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The relation between labor productivity and wages in Brazil: a sectoral analysis

A relação entre produtividade de trabalho e salário no Brasil: uma análise setorial

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Abstract

Labor productivity is a crucial long-run determinant of real wages. Nonetheless, wage and productivity dynamics often diverge in practice due to a range of economic and institutional factors. This study analyzes the relation between the dynamics of labor productivity and wages in Brazil from 1996 to 2014, and adopts a sectoral perspective to account for divergent trends among economic sectors. Analyses are based on pooled data drawn from the National Accounts and the *Pesquisa Nacional por Amostra de Domicílios*, and hierarchical data models are estimated to assess the impacts of state- and sector-level factors on individuals' wages. Results indicate that productivity is significantly positively associated with wage levels for all economic sectors, but that institutional factors such as labor formalization and minimum wage exert equally significant impacts, suggesting that wage growth over the 1996-2014 period was as much the result of institutional changes as of transformation of Brazil's productive structure.

Keywords

labor market; labor productivity; sectoral structure; economic development; wage determinants.

JEL Codes E24; J24; O47.

Resumo

A produtividade do trabalho é um determinante fundamental do salário real. Entretanto, as dinâmicas do salário e produtividade frequentemente divergem na prática em função de uma série de fatores econômicos e institucionais. Este estudo analisa a relação entre as dinâmicas da produtividade do trabalho e do salário no Brasil entre 1996-2014, adotando uma abordagem setorial para considerar divergências entre setores econômicos. As análises baseiam-se em dados do Sistema de Contas Nacionais e da Pesquisa Nacional por Amostra de Domicílios, e em estimativas de modelos hierárquicos para avaliar os impactos de fatores regionais e setoriais nos salários individuais. Os resultados indicam que a produtividade está positivamente associada ao salário em todos os setores econômicos, mas que fatores institucionais, como formalização do trabalho e salário mínimo, influenciam de maneira igualmente significativa, sugerindo que o crescimento do salário entre 1996-2014 foi tanto um resultado de mudanças institucionais quanto de transformações da estrutura produtiva.

Palavras-chave

mercado de trabalho; produtividade do trabalho; estrutura setorial; desenvolvimento econômico; determinantes do salário.

Códigos JEL *E24; J24; O47.*

1 **Introduction**

Labor productivity, understood as the value of output produced per unit of labor input, is a crucial long-run determinant of workers' real wages. Ultimately, workers cannot sustainably earn more value than they create. Neoclassical economic theory formalizes this notion in its assertion that a worker's wage is equivalent to the marginal product of her labor, that is, her productivity (Cahuc *et al*., 2014). Nevertheless, labor productivity and wage dynamics often diverge substantially in practice, due to a range of institutional and market forces, and this divergence can have important implications for a country's economic development. When real wages lag behind productivity growth, the distribution of income between capital and labor shifts in favor of capital, potentially worsening income inequality and depressing aggregate demand. When wage growth exceeds productivity growth, export competitiveness and investment may suffer (Biesebroeck, 2015).

In light of the theoretical importance of labor productivity to wage growth and economic development, this study examines the relation between productivity and wages in Brazil between 1996 and 2014. This time period encompasses two distinct stages in Brazil's recent economic trajectory: the movement towards liberalization and market-oriented reforms that characterized the late 1990s, and the commodity boom and expansion of pro-social reforms of the 2000s. The first stage is characterized by stagnation in productivity and real wages, while the second stage is marked by modest growth in productivity and significant growth of real wages (Maia; Menezes, 2014; IPEA, 2014).

Importantly, these overall trends disguise broad variation in productivity and wage growth at the sectoral level. Some areas of Brazil's economy, such as industry, have seen low growth in productivity, losses in competitiveness, and shrinking representation in national GDP (Jardim; Perin, 2016; Hiratuka; Sarti, 2015). Other areas, such as agriculture, have experienced rapid productivity growth and substantial wage gains (Gasques *et al*., 2014; Maia; Sakamoto, 2014). These evolving dynamics complicate traditional notions of development via industrialization, and suggest alternative sectoral priorities and strategies (Baiardi, 2016).

Motivated by these changing dynamics, this study adopts a sectoral perspective in order to address the following questions: i) to what degree

have gains or losses in wages been the result of gains or losses in productivity? ii) have productivity gains constituted the primary engine of wage growth, or do they pale before institutional or demographic changes? iii) why do different economic sectors present such varying rates of productivity and wage growth? This sectoral perspective complements previous analyses that examine labor productivity and income in Brazil on a national level (Romanatto *et al*., 2008).

We find a universally positive association between labor productivity and real wages. More specifically, our estimates indicate that elasticity between labor productivity and real wages is largest for sectors where earnings are directly based on productivity (such as pay-on-commission in real estate and commerce), or where productivity is easily measured (industry). In turn, elasticities are smaller for those sectors where worker productivity is more difficult for firms to measure, or where there are high levels of informal labor (agriculture and construction). Furthermore, results indicate that wages in many sectors are also strongly influenced by institutional forces, such as worker formalization, labor unions, and minimum wage.

The study is organized as follows. Part 2 explores theoretical explanations of the frequently observed divergence between labor productivity and wages, and situates this debate in the Brazilian context. Part 3 reviews the methodology and data used to compute labor productivity and real wages for eight sectors of the Brazilian economy between 1996 and 2014, and then develops regression models to estimate productivity-wage elasticities for each sector. Part 4 presents data series on sectoral labor productivity and real wages, as well as regression results, and interprets these data and results in light of recent economic developments in Brazil. Finally, Part 5 offers conclusions.

2 **Theoretical interpretations of productivity-wage relationship**

According to neoclassical labor economics, a worker's wage equates to that worker's marginal product of labor in equilibrium. Under perfect competition, a market wage below productivity would induce the firm to hire workers until their marginal product fell below the wage rate (under

the assumption of diminishing marginal returns). A market wage greater than productivity would induce the firm to fire workers until remaining employees' marginal product rose sufficiently to restore equilibrium. If the firm were a price-maker under imperfect competition, the impacts of the firm's hiring and firing behavior on the market wage would only amplify this equilibrating tendency (Biesebroeck, 2015; Cahuc *et al.*, 2014).

There are a number of theoretical explanations for why wages rarely equate to productivity levels in practice. Firstly, wages account for only a fraction of total employee compensation, which may include additional benefits such as pension or insurance. If the proportion of these additional benefits in total compensation grows, then stagnating real wages could actually disguise an increase in overall employee compensation (Feldstein, 2008). In Brazil, where formal employee benefits such as a 13th salary, severance pay, and health insurance are prevalent, recent increases in worker formalization could make this factor a significant determinant of productivity-wage divergence (IPEA, 2009).

Secondly, markets are characterized by information asymmetries, in which firms find it difficult to assess workers' true productivity and effort levels. In this case, firms pay workers according to productivity signals, such as education, which may not directly align with those workers' true productivity (Spence, 1975). Firms may also construct compensation and promotion schedules that incentivize high productivity at the outset of an employee's career by promising higher compensation at the end of the career, thus temporally misaligning productivity and wage (Biesebroeck, 2015).

Thirdly, firms may systematically discriminate against workers based on race, gender, or other characteristics, imposing wage penalties on discriminated workers who are equally as productive as their non-discriminated colleagues (Blau; Kahn, 2016; Sakamoto; Kim, 2014; Fryer, 2011). Specific to Brazil, Bailey, Loveman and Muniz (2013) present evidence on continuing racial discrimination in employment, and Casari, Bastos, and Feltre (2009) measure substantial gender discrimination in employment, suggesting that the racial and gender composition of economic sectors may be an important factor in understanding wage-productivity divergence in Brazil.

Fourthly, as argued in Manning (2010), labor markets are inherently imperfect, and are characterized by both firm and employee rents. Both par-

ties face high search costs, and may thus be willing to close employment agreements at wage rates divergent from productivity rates. The actual division of rents between workers and firms will result from the relative bargaining positions of these groups, as well as the bargaining mechanisms (Pissarides, 1985). Under this interpretation, increasing formalization of the labor force and decreasing unemployment in Brazil could have improved labor's bargaining power throughout the 2000s, thus contributing to rising wages relative to productivity.

