UNIVERSIDADE ESTADUAL DE CAMPINAS
Instituto de Economia

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PRECARIOUSNESS IN UNDERDEVELOPED COUNTRIES' LABOR MARKETS: AN AGENT-BASED MODELLING PERSPECTIVE

PRECARIEDADE NOS MERCADOS DE TRABALHO DOS PAÍSES SUBDESENVOLVIDOS: UMA PERSPECTIVA A PARTIR DE UM MODELO BASEADO EM AGENTES

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Tese apresentada ao Instituto de Economia da Universidade Estadual de Campinas como parte dos requisitos exigidos para a obtenção do título de Doutor em Ciências Econômicas na área de Teoria Econômica.

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Orientador: Marcelo de Carvalho Pereira

ESTE TRABALHO CORRESPONDE À VERSÃO FINAL DA TESE DEFENDIDA PELO ALUNO CHRISTIAN DUARTE CALDEIRA, E ORIENTADO PELO PROF. DR. MARCELO DE CARVALHO PEREIRA.

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Prof. Dr. Marcelo de Carvalho Pereira – Orientador

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To the God Almighty, overall, I give thanks.

Saio do trabalho, hey!

Volto para casa, hey!

Não lembro de canseira maior

Em tudo é o mesmo suor

Milton Nascimento and Fernando Brant

What do people gain from all their labors at which they toil under the sun? (...) For with much wisdom comes much sorrow; the more knowledge, the more grief.

Koheleth

Resumo

Os anos mais recentes viram, entre os países subdesenvolvidos, a retomada da ideia de que as reformas no mercado de trabalho voltadas à sua flexibilização deveriam ser postas em marcha para a modernização das relações de trabalho e melhoria da performance de indicadores econômicos nestes países. Sem embargo, os resultados de reformas similares nos países europeus já vinham revelando que seus efeitos sobre a atividade econômica poderiam ser nulos e sobre os trabalhadores e o mercado de trabalho poderiam ser bastante negativos. Soma-se a isso o fato de que os países subdesenvolvidos partem de um mercado de trabalho desestruturado, com forte presença de informalidade e condições de trabalho inseguras, entre outras características, de maneira que as reformas poderiam ter como um dos principais efeitos o agravamento da precariedade. Esta tese buscou avaliar se as reformas trabalhistas voltadas à flexibilização dos mercados de trabalho em países subdesenvolvidos poderiam implicar no aumento da precariedade do trabalho. Parte-se de Rodgers (1989), onde se entende como dimensões da precariedade a incerteza da continuidade do vínculo empregatício, o baixo controle sobre o trabalho, a dificuldade de acesso aos mecanismos de proteção social e a insuficiência de renda. A tese está dividida em três artigos. O primeiro artigo propõe um indicador sintético de mensuração da precariedade através da análise de componentes principais. Com este índice foi possível comparar as experiências mexicana e brasileira, que implementaram reformas em momentos distintos (2012 e 2017, respectivamente). Os resultados revelaram que a precariedade vem crescendo nos estados mexicanos desde a implementação da reforma em 2012, enquanto o sentido positivo de queda da precariedade nos estados brasileiros se reverteu a partir de 2017. Com o argumento de que os impactos completos das reformas talvez ainda não tenham sido totalmente atingidos, o segundo artigo propõe a construção de um modelo baseado em agentes do mercado de trabalho empiricamente validado com o propósito de servir de "laboratório" para se avaliar os possíveis efeitos das reformas. O modelo foi capaz de reproduzir os principais fatos estilizados dos mercados de trabalho em países subdesenvolvidos, revelando sua utilidade como instrumento teórico para a avaliação de políticas. A partir do modelo desenvolvido no segundo artigo, o terceiro artigo desenvolve dois experimentos para simular os impactos da redução dos custos de demissão e do aumento do peso dos acordos individuais entre empregador e empregado, dois elementos importantes da reforma trabalhista brasileira, sobre as dimensões da precariedade. Os resultados de ambos os experimentos apontaram no sentido da possibilidade de aumento das dimensões da precariedade no mercado de trabalho sem contrapartida de crescimento econômico. Em linhas gerais, a tese conclui que as reformas liberalizantes podem não ser os instrumentos mais adequados para a implementação nos mercados de trabalho pouco estruturados de países subdesenvolvidos e que seus efeitos de longo-prazo devem ser de agravamento das dimensões da precariedade.

