesquisa Mensal de Emprego", a survey representative of the eight largest urban areas in Brazil. There is an important methodological change in 2000, with a new survey launched in 2001q1.

Chile: all series for Chile are taken from the Instituto Nacional de Estadística (INE). The industrial physical production index and the industrial employment index are representative for sectors CIIU Rev 2 311-390 between 1993-2002 and CIIU Rev 3 D15-D36 between 2002-2010. For the nominal remuneration per hour index, the series correspond to CIIU Rev 3. D15-D36. The employment series are calculated using the "Encuesta Nacional de Empleo" (ENE) and the "Nueva Encuesta Nacional de Empleo" (NENE) that changed in 2010. For wages the INE uses the "Encuesta Estructural de Remuneraciones y Costos Laborales"; and for industrial production they use the baseline of the sample of firms from the "Encuesta Industrial Anual".

Colombia: the Industrial employment index and the nominal industrial production index are taken from the Departamento Nacional de estadística (DANE), and the nominal wage index is taken from the Central Bank. The indexes are defined for CIIU Rev 3. A.C. 1510-3690. The survey used to calculate the series is the "Encuesta Mensual Manufacturera" (MMM).

Mexico: the employment index, volume of industrial production index and the nominal remuneration index are taken from INEGI and are representative of 125 classes (scian) from 1980-1995 and 205 classes from 1995-2008. All the variables are calculated using the "Encuesta Industrial Mensual" (http://dgcnesyp.inegi.org.mx).

All employment indexes refer to number of people employed, not to employment rates, and all wage series refer to average hourly wages. For each country we have price

indexes (both CPI and PPI) to deflate the series. Finally, all series are indexes whose base has been change, but not other transformation done (e.g. natural logarithm) and have been seasonally adjusted using X12.

B   Estimation

The model is estimated using a Gibbs sampling algorithm. We refer the reader to the online Appendix of Gali and Gambetti (2014) for the details of the estimation. Here we discuss our priors specification and the calibration.

As standard in the literature, we assume that the initial states and the covariance parameters are independent. The priors for the initial states θ_0, ϕ_0 and $\log \sigma$ are Gaussian, the priors for the inverse covariances matrices Ω^{-1}, Ξ^{-1} and Ψ^{-1} are Wishart. More precisely:

- Time varying coefficients: $P(\theta_0) = N(\hat{\theta}, \hat{V}_\theta)$ and $P(\Omega^{-1}) = W(\Omega_0^{-1}, \rho_1)$;

- Diagonal elements: $P(\log \sigma_0) = N(\log \hat{\sigma}, I_n)$ and $P(\Psi_i^{-1}) = W(\Psi_{0i}^{-1}, \rho_{3i})$;

- Off-diagonal elements: $P(\phi_{i0}) = N(\hat{\phi}_i, \hat{V}_{\phi_i})$ and $P(\Xi^{-1}) = W(\Xi_0^{-1}, \rho_2)$;

The scale matrices are parameterized as follows $\Omega_0^{-1} = \lambda_1 \rho_1 \hat{V}_\theta$, $\Psi_{0i} = \lambda_{3i} \rho_{3i} \hat{V}_{\phi_i}$ and $\Xi_0 = \lambda_2 \rho_2 I_n$.

The hyper-parameters are calibrated using a time invariant recursive VAR estimated using a sub-sample consisting of the first $T_0 = 32$ observations. Mores specifically, we set the means and the variances of the initial states $\hat{\theta}$, $\hat{\phi}_i$, and $\hat{V}_\theta$ and $\hat{V}_{\phi_i}$, equal to the OLS estimates. The mean of $\log \sigma_0$, is set equal to the log of the point estimates of the standard errors of the residuals of the estimated time invariant VAR, the variance is the identity. The degrees of freedom ρ_j are set equal to the dimension of the corresponding covariance matrix plus one.

The parameters λ_i are specified as follows.

- Brasil: $\lambda_1 = 0.0002$, $\lambda_2 = 0.0005$, $\lambda_3 = 0.0005$

- Chile: $\lambda_1 = 0.02$, $\lambda_2 = 0.02$, $\lambda_3 = 0.02$

- Colombia: $\lambda_1 = 0.02$, $\lambda_2 = 0.02$, $\lambda_3 = 0.02$

- Mexico: $\lambda_1 = 0.0002$, $\lambda_2 = 0.0005$, $\lambda_3 = 0.0005$