Finally, overarching these microeconomic dynamics, technology-biased innovation and investment have been identified by many authors as a cause of declining labor shares of income (in other words, as a cause of divergence between labor productivity and wages) across industries and countries (Hogrefe; Kappler, 2012; Bentolila; Saint Paul, 1999). In this analysis, capital-augmenting technical progress, such as the widespread adoption of computers from the 1990s onwards, may generate factor biases between capital and labor, with the degree of bias determined by activity-specific elasticities of substitution between factors (Karabarbounis; Neiman, 2013; Findlay; Jones, 1999; Feenstra; Hanson, 1999).

Changes in total employee compensation, information asymmetries, discrimination, bargaining power, and capital-augmenting technological progress may have widely varying impacts for different sectors of the Brazilian economy, depending on the characteristics of each sector. Employee benefits and career-long incentive structures may have large impacts in highly formalized sectors such as public administration or finance, and smaller impacts in agriculture or commerce. Shifts in labor bargaining power through mechanisms such as labor organization (unions), formalization, and lower unemployment may have greater heft in sectors dominated by low-skilled workers, such as agriculture and construction, relative to sectors characterized by higher barriers-to-entry. And differential rates of technology-adoption across sectors may distort the transmission of productivity gains into real wages, depending on whether technologies are capital- or labor-augmenting for any specific economic activity. One recent development in the Brazilian labor market that has disproportionately impacted low barrier-to-entry sectors is the significant real valorization of the minimum wage since 2000. This valorization has contributed meaningfully to income growth among less-qualified workers (Saboia; Hallak, 2016).

3 **Data and methodology**

3.1 **Data sources**

Sectoral labor productivity in Brazil is computed as the quotient of Gross Value Added (GVA) to total hours worked for each sector. Annual data on sectoral Gross Value Added (GVA) are drawn from the National Accounts, presented by the *Instituto Brasileiro de Geografia e Estatística* (IBGE). IBGE reports GVA for twelve sectors: 1) Agriculture, 2) Extractive Industry, 3) Manufacturing, 4) Electricity, Gas, Water, and Sewage, 5) Construction, 6) Commerce, 7) Transportation, Storage, and Mail, 8) Information Services, 9) Financial Services, 10) Real Estate, 11) Other Services, and 12) Public Administration, Health, Education, and Social Security. We combine sectors 2 and 3, sectors 4 and 5, sectors 8 and 9, and sectors 10 and 11 in order to reduce the influence of extreme outliers and to make data trends visually comparable while preserving the conceptual integrity of each sector to the greatest degree possible.[1] The resulting eight aggregated sectors employed throughout this study are: 1) Agriculture, 2) Industry (Manufacturing and Extractive), 3) Construction and Utilities, 4) Commerce, 5) Transportation, Storage, and Distribution, 6) Financial and Information Services, 7) Real Estate and Other Services, and 8) Public Administration, Health, Education, and Social Security.

Data on total hours worked per sector, as well as a range of additional variables employed in our analysis, are drawn from the *Pesquisa Nacional por Amostra de Domicílios* (PNAD), sponsored by IBGE. Data are pooled over the years 1996 to 2014. Data from Brazil's Northern region are excluded

1 Specifically, labor productivity for extractive industries and real estate is extremely high relative to negligible levels of employment in those sectors. Extractive industries employed just 0.4% of workers in 2014 (and just 3.47% of total industrial workers), but displayed an average labor productivity value of US$116.4 per hour for that year, over four times higher than the next most productive sector. Likewise, real estate employed only 1.1% of workers in 2014, and displayed a labor productivity value of US$116.0 per hour for that year. For comparative purposes, we merged these sectors with manufacturing and other services, respectively. The elevated value-added per labor hour in extractive industry is likely the result of substantial accumulated capital (e.g. mines, drilling platforms) more than of real contributions of labor in that sector. Thus, presenting extractive industry separately could be misleading, especially considering the minimal size of extractive industrial employment in the PNAD sample. Nonetheless, the sector should not be excluded entirely, given its contribution to national GDP and important interlinkages with advanced areas of Brazilian manufacturing. In sum, the most computationally and conceptually consistent approach appears to be merging extractive industry and manufacturing into an aggregated measure of industry.

due to lack of data on rural areas of this region before 2004.[2] The four-digit economic Activity codes from the PNAD were grouped into the eight sectors described above, and incorporate the methodological changes introduced in the *Classificação Nacional de Atividades Econômicas* (CNAE) after the year 2000 (Dedecca; Rosandiski, 2003).

Income data from the PNAD were deflated to 2014 constant values using the *Índice Nacional de Preços ao Consumidor*, provided by IPEA. GVA values were deflated to 2014 constant values using the World Bank's GDP deflator. Deflated values in Brazilian Reals were then converted to Purchasing Power Parity (PPP) constant 2014 US dollars using data from the IMF's 2014 World Economic Outlook report.[3] Conversion to US dollars was intended to facilitate international comparisons.

3.2 **Empirical analysis**

Sectoral variation in the productivity-wage relationship may be the result of variation in institutional and market forces among different types of economic activities. Alternatively, it may be the result of differences in average worker characteristics across sectors. To distinguish between these alternative dynamics, we fit a regression model to pooled annual data from the PNAD for years 1996-2012.[4] The objective is to measure the impact of sectoral labor productivity on individual hourly wages. We limit our sample to working adults between the ages of 15 and 65. The dependent variable is the natural logarithm of the i-th individual's labor income per hour (w), which is assumed to be a function of the i-th individual's personal characteristics (vector x), j-th economic sector's characteristics (z) in the state where that individual is employed, and national minimum wage (v) in year t:

2 In 2014, the seven excluded states of Brazil's Northern region (Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, and Tocantins) hosted only 6.6% of Brazil's total labor force, suggesting that the exclusion of these states to maintain sample consistency should not significantly alter the descriptive power of our results. Also note that the PNAD was not applied in years 2000 and 2010 corresponding with application of the National Census.

3 Conversion to 2014 Constant US Dollars was made using the Implied PPP Conversion Rate of 1.7 Brazilian Reals per US Dollar. Conversion rate was obtained from the IMF's 2014 World Economic Outlook dataset: http://www.imf.org/external/pubs/ft/weo/2015/02/weodata/download.aspx.

4 While national-level GVA data are available from IBGE up until 2014, state-level GVA data are only available until 2012. Thus, data from the 1996-2012 period are pooled for regression analysis.

$$\ln\left(w_{ijt}\right) = \alpha + \boldsymbol{x}'_{ijt}\beta + \boldsymbol{z}'_{jt}\delta + \phi v_t + r_i + c_t + \varepsilon_{ijt} \quad (1)$$

Factor r_i captures unobserved regional heterogeneity and is controlled by fixed effects using 26 binary variables to represent Brazil's 27 federal units (UF). The factor c_t represents economic, political and/or institutional cycles affecting wages. These cycles are controlled for by 4 binary variables representing five federal governments over the sample period (1996-1998: first term of Fernando Henrique Cardoso; 1999-2002: second term of Fernando Henrique Cardoso; 2003-2006: first term of Luiz Inácio Lula da Silva; 2007-2010: second term of Luiz Inácio Lula da Silva; 2011-2014: first term of Dilma Rousseff). ε_{ijt} is an idiosyncratic error term. Coefficients β, δ and ϕ express the net impact of the explanatory variable on the log of hourly wage. Regression estimates are computed by Ordinary Least Squares (OLS) with heteroscedasticity consistent standard errors.