Palavras-chave: Mercado de trabalho; Emprego precário; Economia – modelos matemáticos

Abstract

Recently, the idea that labor market flexibilizing reforms should be carried out for the modernization of labor relations and performance improvement of economic indicators of underdeveloped countries has been gaining strength. Nevertheless, the results of similar reforms in European countries revealed that the effects over economic activity may be null and over workers and the labor market may be negative. In addition to that, underdeveloped countries' starting point are unstructured labor markets, with a high prevalence of informality and insecure working conditions, in such a way that the reforms may have as a main effect the deepening of precariousness. This thesis sought out to evaluate whether flexibilizing labor reforms in underdeveloped countries would implicate higher labor precariousness. We follow Rodgers (1989), which understands as precariousness dimensions the uncertainty in continuing working, low control over work, difficulty in access social protection and insufficient income. Three papers compose the thesis. The first article proposes a synthetic index for measuring precariousness through principal component analysis. With this index, it was possible to compare the Mexican and Brazilian experiences, which have implemented reforms in distinct moments (2012 and 2017, respectively). Precariousness has been rising in Mexican states since the reform implementation in 2021, while the positive path of precariousness decreasing in Brazilian states started to reverse in 2017. With the argument that the full impacts of the reforms may not yet been totally achieved, the second paper proposes the construction of an empirically validated labor market agent-based model with the purpose of function as a "laboratory" to evaluate the reforms' possible effects. The model was capable of reproduce the main labor market stylized facts in underdeveloped countries, showing its usefulness as a theoretical tool for policy evaluation. From the model built in the second paper, the third paper developed two experiments to simulate the impacts of the reduction of dismissal costs and the increase of the weight of individual-level agreements between employer and employees, two important features of Brazilian labor reform, over precariousness dimensions. The results of both experiments point out towards the possibility of aggravation of labor market precariousness dimensions without counterpart in economic growth. In broad lines, the thesis concludes that flexibilizing reforms may not be the most adequate instruments to be implemented in the poorly structured underdeveloped countries' labor markets and the long-run effects may be the worsening of the precariousness dimensions.

Keywords: Labor market; Precarious job; Economics – mathematical models

TABLE OF CONTENTS

Introduction

Over one's lifespan, people spend roughly one fifth of the waking hours working. Reproduction of everyday life looms largely on the ability to make it through work. In this sense, it is crucial that the period spent on a job is surrounded by stability and good working conditions. Over the course of the 20th century, the labor movement in the advanced countries was able to influence on legislation to assure job security. What came to be known as the "standard employment relationship" set the benchmark to what should be an appropriate relation between employee and employer. The idea even influenced developing countries, shedding light on the path to be followed to build a fair and egalitarian labor market.

Recently, the situation has turned. The dismantling of the standard employment relationship, by means of labor "flexibilization" reforms, led to an increase of insecure and unstable working forms. Workers in developed countries, which were previously granted job security, good working conditions and an adequate income, began to see a rupture of these rights. This change came to be known as the "precarization process", where workers loss of rights moved many of them into precarious forms of job insertion.

When the labor flexibilization trend landed, countries in the developing world were in the middle of a struggle to constitute the labor regulation to support a protective labor market. There, results were more severe, given just part of the workers had achieved some protection and most were already inserted in precarious conditions, losing the opportunity of change.

The dismantling of the protective labor legislation was put forward by means of labor reforms. Particularly in Latin America, the reforms were prescribed as a panacea to most of the countries' economic problems, ranging from high unemployment to weak output growth, to increase productivity and modernize labor relations alike. However, evidence about the advanced countries – which implemented such reforms first – were neither conclusive on the benefits of the reforms, nor on their negative impacts on precariousness.

Despite the lacking evidence from the developed world, flexibilizing labor reforms gained terrain in Latin America. The two largest countries – Brazil and Mexico – implemented such reforms during the 2010s. In this context, the first paper in this thesis aims at understanding how labor precariousness evolved throughout the decade, covering the 2012 Mexican and 2017 Brazilian labor reforms.

We start highlighting the concept of "precarious work" used throughout the thesis. Following Rodgers (1989), we define as precarious the worker in a job with a reduced degree of certainty in continuing working, lacking of control over work, with reduced social protection,

and receiving low wages. We used proxy variables of the aforementioned dimensions to build a precariousness index using principal component analysis. Results showed that precariousness increased in Mexico after 2012, and in Brazil after 2017, coinciding with the respective introduction of each reform.

Nevertheless, solely analyzing the index performance over the years may not fully address to which extent the labor reforms contributed to the evolution of work precariousness. For this reason, the second paper proposes a theoretical agent-based model (ABM) of the labor market. ABMs are computer simulation models based on the interaction of sets of heterogeneous agents, representing a complex evolving system. When empirically validated, they constitute a "laboratory" suitable to perform experiments about institutional change.

The proposed model goal is to evaluate the role of increasing labor flexibility in explaining rising work precariousness in Mexico. By setting up an ABM with labor market characteristics similar with those present in the country, it is possible to sensibly explain why labor markets with increased flexibility led to higher turnover rates, lower wages, and reduced tenure. These consequences, spotted in Mexican labor market after 2012, became the main drivers of precariousness in the country, representing higher insecurity about continued work and sufficient income.

The model is also employed in the third article to study the potential of the 2017 Brazilian reform on the deepening of work precariousness. Since this reform is more recent, the empirical assessment of long-standing impacts is not yet completely available. Therefore, we propose two theoretical experiments to evaluate how the two main points of the reform may affect precariousness.

The first experiment analyzes the effect of the reduction of labor costs by means of a reduced termination fee. Results show that lower dismissal barriers increase firms' incentives for firing, and reduce workers' incomes. The second experiment addresses the impact of the introduction of the individually-negotiated agreements, replacing collective ones. Results demonstrate that the main consequence is an increasing income and wage inequality. The perspective for the effects of the Brazilian reform is, thus, an increased level of work precariousness by rising job uncertainty, expanding unemployment, and inducing inequality.

Bottom line, the labor flexibilizing reforms on developing countries do not address, and sometimes aggravate, the main issues of these economies, namely, inequality, informality, unemployment, and poverty. Neither they provide higher economic growth or productivity gains. The underlying objective, at the end, seems to be increasing the capitalist class appropriation of income. In the meanwhile, facing the economic recessions and the tougher

labor market, workers remain between the Scylla of precarious work and the Charybdis of unemployment.

Paper 1 – The evolution of labor precariousness in Brazilian and Mexican labor markets: a principal component analysis

Introduction

The dismantling of the "standard employment relationship" in Europe in the last quarter of the 20th century raised alarm on the subject of increasing precarious work in the advanced countries. Nevertheless, if we look to the historical development of Latin American labor markets, we will see that precarious forms of employment have always been the norm, not the exception. For this reason, although it could be arguable the existence of a general concept of precarious work, the process of precarization, that is, the movement which inserts workers into precarious occupations has different starting points in Latin America and in Europe, and the process may unroll itself differently.

In this paper we aimed at answering the following research questions: what does explain the incidence of precarious work in the labor market and how did these mechanisms impact the level of precariousness in Brazil and Mexico between 2012 and 2019? Brazil and Mexico are the two largest economies of Latin America and in the 2000s took opposing options of economic policies. In 2012, Mexico carried out a labor legislation reform in the spirit of regulating new types of employment contracts, flexibilizing the hiring and dismissal of the labor force, and reducing labor costs. In this sense, the Mexican case and how it impacted the country's labor market during these years may provide a preview for the consequences of the 2017 Brazilian labor reform, which had similarities with the Mexican counterpart.

We propose the creation of a labor precariousness index for two reasons. First, as precariousness cannot be directly measured and due to the multidimensionality of the phenomenon, it is necessary to come up with some way to summarize the idea into one single value. We achieve this using principal component analysis (PCA) to reduce the set of variables composing the concept of precarious labor market into a single number, thus called the "labor market precariousness index". The advantage of this approach is to address the question of precarious labor market multidimensionally, reducing the reliance on stricter definitions of precarious the worker who has at least one, some or all of the precariousness dimensions. The second reason why we proposed the index is for its further usage to test the hypothesis of the mechanisms affecting the incidence of precarious work by means of a time-fixed effects model.

With this model we want to see whether the labor market conditions, its structure, and the modifications in the system of labor regulation do impact in the countries' precariousness.

The article is structured as follows. In Section 1 we review the factors behind the expansion of precarious work in Europe and why these are not suitable to understand the reality of Latin American labor markets. We use Rodgers' (1989) definition of precarious work and review the main factors driving the increase and incidence of precarious work in nation-specific contexts, largely based on Rubery (1989). In Section 2, we analyze how these factors acted on Brazilian and Mexican labor markets during the period 2012-2019 in order to hypothesize whether precariousness would have risen or decreased in these countries. Then, in Section 3, we provide a literature review of labor precariousness indices, describe the methodology for the construction of our proposed index. We show the behavior of the index for both countries regional labor markets during the 2012 – 2019 to evaluate how the precariousness level developed during the period and to raise questions on its main drivers. The article ends with Conclusions.