Table 1 **Variables and mean values**

Variable	Description	Mean	
		1996	2014
W	Labor income per hour (constant 2014 USD)	5.06	7.00
School	Years of education	6.4	9.2
Female	Proportion female	0.40	0.45
Non-white	Proportion black or indigenous	0.46	0.54
Age	Years of age	32.1	35.4
Productivity	Labor productivity, by UF (constant 2014 USD)	9.44	10.71
Minwage	National monthly min. wage (constant 2014 USD)	199	426
Unionized	% of workers unionized, by UF	0.18	0.16
Formal	% of workers formalized, by UF	0.59	0.7

Source: PNAD (IBGE).

This is a hierarchical approach, where the minimum wage v only varies by year (level 1), economic sectors' characteristics vary by sector/state and year (z, level 2) and individuals' characteristics vary for each individual i of the sector/state s and year t (x, level 3). In a comparative model, we replace the variable *minimum wage* and cycles c_t with temporal fixed effects, using 16 binary variables to represent the 17 years included in the sample. The intention is to estimate the model under alternative speci-

fications. The set of individuals' and sectors' characteristics used in our analysis is described in Table 1. More detailed descriptive statistics are presented in Appendix A.

The main advantage of this pooled hierarchical strategy is that it allows for wider variability of the independent variables. This is particularly important for structural characteristics, which only vary across sectors (e.g. productivity), and/or years (e.g. minimum wage). In turn, the main disadvantage of the pooled models is that variability may differ across years (heteroscedasticity), resulting in biased estimates for the standard errors. This problem was avoided by estimating standard errors robust to heteroscedasticity (Wooldridge, 2003, p. 258).

Since explanatory variables in vectors x and z are measured in different scales, we cannot directly compare coefficients in β or δ in order to identify variables with the largest impact on w. Consequently, *standardized coefficients* were estimated which permit measurement of explanatory variable effects on w in standard deviation units, rather than in terms of the original units of x and z (or w). Standard deviation units are the resultant parameters when all variables are standardized to a mean of 0 and a variance of 1, and are estimated by (Wooldridge, 2003):

$$\hat{\beta}_j^s = (\hat{\sigma}_j / \hat{\sigma}_w)\hat{\beta}_j \tag{2}$$

where $\hat{\beta}_j$ is the OLS estimator, $\hat{\sigma}_j$ is the sample standard deviation for the j-th explanatory variable, and $\hat{\sigma}_w$ is the sample standard deviation for the dependent variable *ln w*.

First, baseline regressions were estimated on all pooled observations using Equation 1. Baseline regressions establish economy-wide coefficient parameters for subsequent comparison with sectoral results. Furthermore, baseline results provide a sensitivity analysis of alternative model specifications (progressively controlling for time (or political-economic cycle) fixed effects and institutional factors). We next estimate Equation 1 for each economic sector individually, drawing upon only those observations that fall into each economic sector, successively. Sectoral results illustrate variations in the productivity-wage relationship between different economic activities.

4 **Results**

4.1 **Productivity and wage trends in Brazil (1996-2014)**

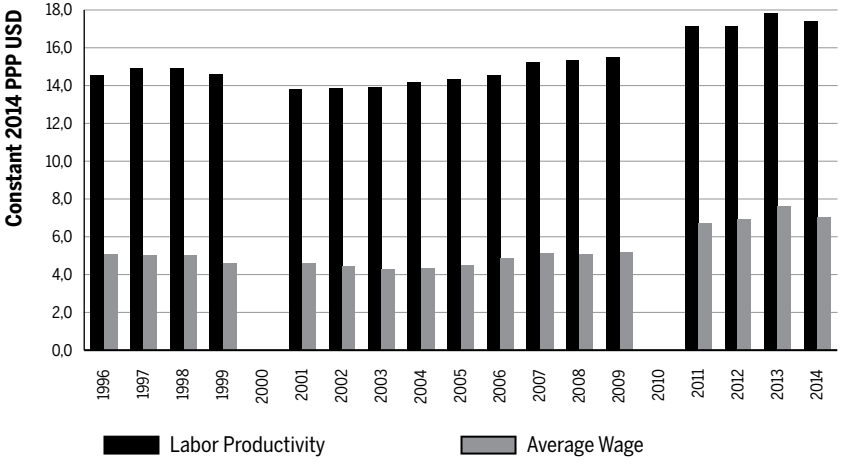
Brazil successfully managed to bring its hyperinflationary experience to an end in 1994 with the Plano Real under the presidency of Fernando Cardoso. Nevertheless, the side effect of a series of initiatives to control inflation and the growing public deficit (such as privatization, reduction of tariff barriers, and strong valorization of the Real), coupled with simultaneous international crises in Mexico (1994), Asia (1997), and Russia (1998), led to an increase in unemployment, stagnation in productivity, and declines in real wages over this period, as observed in Figure 1 (Dedecca, 2005; Gennari, 2002). Markets balked briefly again in 2002 over the election of Luiz Inácio Lula da Silva of the Workers Party to the presidency, but growth soon returned in full force with the international commodity boom of the 2000s. Fueled primarily by China's explosive growth, international commodity prices rose sharply for major Brazilian exports such as iron and soybeans, improving Brazil's terms of trade and attracting foreign investment (Giambiagi, 2011).

From 2003 onwards, Lula's government capitalized on this commodity boom by facilitating the expansion of consumer credit and fostering income redistribution through significant real increases in the minimum wage and spending programs like *Bolsa Familia*. Unemployment shrank, the number of formal salaried jobs multiplied, and income inequality and poverty experienced historic declines (IPEA, 2012). This period was accompanied by a rise in real wages that outstripped growth in labor productivity, as illustrated by the notable rise in real wages relative to productivity in Figure 1. This development suggests that, for the Brazilian economy as a whole, rising real wages over the 2003-2013 period may have been more the result of minimum wage increases and formalization of the labor market than of structural development toward more productive employment. This apparent failure to capitalize on the commodity boom of the 2000s to promote structural productivity gains bodes poorly for prospects of further sustained wage growth in Brazil (Maia; Menezes, 2014).

Finally, the decline in both productivity and wages after 2013, as observed in Figure 1, marks the onset of Brazil's current economic crisis. The slowing of China's commodity boom and the crash in oil prices in 2014

reversed Brazil's terms of trade, leading to a rising deficit that in turn provoked pro-cyclical austerity measures. These recent dynamics have corresponded with declines in real wages and productivity levels.