1. Precarious work: definition and hypothesis on its causes

The concept of "precarious work" is usually built in opposition to the idea of a "standard employment relationship". The standard employment relationship (SER) - or, broadly, the system of labor regulation - came into being after the Second World War as a response to the workers' struggles to better life and working conditions and to the political and economic transformations that took place in the advanced countries, especially in Western Europe (Castel, 1998). The SER is characterized by a full-time continuous employment relationship where the worker usually had, for his whole working career, only one employer and worked under his direct supervision, having access to comprehensive benefits and entitlements (Vosko, 2010).

The set of labor regulations that defined the SER were developed under the protection of legislation or collective agreements and incorporated a degree of regularity and durability in employment relationships. These laws protected workers from socially unacceptable practices and working conditions, establishing rights and obligations, and providing a core of social stability to underpin economic growth (Rodgers, 1989). The conformation of this framework of social protection guaranteed the availability of secure employment at reasonable pay, which led to the stability of the advanced capitalist world in the post-war period (Kalleberg and Vallas, 2017).

In the 1970's, the SER began to dismantle (Glynn, 2006). The causes of this process can be summarized by three sets of explaining factors: i) financialization; ii) globalization and productive restructuring; iii) neoliberalism (Streeck, 2013). Financialization can be understood

as the imposition of a short-term, speculative logic among economic agents - households and firms alike. The most prominent facet of this financialization logic in firms is the emergence of the concept of maximizing shareholder value (Lazonick and O'Sullivan, 2000), which diminished the value for firms' other stakeholders, particularly workers. This increasingly exposed the labor force to outsourcing and downsizing, once these strategies resulted in the valorization of the stock price (Jacoby, 2005; O'Sullivan, 2001). In other words, the durability in employment relationships was jeopardized by these strategies aimed to increase shareholders' value.

The processes of globalization and productive restructuring increased the threat of unemployment upon workers in three ways: i) the possibility achieved by the firms of advanced countries to globally outsource their production plants posed a permanent threat over the workers of taking their jobs to other parts of the world; ii) the technological revolution made labor highly replaceable and rendered possible to redefine workers as independent contractors who had to assume risks previously handled by the firm (Kalleberg and Vallas, 2017); and iii) behind these two was the ideology of lean firms (Gordon, 1996), where the reduction of labor costs was mandatory for the firm to compete in the new scenario of intensified intercapitalist competition.

Finally, neoliberalism emerged as the main political and economic ideology inserted in the spaces of power and decision-making centers of advanced countries, advocating for a market-oriented economy and more flexible labor markets. This culminated into a strand of legislation which sought to increase the power of the employer over the allocation, use, and remuneration of the workforce. It was implemented by the regulation of flexible work arrangements and the undermining of workers' organization protections (Kalleberg and Vallas, 2017), unleveling the playing field to favor capital over labor.

The "precarization process" can be defined as this dismantling of the SER that begin to occur in the last quarter of the 20th century. It meant the increase of "non-standard" forms of work, and, simultaneously, the increased sense of insecurity in the employment relations felt by the workers. The characteristics of this stage in the employment relations are: i) the reduced degree of certainty of continuing work, for which the risk of job loss is high; ii) the lack of the workers' control over their own work, since the balance of power had shifted favorably to the employer; iii) the reduced extent to which workers are protected by law, collective organization, or customary practice; and iv) the declining wages and the creation of low income jobs, frequently associating the working class with poverty and insecure social insertion (Rodgers, 1989). The presence of the aforementioned elements together in an employment relation is the

definition of "precarious work", i.e., the absence of the elements that have conformed the "standard employment relationship" before.

Therefore, the framework of labor regulation built in the Western European countries in the post-war, and its subsequently erosion underlies the concept of precarious work usually present in the literature. Nevertheless, the case of Latin America differs from the European one. The latter went through a process of precarization during the neoliberal era in the sense that they had constituted a well-regulated labor market which has been dismantled ever since. The former, conversely, had not constituted completely the framework of social protection (Haggard and Kaufman, 2008; Cruz-Martínez, 2014).