Figure 1 **Brazil: overall labor productivity and wage growth (1996-2014)**

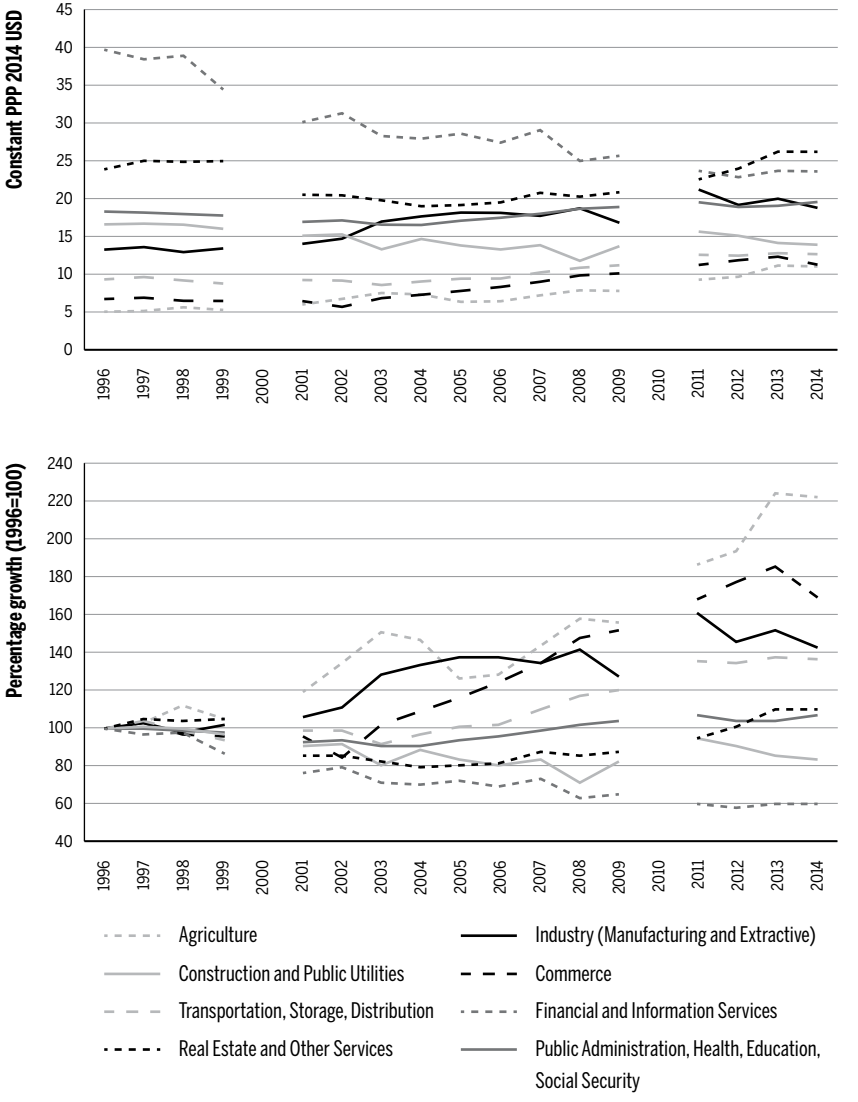


Source: Figure constructed by author from PNAD (1996-2014) and National Accounts.

Examining the Brazilian economy on a sectoral level, the wide divergence in productivity levels among different economic activities becomes clear (Figure 2).[5] For instance, in 1996 an average hour of labor in the lowest-productivity sector, agriculture, produced US$4.93 in value (in constant 2014 US dollars), while an average hour of labor in the highest productivity sector, financial and information services, produced US$39.67. From 1996 onwards, these sectoral productivity values display a convergent tendency, such that the difference between the lowest productivity sector in 2014 (commerce) and highest (real estate and other services) was only 43% of the difference in 1996.

5 Observing the striking differences in productivity among economic sectors, it is tempting to think that huge production gains could be realized simply by moving workers from low productivity to high productivity activities. While this indeed is the long-term objective of many national development policies, instantaneous productivity gains from activity-switching are limited because, as noted in Biesebroeck (2015), the values in Figure 2 represent *average* productivities, not marginal productivities. Productive sectors are typically productive because they embody high capital accumulation and complex infrastructures. Thus, adding an additional worker at the margin will not likely boost overall production by a level commensurate with the average productivity rate of that sector.

Figure 2 **Brazil: labor productivity (value added per labor hour)**
By economic sector, absolute and relative growth (1996-2014)



Source: Figure constructed by author from PNAD (1996-2014).

This convergence is the result of two sectoral developments. The first, the surprising decline in productivity for Financial and Information Services, is the combined result of real productivity trends and changing occupa-

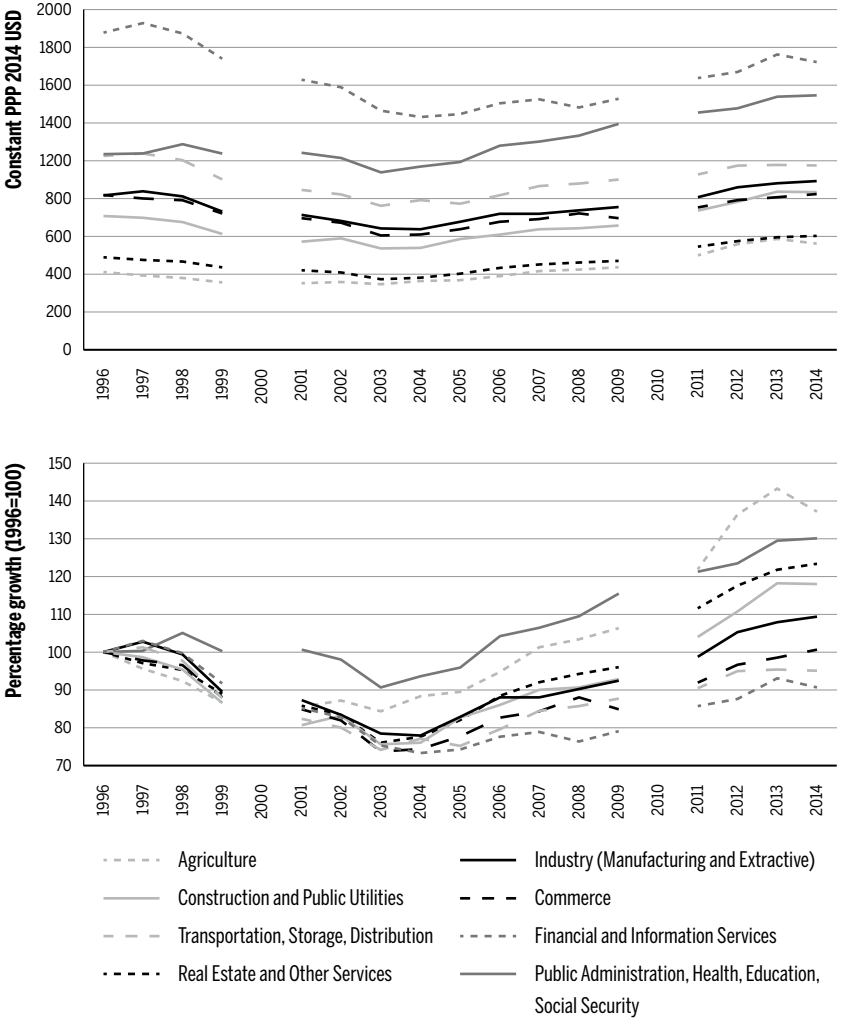
tional distributions within the sector. In real terms, the financial services subsector suffered a 40% productivity loss between 1998 and 2014. This dynamic could be related to changes in Brazilian banks' "earnings spread" between lending and borrowing rates, which fell sharply with the decline in interest rates over this period, bringing value-added down with it (Freitas; Prates, 2016; Afonso; Köhler; Freitas, 2009).[6] Parallel to these real value-added losses in the financial sector, the activity composition of the information services subsector evolved toward lower-productivity activities such as telemarketing and "other business services." Employment in these lower-productivity components of information services grew by 37% over the 1996-2014 period (relative to overall employment growth of 24%), thus coming to occupy an inflated proportion of total sectoral employment by 2014 (PNAD, 2016).

The second trend leading to sectoral productivity convergence is the dramatic rise in agricultural productivity since 1996. Labor productivity in agriculture (historically Brazil's lowest productivity sector) grew by 121.7% over the 1996-2014 period, with an annual growth rate of 4.8%. This rapid growth was the result of a number of interrelated dynamics. Rural labor shortages incentivized investments in labor-augmenting technologies, rural workers' average education levels increased, new transgenic seeds boosted yields, and domestic and international research and extension improved innovation and technology adoption. Overarching these trends, agribusiness assumed an expanded role in capital-intensive, monoculture production for export, especially on the newly opened *Cerrado* frontier (Buainain, 2014; Guanziroli, 2014; Maia; Sakamoto, 2012; Gasques *et al*, 2014).

Two additional trends should be noted in Figure 2. Firstly, Real Estate and Other Services' high levels of "productivity" are misleading, since much of real estate's value derives from accumulated capital (past labor embodied in property). Thus, when dividing the large value gains enjoyed by real estate during Brazil's sustained property appreciation by the small number of hours worked in this sector, the resulting labor productivity values appear surprisingly high. These values should be treated with due caution.

6 Value-added in the financial services sector is imputed directly from the spread between lending rates and interest rates. Thus, when annual interest rates declined from 34.2% at the beginning of 1998 to 17.7% at the end of 2004, financial spreads declined in parallel, reducing financial sector "productivity" (Banco do Brasil, *Histórico das taxas de juros*, 2016: https://www.bcb.gov.br/Pec/Copom/Port/taxaSelic.asp).

Figure 3 **Brazil: monthly labor income**
By economic sector, absolute and relative growth (1996-2014)



Source: Figure constructed by author from PNAD (1996-2014).

With the exception of public employment, real wages declined across all sectors throughout the late 1990s and early 2000s. The year 2003 appears to be an inflection point, at which all sectors reverse negative income trends and begin enjoying real income gains, which are sustained until 2013. Over the 1996-2014 period, agriculture exhibits the strongest

income gains (37.1% total increase), and financial and information services exhibit the greatest losses (9.3% total decrease) (Figure 3).[7]

Wages for most sectors roughly follow productivity trends for the corresponding sector, with three noteworthy exceptions. Firstly, despite monotonic declines in productivity in the financial and information services sector, wages for this sector nevertheless pick up after 2003, suggesting a rise in the relative wage (an increasing share of average value-added going to wages). This divergence may be the result of the information asymmetries and bargaining power dynamics described above. Financial and information services jobs are more likely to be career-track, and thus subject to the type of seniority-biased incentive structuring identified as a potential source of wage-productivity divergence by Biesebroeck (2015). Furthermore, jobs in this sector require higher education levels, potentially allowing educated workers (still relatively scarce in the Brazilian labor market) to exert greater bargaining power over employers.[8] Finally, despite the erosion of union power in the financial sector throughout the 1990s and early 2000s, labor organization in this sector remains high relative to other areas, further improving workers' bargaining power and driving up relative wage (PNAD, 2016).

In the second incidence of productivity-wage divergence, public employees' wages realize a total increase of 30.1% between 1996 and 2014, despite total productivity growth of only 6.9% over this period. It is important to note that productivity in the public sector must be interpreted carefully. Because output in the government sector is measured as equal to the total value of inputs, the appreciation of relative wages in the public sector indicates only that salaries constitute a higher share of total costs in the sector, not that public workers are necessarily retaining a greater proportion of their value-added (Boyle, 2006). Alternatively, this appreciа-

7 One should note that these data represent sectoral aggregates, and may hide divergent trends within individual sectors. For instance, the strong increase in median agricultural wages over the 1996-2014 period disguises growing inequality within this sector. Those agricultural workers inserted into modern agricultural practices in core production regions enjoyed significant wage gains, while smaller producers in less developed regions saw much smaller gains or real losses (Maia and Sakamoto, 2014). In industry, declining sector-wide productivity levels hide booming productivity gains in extractive industries.

8 This disproportional compensation for highly qualified workers parallels similar trends in the United States, identified as "skill-biased technological progress", whereby disequilibrium between the supply and demand of highly qualified workers has led to enormous compensation gains in knowledge-intensive sectors (Autor, 2010).

tion of the relative wage may indeed be a consequence of the significant bargaining power imparted on public employees by institutional protections and benefits, high levels of labor organization, and the relatively high education levels of these workers.

In the third notable instance of productivity-wage divergence, the low wage-levels of workers in the real estate and other services sector illustrates the extent to which value added per hour in this sector, as displayed in Figure 2, is in fact constituted by property rents rather than true labor productivity.

In sum, sectoral labor productivity and real wages both evolved in significant ways over the 1996 to 2014 period. To what degree were these developments related? Did gains in productivity drive gains in wages, as neoclassical labor economics would predict, or were institutional and/or personal worker characteristics more determinative of earnings levels? In order to disentangle these alternative scenarios, estimates of micro-level wage equations are presented in the following section.

4.2 **Impacts of sectoral productivity on wages**

We first estimate alternative baseline specifications (Equation 1), and report results in Table 2. All model specifications fit relatively well to the PNAD pooled sample, with coefficients of determination above 46%. Standard errors are robust to heteroscedasticity and estimates are stable and significant over multiple specifications.

Signs and magnitudes of control variables are as expected from the literature. The coefficient of 0.089 for *schooling* in Model 3 indicates that a one-year increase in an employed individual's years of schooling, all else equal, is associated with a 9.3% ($e^{0.089} - 1 = 0.092$) increase in hourly earnings. The coefficient of –0.274 for *female* indicates that, all else equal, women's average hourly wages are 24.0% ($e^{-0.274} - 1 = -0.240$) lower than men's, indicating extensive gender inequalities in the Brazilian labor market. The coefficient of –0.114 for *non-white* indicates that, all else equal, black and indigenous workers present an average hourly wage that is 10.8% ($e^{-0.114} - 1 = -0.108$) lower than white and Asian workers, indicating the presence of strong racial inequalities in employment. The positive coefficient estimates for *age* and negative estimates for age^2 indicates an invert-

ed-U relation between wages and working experience[9].

The coefficient estimates of *productivity*, 0.123 in Models 1 and 2, indicate that a 1% increase in each observed worker's state- and activity-specific labor productivity is associated with a 0.123% increase in real hourly wages for the average worker. This impact increases only slightly when we control for unionization and formal employment in Model 3 (0.166%). While positive and significant, this elasticity appears to be low by international standards (Peeters; Den Reijer, 2011).

Table 2 **Baseline regression estimates for the dependent variable *ln of hourly wage***

Variable	Beta			Standardized Beta		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
School	***0.099	***0.099	***0.089	***0.504	***0.504	***0.451
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age	***0.072	***0.072	***0.070	***0.999	***0.998	***0.974
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Age^2	***-0.001	***-0.001	***-0.001	***-0.727	***-0.726	***-0.704
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Female	***-0.311	***-0.311	***-0.274	***-0.185	***-0.185	***-0.163
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Non-white	***-0.123	***-0.123	***-0.114	***-0.074	***-0.074	***-0.068
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ln productivity	***0.123	***0.123	***0.166	***0.091	***0.091	***0.122
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ln minwage		***0.251	***0.238		***0.070	***0.066
		(0.009)	(0.009)		(0.009)	(0.009)
Unionized			***1.019			***0.098
			(0.012)			(0.012)
Formal			***0.394			***0.089
			(0.006)			(0.006)
UF	***FE	***FE	***FE	***FE	***FE	***FE
Year	***FE			***FE		
Cycle		***FE	***FE		***FE	***FE
Constant	-1.138	-2.615	-2.854			
	(0.009)	(0.056)	(0.055)			

(continues on next page)

9 Age is employed throughout this analysis as a proxy for working experience.

Table 2 **(continued)**

Variable	Beta			Standardized Beta		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
N	1,208,080	1,208,080	1,208,080	1,208,080	1,208,080	1,208,080
Adjusted R^2	0.461	0.461	0.479	0.461	0.461	0.479
F	16,933	21,958	22,660	16,933	21,958	22,660

Heteroskedasticity Robust Standard Errors are Presented in Parentheses.

*$^+$ = Significant at 10%; * = Significant at 5%; ** Significant at 1%; *** Significant at 0.1%.*

FE Indicates Control of Fixed Effects using Dummy Variables.

Institutional factors also play a significant role in determining wage levels. The coefficient value of *minimum wage*, 0.251 in Model 2 (0.238 in Model 3), indicates that a 1% increase in the national real minimum wage is associated with a 0.251% increase in real wages (0.238% in Model 3). The coefficient value of 1.019 for *union* in Model 3 indicates that a 1 percentage point increase in the proportion of organized workers in an observed worker's state is associated with a 1.019% increase in real wages for that worker, all else equal. Finally, the coefficient of 0.394 for *formal* indicates that a 1 percentage point increase in the proportion of formalized workers in an observed worker's state is associated with a 0.394% increase in real wages for that worker.

Estimates for the standardized coefficients allow us to understand to what extent relative change (one standard deviation) in an explanatory variable affects relative variation in the dependent variable. The similar estimates for *log of productivity* (0.122), *unionized* (0.098), and *formal* (0.089) suggest that real wages were equally affected by both relative variations in labor productivity and institutional factors. This finding suggests that remuneration in the Brazilian labor market (both absolutely and relatively between sectors) is not merely determined by market-driven forces such as labor productivity, but also by structural characteristics, many of which are activity-specific. The association between relative changes in the minimum wage and in the hourly wage is slightly lower (0.066), but this result may hide important differences between labor- and capital-intensive sectors. Thus, we next estimate sectoral regressions in order to assess the activity-specific nature of wage-determinants.