In other words, Latin American labor markets have always been "precarious" in some sense, conforming some precarious structural characteristics such as low wages, absence of social protection and high informality (Loayza *et al.*, 2009). For that reason, it is important to analyze the adequacy of the process of precarization as it happened in Europe in the contexts and social configurations of Latin American countries, in which social protection and welfare have not become historically guaranteed by state policies (Vejar, 2017). The downfall of the idea of welfare state also affected working conditions in Latin America. However, while in Europe it meant the dismantling of the SER, in Latin America it implied the aggravation of a relatively unprotected labor market characterized - among other things - by the prevalence of precarious work (Vejar, 2014).

Therefore, we are aiming at a more general concept of precariousness. We go beyond the idea of precarious as a worker who has lost a set of rights and entitlements in the context of the SER to embrace multiple employment relations with the characteristics proposed in Rodgers (1989). Relations that inflict insecurity and instability, regardless of the society framework of labor and social protection. By dismissing the SER as a starting point, this concept becomes suitable for understanding precarious work in Latin America. For this reason, we establish the labor market – not the individual worker – as the reference frame for the precariousness analysis. A labor market is considered more or less precarious if a worker entering into it has a higher or lower probability of insertion into a type of occupation containing one or more precarious dimensions.

Throughout the national labor markets, the occurrence of precarious work has not been homogeneous, the acknowledgement of the national specificity of the phenomenon (Rubery, 1989; Meardi, 2014). We consider three main drivers of the process of constitution of precarious work which are meant to be "general" in the sense that they are suitable both for

countries that constituted the SER and those which did not. The first one is the conditions for the supply and demand of labor force and their relations in the labor market.

In a context of high labor force supply and stagnated demand – due to either demographic or economic conditions – the increase and persistence of unemployment would weaken the position of the job seekers, expanding the capacity of employers to offer precarious jobs. Another situation may arise in a context of high labor force demand with shortage of labor supply in a low average wage economy. Here, workers would be required to hold multiple jobs to complement the own income. In this situation, precarity arises not only because secondary jobs are usually more precarious, but also due to long working hours.

The labor market structure – how workers are distributed along occupations and sectors – also plays an important role in determining the creation and incidence of precarious work. We can think – based on the labor market segmentation theory (Fine, 2002; Fernández-Huerga, 2010) – in a labor market segmented in two sectors. The primary sector encompasses capital-intensive, high-productivity, oligopolistic firms that are able to pay higher wages and to provide better working conditions, whereas in the secondary sector the low-scale, labor-intensive, small firms offer much less attractive and insecure jobs, more prone to precarization. Nevertheless, precarious jobs are not confined only to the secondary sector. The internal labor markets conformed in the primary sector also create a hierarchical structure in which the firms maintain a core of high-skilled, protected workers - mainly white collars jobs - at the same time they keep a periphery of low-skill, blue-collar jobs that can be adapted to production needs, rising the insecurity for these workers. Therefore, the twofold process of increasing polarization due to the segmentation of the labor market and the maintenance of a reserve of low-skill workers simultaneously weakens workers' bargaining power and yields higher labor flexibility, which thus impacts the creation of precarious jobs (Kalleberg, 2009; Kalleberg, 2011; Vallas and Prener, 2012).

Finally, the last aspect to be considered is the institutional framework of the labor market and how the system of labor regulation is built. The regulatory system shapes the definition of precarious work and determine the distinction between precarious and non-precarious employment. Furthermore, two aspects of the institutional framework must be taken into account: the role of the State both as an employer – providing jobs precarious or not – and as a legislator, impacting the shape of the regulatory system, and the role of the collective organization of workers as a means of levelling the playing field in the capital-labor struggle, against the expansion of precarious work (Rodgers, 1989).

In conclusion, we follow Rodgers (1989) in defining the dimensions of precarious work as: i) low certainty of the continuity of the employment relation; ii) less worker control over his own working conditions, wages, and pace of work; iii) absence of social protection, usually expressed as access to social security; and iv) insufficient income in relation to an historical and socially determined minimum to provide for adequate life conditions. This set of dimensions can be immediately extended to the concept of "precarious labor market", which consists in a labor market with the prevalence of workers combining these dimensions and in which incoming workers have a higher probability of precarious insertion.

In the following, we shed light on how did these three drivers develop in Brazil and Mexico between 2012 and 2019. The goal is to formulate hypothesis on how have precariousness evolved in these countries by analyzing how the precarization drivers behaved in the period.

2. Labor market conditions, structure, and system of labor regulation in Brazil and Mexico

Brazil and Mexico took diverging paths in terms of economic policies and its subsequent outcomes in the labor market during the 2000s: while Brazil opted for more social-oriented policies, Mexico adopted more market-oriented economic policies. The consequences for these countries were a decrease in unemployment and inequality in Brazil, with rising real wages, and stagnation for the Mexican labor market indicators (Salas and Santos, 2011).

In the previous section, we introduced a theoretical framework which affirms that we should analyze both the labor market conditions and structure, together with the system of labor regulation, to understand how precariousness develops in a country.

Therefore, in the present section we aim to discuss how have these drivers evolved in order to formulate some hypotheses on how have precariousness developed in these countries in the recent years. During the period between 2012 and 2019, Brazil and Mexico faced different labor market conditions due mainly to differences in economic growth. Brazil experienced a downfall in its economic growth, facing two years of recession, whereas Mexico maintained its growth rate around 3% (Fig. 1). These differences in the economic growth implied in different situations in terms of unemployment rate. The economic crisis made the Brazilian unemployment rate rise sharply, from around 7% in 2012 up to 12,8% in 2017. In Mexico, by the other hand, unemployment remained in low levels, below the 5%, and even reducing to 3,28% in 2018 (Fig. 1).
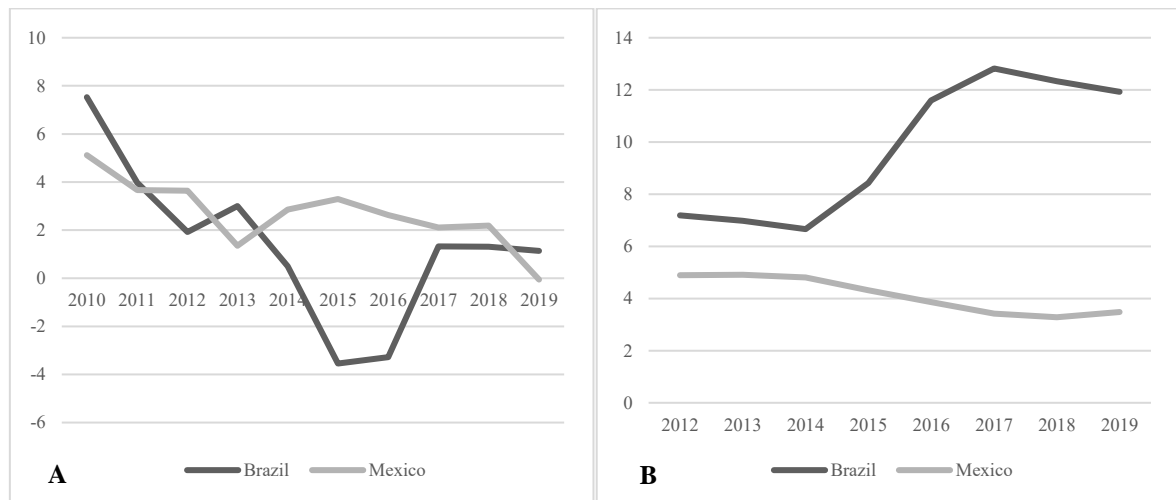
Figure 1: GDP growth rate (A) and unemployment rate (B) (%). Source: World Development Indicators (WDI).

The analysis based solely on the growth and unemployment rates would be misleading, leading to the belief that precariousness would have increased more in Brazil than in Mexico throughout the period under analysis. Nonetheless, the labor market structure and the system of labor regulation of both countries should be taken into account before drawing any further conclusion.

The low unemployment rates in Mexico conceal two facts. First, Mexican workers historically seek out immigration to the United States as an alternative to the lack of opportunities or to achieve a better standard of living for themselves and their families (Canales, 2002). According to the 2019 U.S. Census Bureau of Statistics, the Mexican adult population in the United States comprised roughly 10 million people, around 17% of Mexico labor force in that year. Had this population stayed in Mexico, it would have caused a surplus pressure on the labor market, which likely would not be satisfied by the demand for workers, thus resulting in higher unemployment (Hernández *et al*, 2012).

Second, the absence of unemployment benefits induces people to constantly look for an occupation, especially autonomously and in small firms (Salas, 2002; García and Salas, 2007). For that reason, it is also important to analyze the labor market structure, especially with respect to firm size and autonomous work.