Table 3 reports sectoral regression results, generated by fitting the wage-regression model developed above to seven pooled datasets, each of which include only individuals employed in the respective economic

sector.[10] Standard errors are robust to heteroscedasticity, and estimates, with some exceptions, are significant at the 1% level. Estimates for the standardized coefficients are presented in Appendix C.

Signs and magnitudes of social control variables are again as expected, though there is notable sectoral variation. Results indicate that returns to schooling are higher than the baseline average in financial and information services ($e^{0.131}-1=14{,}0\%$ per year of education), and public administration and services ($e^{0.119}-1=12.7\%$). Returns to formal education are lowest in agriculture ($e^{0.043}-1=4.4\%$) and real estate and other services ($e^{0.054}-1=5.5\%$).[11] These results indicate that returns to education are higher in more skill-intensive sectors, suggesting the presence of skill-biased technological change and job polarization (increasing separation between high- and low-paying activities) as potential generators of both wage differentiation and persistent inequality among sectors (Berman *et al.*, 1997; Autor, 2010).

Table 3 **Sectoral regression estimates for the dependent variable *log of hourly wage***

Variable	Agriculture	Industry	Construction & Utilities	Commerce	Financial & Info Services	Real Estate & Other Services	Public Services
School	***0.043	***0.095	***0.084	***0.076	***0.131	***0.054	***0.119
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Age	***0.043	***0.080	***0.069	***0.075	***0.085	***0.060	***0.051
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Age^2	***-0.001	***-0.001	***-0.001	***-0.001	***-0.001	***-0.001	***-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Female	***-0.201	***-0.351	*-0.019	***-0.226	***-0.255	***-0.324	***-0.289
	(0.006)	(0.003)	(0.010)	(0.003)	(0.005)	(0.003)	(0.004)
Non-white	***-0.060	***-0.124	***-0.124	***-0.112	***-0.169	***-0.072	***-0.128
	(0.004)	(0.003)	(0.005)	(0.003)	(0.006)	(0.003)	(0.004)
ln productivity	0.003	***0.148	***0.091	***0.201	***0.095	***0.342	***0.192
	(0.005)	(0.004)	(0.005)	(0.004)	(0.008)	(0.004)	(0.006)

(continues on next page)

10 Transportation is excluded from Table 3 due to the absence of state-level value-added data for this sector.

11 It is noteworthy that many skilled workers in sectors such as agriculture and construction gain qualifications through on-the-job training and apprenticeships rather than formal education. Thus, low estimates of returns to schooling in these sectors should not be interpreted as non-responsiveness of wages to skills or qualifications.

Table 3 **(continued)**

Variable	Agriculture	Industry	Construction & Utilities	Commerce	Financial & Info Services	Real Estate & Other Services	Public Services
ln minwage	***0.496	***0.100	***0.218	***0.269	*0.081	***0.460	***0.200
	(0.026)	(0.020)	(0.034)	(0.021)	(0.039)	(0.019)	(0.027)
Unionized	***-0.301	-0.006	***0.378	***-0.336	***0.292	0.115	***0.628
	(0.055)	(0.046)	(0.082)	(0.061)	(0.079)	(0.095)	(0.063)
Formal	***0.643	***0.527	***0.343	***0.458	**0.208	***0.214	
	(0.038)	(0.048)	(0.051)	(0.057)	(0.075)	(0.049)	
UF	***FE	***FE	***FE	***FE	***FE	***FE	***FE
Cycle	***FE	***FE	***FE	***FE	***FE	***FE	***FE
Constant	***-3.310	***-1.994	***-2.246	***-2.997	***-1.848	***-4.385	***-2.314
	(0.152)	(0.120)	(0.197)	(0.121)	(0.236)	(0.111)	(0.162)
N	115,631	233,268	95,621	213,266	88,555	307,125	154,614
Adjusted R^2	0.321	0.475	0.408	0.378	0.479	0.366	0.444
F	1,497	4,108	1,263	2,592	1,687	3,980	2,867

Heteroskedasticity Robust Standard Errors are Presented in Parentheses.

*+ = Significant at 10%; * = Significant at 5%; ** Significant at 1%; *** Significa at 0.1%.*

FE Indicates Control of Fixed Effects Related to Year or State Dummy Variables.

The gender wage-penalty varies significantly by sector. The negative wage impact of being female is greatest in industry ($e^{-0.351}-1=-29.6\%$) and real estate and other services ($e^{-0.324}-1=-27.6\%$), and smallest in construction ($e^{-0.019}-1=-1.9\%$) and agriculture ($e^{-0.201}-1=-18.2\%$). The effects of race on wages appear to be more robust and consistent over economic sectors. Race-related wage penalties range from a minimum impact of –5.8% for non-whites in agriculture, to a maximum impact of –15.5% for non-whites in Financial & Information Services.

The variable of focus in this study, *log of productivity*, exhibits significant variation over economic sectors, though its impact is universally positive. All else equal, a 1% increase in the level of labor productivity in an observed worker's state and economic sector has the largest positive impact on real wages in real estate and other services (+0.34%), commerce (+0.20%), public services (+0.19%), and industry (+0.15%). Productivity has lower impact on wages in financial and information services (+0.10%), construction and utilities (+0.09%), and agriculture (insignificant).

The relatively large positive impacts measured in real estate and commerce may be due to the prevalence of work-on-commission in these sectors. Many workers earn according to their sales performance, and should thus exhibit high levels of association between labor productivity and earnings. The relatively large impact of labor productivity on wages in the public sector is likely the result of labor productivity accounting methods. As noted before, public sector workers' value-added is calculated directly from inputs, thus eliciting a positive association between productivity and wages. The labor productivity-wage relationship is potentially relatively low in the financial and information services sector due to information asymmetries inherent to these activities. In banking, marketing, research, and other activities in this sector, firms find it difficult to assess employees' true productivity levels. In contrast, productivity impacts on wages in industry are relatively high due, presumably, to the facility with which firms can measure employees' productivity and by the degree to which employers regulate employees through employment contracts (Rose; O'Reilly, 1998). Finally, the impacts of labor productivity on wages are smallest in construction and agriculture. This may be due in part to the generally low levels of worker qualification and the substantial influence of institutional variables such as minimum wage in these sectors. It is important to note that agriculture exhibits especially high levels of heterogeneity in firm and worker productivity, causing low sector-level elasticity to obscure noteworthy real productivity and wage gains among modern agricultural practices (Maia; Sakamoto, 2014).

Institutional variables also exert strong and significant effects on real wages at the sectoral level. Results indicate that a 1 percentage point increase in union participation in an observed worker's state is significantly negatively associated with real wages in agriculture (–0.30%) and commerce (–0.34%), and significantly positively associated with real wages in public services (+0.63%), construction & utilities services (+0.38%) and financial and information services (+0.29%). This divergent behavior may reflect divergent levels of labor organization across sectors. For example, agriculture and commerce are characterized by low levels of labor organization (14% and 15% respectively in 2014), while financial and information services and public services are characterized by high levels of labor organization (25% and 27%, respectively).[12] Furthermore, financial and

12 These data refer only to employees, and exclude self-employed workers. Since rates of self-employment are much higher in agriculture and commerce than in public services or

information services and public services are characterized by higher barriers to entry, high-skilled (difficult to replace) jobs, and institutional protections that facilitate labor organization and action (IPEA, 2009).

As a result, an increase in labor organization in unorganized sectors (agriculture and commerce) may have the effect of pulling resources away from the large majority of non-organized workers, thus resulting in the negative coefficient reported in Table 3. In organized sectors (financial and information services and public services), an increase in labor organization benefits a large enough proportion of workers to pull up sectoral wages as a whole, resulting in the positive coefficient measured for these sectors.

The impacts of *formal* (measuring the proportion of formalized workers in each state) are significant and positive across all sectors.[13] Since worker formalization primarily impacts labor markets by requiring firms to pay minimum wage, this variable should exhibit the largest impact on sectors characterized by high proportions of minimum-wage employment, i.e. sectors with low average wages. Indeed, results in Table 3 indicate that a 1 percentage point increase in state-level formalization is associated with the largest wage gains (+0.64%) in agriculture, which presents the lowest wage levels of any economic sector, and the smallest wage gains (+0.21%) in real estate and other services and financial and information services, the latter of which presents the highest wage levels of any economic sector. Despite low average wages in real estate and other services, the net impact of formalization on wages in this sector is likely low due to high within-sector heterogeneity–ranging from extremely high wage activities, such as real estate, to low wage activities, such as cleaning and security services.

The substantial increases of the minimum wage over the sample period primarily favored low-wage sectors: agriculture and real estate and other services. For each 1% variation in the minimum wage, average wages in these sectors increased by 0.50% and 0.46%, respectively. In turn, the impact of minimum wage on high-skill jobs, such as in financial and informa-

financial and information services, the true contrast in levels of labor organization between the former and latter sectors is even larger than the quoted statistics suggest. Furthermore, to avoid overgeneralization, it should be noted that some specific subsectors in construction and utilities are also characterized by high levels of unionization, namely, production and provision of electric energy and water (41%).

13 Formally employed public sector workers do not possess a "*carteira assinada*" (formal employment registration) certifying their formal employment status. They thus appear among informal workers in the PNAD sample. To avoid misestimation based on this misleading classification, the variable *formal* was dropped from the public services sectoral regression model.

tion services, are negligible.

Overall, the standardized coefficients in Appendix C highlight that labor productivity has played an important role in increasing hourly wages. Relative changes in labor productivity exerted larger effects on average wages in sectors characterized by productivity-based pay, i.e. commerce and real estate and other services. Nevertheless, institutional factors such as minimum wage also significantly explain the dynamics of average wages in Brazil, especially in low-paying sectors. Relative variation in the minimum wage exerted the largest impact on hourly wages in agriculture, real estate and other services, commerce, and construction and other utilities.

5 **Conclusions**

Real wages may diverge from labor productivity due to a range of economic and institutional factors. Economic factors include changes in non-pay compensation, information asymmetries between workers and firms, the emergence of worker or firm rents as the result of labor market disequilibrium and search costs, and technology-biased innovation and investment that distorts factor income shares. Institutional factors include labor market formalization, labor organization, and minimum wages. The degree to which these factors cause wage growth to diverge from productivity growth has significant implications for economic competitiveness, investment, and the distribution of income among factors of production.

In Brazil, real wages grew significantly more than did labor productivity between 1996 and 2014. However, this general trend disguises significant sectoral variations, which can be grouped into four conceptual trends. Firstly, in the agriculture and commerce sectors, large gains in labor productivity were accompanied by real wage increases and improvements in the quality of employment. This dynamic was likely due to a positive interplay between productivity-enhancing market developments (incorporation of new technologies, high levels of investment, exploitation of new consumer markets/agricultural frontiers) and income-enhancing institutional developments (formalization and minimum wage valorization). In conjunction, these forces resulted in productivity gains that outpaced wage growth, leading to declining relative wages in agriculture and commerce (see Appendix A for data on relative wages).

In a second sectoral trend, the construction and real estate and other services sectors enjoyed real wage gains over the 1996-2014 period, despite stagnation in labor productivity. Both sectors offer little natural room for drastic productivity growth through the incorporation of new technologies, investments, or practices. And both were major beneficiaries of institutional interventions such as formalization and valorization of the minimum wage.[14] Together, these forces resulted in a sharp rise in relative wage for construction and real estate and other services.

In a third variation of the productivity-wage relationship, both labor productivity and real wages largely stagnated or declined slightly in the industry and transportation sectors. In the case of industry, international competition likely held down wages, while productivity suffered from ongoing processes of deindustrialization. By its nature, the transportation sector offers little room for major productivity gains, while the average wage may have fallen as a result of changing forms of employment relations (i.e., increasing levels of self-employment) and increasing relative costs of transport (Chahad; Cacciamali, 2005). These dynamics explain the moderate decline in relative wages for industry and transportation.

In a fourth and final trend, the financial and information services and public services sectors saw stable or declining levels of labor productivity, accompanied by increasing or stable real wages. Productivity declines in financial and information services were due largely to changes in the Brazilian banking system over the 1998-2004 period. Earnings increases in both sectors may have resulted from persistently high returns to education, growing demand for qualified workers, and high levels of labor organization. As a result, the relative wage rose sharply for these sectors between 1996 and 2014.

It is important to note that all analyses above should be interpreted with caution, due to the difficulty inherent in estimating absolute values of labor productivity for some sectors, particularly public services and real estate. Nevertheless, the values serve to elucidate temporal dynamics of labor productivity within (if not necessarily across) sectors, revealing essential patterns in the productivity-wage relationship.

Estimation of hierarchical wage models using pooled data assessed the main structural and individual determinants of real wages over the sample period. Growth in sector- and state- level labor productivity was signifi-

14 The Real Estate and Other Services sector includes domestic maid services, a large minimum-wage employment sector in Brazil.

cantly positively associated with growth in real wages for all economic sectors from 1996 to 2012. Elasticity between labor productivity and real wages was greatest for sectors where workers' earnings are often based directly on productivity (real estate, commerce), or where firms can easily measure employees' productivity (industry). Elasticities appear smaller in sectors where productivity is more difficult for firms to measure, or where there are high levels of minimum wage employment (agriculture, construction) or labor organization (financial and information services).

In general, productivity's impact on wages was comparable to the impacts of institutional factors, particularly worker formalization and minimum wage. Formalization, which primarily impacts labor markets through the enforcement of a minimum wage-floor, exhibited the largest impacts on sectors with high proportions of minimum wage employment. Labor organization had varied effects on wage levels. In sectors with high levels of organization, increases in union-participation exhibited a significantly positive association with wages. In contrast, increases in union-participation in less-organized sectors were negatively associated with wages, perhaps because union activity served to draw earnings away from the larger share of non-unionized workers. Nonetheless, unionization changed little over the sample period and exerted a relatively small impact on hourly wages.

Wage growth in line with the first sectoral trend (observed in the agriculture and commerce sectors) may be the most sustainable in the long term, in the sense that increased earnings over the 1996 to 2014 period accompanied real gains in labor productivity. In contrast, rising relative wages in the financial and information services and public services sectors highlight the capacity of labor organization, institutional protections, and skill-biased job polarization to decouple wages from productivity levels. In sum, institutional mechanisms display the capacity to substantially reallocate factor incomes toward workers, but these mechanisms face natural limitations if not accompanied by growth in labor productivity. Thus, sustainable future wage growth in Brazil will likely depend on positive interplays between market-driven productivity gains and continued institutional interventions.