In the terms of the labor market segmentation theory, the "secondary sector" would be the one composed by small firms (with five employees or less) and autonomous workers (Fine, 2002; Fernández-Huerga, 2010). Although it cannot be directly assumed that all workers in self-employment or in small firms are precarious, the high incidence of workers in these situations constitute evidence for an increased precarization of the labor market (Schippers,

2019). This will be contrasted with the waged workers in larger firms, which would constitute the "primary sector" of the segmented labor markets. The distinction between "primary" and "secondary" sectors is used for analytical purposes, but while precariousness is indeed pervasive in the "secondary" sector, it is also present in the "primary" sector.

Brazil and Mexico share the characteristic of a significant presence of workers in self-employment and in small firms. Approximately one in four workers in Mexico and one third of Brazilian workers were self-employed in 2012. Nevertheless, the proportion of self-employed in Brazil increased 3.3 p.p. thereafter, whereas the proportion of autonomous Mexican workers only slightly increased, but with the absolute number of self-employed increasing (Table 1). In this sense, self-employment remained an important strategy to counteract unemployment both in Brazil and in Mexico.

Likewise, both countries have always had a large share of its working population employed in small firms (Salas, 2002; Santos *et al.*, 2012). Nearly 15% of Brazilian and 30% of Mexican workers were in businesses with five employees or less between 2012 and 2019. The recent trend in small-firm employment shows that in Brazilian labor market the participation of workers in small firms stagnated. This figure slightly decreased in Mexico, although the absolute number of workers in small firms has grown in this country (Table 1).

In conclusion, in Brazil, the 2014 – 2017 economic recession led to increasing unemployment, which lead workers to search for alternatives mainly in self-employment. In the meanwhile, the Mexican economic stagnation did little to change the country's labor market structure. However, it is necessary to look deeper into the labor market structure to see the different conditions in which Brazilian and Mexican workers are inserted in the segmented labor market.

	2012			
	Brazil		**Mexico**	
	Count	Share (%)	Count	Share (%)
Primary sector	**40.040.977**	**51,10**	**20.059.953**	**45,00**
Workers in small firms	*11.743.332*	*14,99*	*13.563.239*	*30,43*
Self-employed workers	*26.574.819*	*33,91*	*10.954.317*	*24,57*
Secondary sector	**38.318.151**	**48,90**	**24.517.556**	**55,00**
Total workers	**78.359.128**	**100,00**	**44.577.509**	**100,00**
	2019			
	Brazil		**Mexico**	
	Count	Share (%)	Count	Share (%)
Primary sector	**39.431.468**	**47,85**	**22.988.830**	**46,50**
Workers in small firms	*12.282.497*	*14,91*	*14.165.860*	*28,66*

Self-employed workers	*30.687.136*	*37,24*	*12.281.162*	*24,84*
Secondary sector	**42.969.633**	**52,15**	**26.447.022**	**53,50**
Total workers	**82.401.101**	**100,00**	**49.435.852**	**100,00**

Table 1: Workers by labor market segment: 2017-2019. Source: National Household Sample Survey (PNAD – Brazil) and National Survey of Occupation and Employment (ENOE – Mexico).

In general, among those in self-employment and in small firms exist a prevalence of workers inserted into job positions with any one of each precarious dimensions stated earlier. In other words, labor market structures with higher presence of self-employed and small firms usually are more precarious labor markets (Schippers, 2019). For the analysis, we highlighted three dimensions of precarity: the lack of access to social security, atypical working hours, and insufficient income. To get a more complete picture, the following tables aim at demonstrating that the division between primary and secondary sectors provide a way for distinguishing workers in terms of precariousness dimensions.

Table 2 shows that, regarding access to social security, Brazil and Mexico face distinct realities. Most of the Brazilian working population has access to social security, while few Mexican workers have. Nevertheless, the division between "primary" and "secondary" sectors shows that, in both countries, workers in the "secondary" sector lack access to a higher extent, being the situation worse in Mexico.

	2012			
	Brazil		**Mexico**	
	Access	No access	Access	No access
Primary sector	**86,00**	**14,00**	**74,57**	**25,43**
Workers in small firms	*34,08*	*65,92*	*7,36*	*92,64*
Self-employed workers	*26,84*	*73,16*	*0,41*	*99,59*
Secondary sector	**29,06**	**70,94**	**4,25**	**95,75**
Total workers	**58,16**	**41,84**	**35,17**	**64,83**
	2019			
	Brazil		**Mexico**	
	Access	No access	Access	No access
Primary sector	**86,78**	**13,22**	**76,75**	**23,25**
Workers in small firms	*37,15*	*62,85*	*6,73*	*93,27*
Self-employed workers	*31,81*	*68,19*	*0,26*	*99,74*
Secondary sector	**33,34**	**66,66**	**3,73**	**96,27**
Total workers	**58,91**	**41,09**	**37,39**	**62,61**

Table 2: Share of workers by access to social security: 2012 – 2019 (%). Source: National Household Sample Survey (PNAD – Brazil) and National Survey of Occupation and Employment (ENOE –Mexico).