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About the article

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APPENDIX A

Table A1 **Labor market developments in Brazil, by sector (1996-2014)**

		1996	2002	2008	2014	Total Change
Value Added (Millions of Constant 2014 PPP US$)	**Agriculture**	93,524	122,082	130,301	149,858	**56,335**
	Industry (Manufacturing & Extractive)	269,853	314,074	490,071	443,091	**173,237**
	Construction and Public Utilities	168,301	187,505	168,449	244,655	**76,354**
	Commerce	137,260	147,132	295,463	371,897	**234,637**
	Transportation, Storage, Distribution	55,159	69,914	95,866	126,776	**71,618**
	Financial and Information Services	208,848	231,751	261,838	285,407	**76,559**
	Real Estate and Other Services	504,855	516,306	568,914	761,220	**256,365**
	Public Services	276,916	313,595	398,302	486,469	**209,553**
Labor Productivity (Value Added per Labor Hour) (Constant 2014 PPP US$)	**Agriculture**	4.93	6.64	7.77	10.93	**6.00**
	Industry (Manufacturing & Extractive)	13.16	14.63	18.66	18.71	**5.54**
	Construction and Public Utilities	16.52	15.19	11.68	13.82	**-2.70**
	Commerce	6.62	5.59	9.74	11.17	**4.56**
	Transportation, Storage, Distribution	9.22	9.06	10.76	12.56	**3.34**
	Financial and Information Services	39.67	31.25	24.92	23.53	**-16.14**
	Real Estate and Other Services	23.82	20.37	20.20	26.14	**2.32**
	Public Services	18.23	17.04	18.59	19.49	**1.26**
Average Hourly Wage (Constant 2014 PPP US$)	**Agriculture**	2.61	2.18	2.73	4.26	**1.65**
	Industry (Manufacturing & Extractive)	4.98	4.24	4.77	6.33	**1.35**
	Construction and Public Utilities	4.40	3.64	3.97	6.08	**1.68**
	Commerce	5.28	4.19	4.52	5.84	**0.56**
	Transportation, Storage, Distribution	5.92	4.77	5.51	6.95	**1.03**
	Financial and Information Services	11.72	9.54	8.75	11.64	**-0.07**
	Real Estate and Other Services	3.40	2.94	3.46	5.02	**1.62**
	Public Services	8.06	7.80	8.71	11.44	**3.38**
Average Monthly Wage (Constant 2014 PPP US$)	**Agriculture**	453	395	468	621	**168.03**
	Industry (Manufacturing & Extractive)	905	755	817	990	**84.39**
	Construction and Public Utilities	784	652	711	925	**140.99**
	Commerce	908	744	799	913	**5.47**
	Transportation, Storage, Distribution	1,138	910	975	1,082	**-56.11**
	Financial and Information Services	1865	1542	1424	1691	**-173.71**
	Real Estate and Other Services	541	451	509	667	**126.12**
	Public Services	1,149	1,126	1,257	1,495	**346.00**

Table a1 **(continued)**

		1996	2002	2008	2014	Total Change
Proportion of Total Workers (%)	**Agriculture**	21.5	19.0	16.6	13.9	**-7.6**
	Industry (Manufacturing & Extractive)	14.1	13.2	13.8	11.9	**-2.2**
	Construction and Public Utilities	7.8	7.9	8.3	10.0	**2.2**
	Commerce	16.9	17.7	17.8	18.5	**1.6**
	Transportation, Storage, Distribution	4.0	4.4	4.5	5.1	**1.1**
	Financial and Information Services	4.3	5.0	6.1	6.6	**2.3**
	Real Estate and Other Services	17.3	18.2	18.2	18.0	**0.7**
	Public Services	14.2	14.6	14.7	16.0	**1.9**
Average Years of Schooling	**Agriculture**	2.6	3.0	4.0	5.0	**2.3**
	Industry (Manufacturing & Extractive)	6.6	7.5	8.5	9.2	**2.6**
	Construction and Public Utilities	4.8	5.4	6.4	7.1	**2.3**
	Commerce	7.2	7.9	8.8	9.4	**2.2**
	Transportation, Storage, Distribution	6.6	7.2	8.2	8.7	**2.1**
	Financial and Information Services	11.0	11.5	11.8	12.4	**1.4**
	Real Estate and Other Services	5.4	6.3	7.4	8.1	**2.7**
	Public Services	10.1	10.8	11.6	12.2	**2.2**
Total Hours Worked (Millions of Hours)	**Agriculture**	18,967	18,394	16,776	13,711	**-5,256**
	Industry (Manufacturing & Extractive)	20,500	21,474	26,268	23,685	**3,184**
	Construction and Public Utilities	10,185	12,347	14,421	17,701	**7,516**
	Commerce	20,737	26,333	30,325	33,280	**12,543**
	Transportation, Storage, Distribution	5,980	7,713	8,911	10,091	**4,112**
	Financial and Information Services	5,265	7,415	10,507	12,129	**6,864**
	Real Estate and Other Services	21,193	25,346	28,164	29,121	**7,928**
	Public Services	15,194	18,401	21,420	24,962	**9,768**
Relative Wage (Avg. Hourly Wage / Avg. Value Added per Labor Hour)	**Agriculture**	0.53	0.33	0.35	0.39	**-0.14**
	Industry (Manufacturing & Extractive)	0.38	0.29	0.26	0.34	**-0.04**
	Construction and Public Utilities	0.27	0.24	0.34	0.44	**0.17**
	Commerce	0.80	0.75	0.46	0.52	**-0.27**
	Transportation, Storage, Distribution	0.64	0.53	0.51	0.55	**-0.09**
	Financial and Information Services	0.30	0.31	0.35	0.49	**0.20**
	Real Estate and Other Services	0.14	0.14	0.17	0.19	**0.05**
	Public Services	0.44	0.46	0.47	0.59	**0.14**

Source: Table constructed by author from PNAD and National Accounts (1996-2014).

APPENDIX B

Table A2 **Brazil: percentage growth, by sector (1996-2014)**

Sector	Percentage Growth (1996-2014)			
	GVA	Labor Productivity	Monthly Income	Relative Wage
Agriculture	60	122	37	-26
Industry (Manufacturing and Extractive)	64	42	9	-11
Construction and Public Utilities	45	-16	18	65
Commerce	171	69	1	-34
Transportation, Storage, Distribution	130	36	-5	-14
Financial and Information Services	37	-41	-9	68
Real Estate and Other Services	51	10	23	35
Public Services	76	7	30	33

Source: Table constructed by author from PNAD and National Accounts (1996-2014).

APPENDIX C

Table A3 **Standardized coefficient estimates for dep. variable *log of hourly wage*, by sector**

Variable	Agriculture	Industry	Construction & Utilities	Commerce	Financial & Info Services	Real Estate & Other Services	Public Services
School	***0.211	***0.459	***0.442	***0.363	***0.484	***0.270	***0.554
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
Age	***0.828	***1.116	***1.066	***1.128	***1.008	***0.952	***0.684
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Age^2	***-0.7160	***-0.7879	***-0.7471	***-0.8100	***-0.6597	***-0.7402	***-0.4053
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Female	***-0.097	***-0.203	*-0.006	***-0.157	***-0.142	***-0.193	***-0.160
	(0.006)	(0.003)	(0.020)	(0.003)	(0.005)	(0.003)	(0.004)
Non-white	***-0.043	***-0.078	***-0.080	***-0.078	***-0.088	***-0.048	***-0.074
	(0.004)	(0.003)	(0.005)	(0.003)	(0.006)	(0.003)	(0.004)
ln productivity	0.003	***0.084	***0.067	***0.103	***0.055	***0.216	***0.109
	(0.005)	(0.004)	(0.005)	(0.004)	(0.008)	(0.004)	(0.006)
ln minwage	***0.173	***0.030	***0.068	***0.087	*0.021	***0.140	***0.055
	(0.026)	(0.020)	(0.034)	(0.021)	(0.039)	(0.019)	(0.027)
Unionized	***-0.032	0.000	***0.018	***-0.017	***0.016	0.003	***0.036
	(0.055)	(0.046)	(0.082)	(0.061)	(0.079)	(0.095)	(0.063)
Formal	***0.173	***0.061	***0.040	***0.055	**0.014	***0.029	
	(0.038)	(0.048)	(0.051)	(0.057)	(0.075)	(0.049)	
UF	***FE	***FE	***FE	***FE	***FE	***FE	***FE
Cycle	***FE	***FE	***FE	***FE	***FE	***FE	***FE
N	115,631	233,268	95,621	213,266	88,555	307,125	154,614
Adjusted R^2	0.321	0.475	0.408	0.378	0.479	0.366	0.444
F	1,497	4,108	1,263	2,592	1,687	3,980	2,867

Heteroskedasticity Robust Standard Errors are Presented in Parentheses.

*$^+$ = Significant at 10%; * = Significant at 5%; ** Significant at 1%; *** Significant at 0.1%.*

FE Indicates Control of Fixed Effects Related to presidential periods or State Dummy Variables.