Similarly, Table 3 reveals that Brazilian workers seem better off in terms of working hours, with more people working typical hours (between 40 and 48 hours a week). Waged workers in Brazil usually work typical hours; within these workers, the share in larger firms is bigger. On the other hand, autonomous workers usually do atypical journeys. In the Mexican "secondary" sector atypical hours are pervasive, with a significant share of workers in small firms working less than 40 or more than 48 hours a week.

	2012			
	Brazil		**Mexico**	
	40-48h	Less than 2 MW	40-48h	Less than 2 MW
Primary sector	**34,39**	**66,84**	**48,48**	**40,56**
Workers in small firms	*53,16*	*68,30*	*69,26*	*61,20*
Self-employed workers	*62,85*	*78,37*	*76,57*	*59,75*
Secondary sector	**59,88**	**75,28**	**72,53**	**60,55**
Total workers	**46,85**	**70,97**	**61,69**	**51,43**
	2019			
	Brazil		**Mexico**	
	40-48h	Less than 2 MW	40-48h	Less than 2 MW
Primary sector	**31,37**	**60,22**	**47,54**	**62,27**
Workers in small firms	*47,68*	*71,90*	*68,00*	*77,70*
Self-employed workers	*59,88*	*75,83*	*76,28*	*72,92*
Secondary sector	**56,39**	**74,71**	**71,84**	**75,48**
Total workers	**44,42**	**67,78**	**60,34**	**69,17**

Table 3: Share of workers by weekly hours worked and wage level: 2012 – 2019 (%). Source: National Household Sample Survey (PNAD – Brazil) and National Survey of Occupation and Employment (ENOE –Mexico).

In terms of income level, Table 3 shows that, in Brazil, most of the working population receives less than two times the minimum regulatory wage, with the situation being particularly negative for workers in small firms and in self-employment. Nonetheless, even workers in large firms – roughly 60% in 2019 – receive below two minimum wages, revealing the pervasive nature of low payment in the country. In Mexico, most of the workers in large firms received more than two minimum wages[1] in 2012, but the scenario was reversed in 2019, with the majority receiving below this threshold. The evolution is not favorable for the workers in small firms and the self-employed either, with the participation in low income increasing throughout the period.

Brazilian minimum wage exerts a major impact into the wage setting among distinct workers categories, acting as a "lighthouse" for lower wages which tend to follow it closely (Souza and Baltar, 1979; Rani *et al*., 2013). In this context, even though the minimum wage appreciation policy put on course during the 2000s was responsible for the significant increase of all lower wages in the period (Souen, 2013), most workers kept earning wages close to the

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[1] In terms of purchasing power parity, Brazilian minimum wage is significantly larger than the Mexican one, so a direct comparison between the countries is not precise. In 2012, the Brazilian minimum wage as 387 USD PPP, while the Mexican minimum wage was 169 USD PPP. In 2019, the figures were 438 USD PPP and 255 USD PPP for Brazil and Mexico, respectively.

minimum. Mexico, on the other hand, has faced stagnant minimum wages during the same period, which contributed for the considerable number of workers receiving wages above it in 2012. From 2012 onwards, the income situation for Mexican workers deteriorated to the point that almost 70% received less than two minimum wages in 2019, with an increase of 18 p.p. with respect to 2012. One thing to notice is that, in both countries, workers in self-employment and in small firms are more likely to receive less than two minimum wages.

In a broad sense, data shows that small firms and self-employment usually are the *loci* of precarious work. But this is not restricted to them, with large firms encompassing a significant share of work positions with precarious characteristics. In that sense, we can spot a link between the labor market conditions and segmentation and, further, the evolution of precariousness. It is possible to estimate, in a first moment, the likelihood of a new worker to enter a precarious position in the labor market or of a transition of a current employee to a more precarious job.

Thus far, the labor market conditions and structure in Brazil followed a path of increasing unemployment along with rising precarious alternatives to it, mainly self-employment and work in small firms. On the other hand, the Mexican economy managed to keep unemployment at lower rates, but with a worsening of its occupational structure towards more precarious insertion.

The last explanatory factor for the incidence of precarious work is the system of labor regulation. In this sense, Brazil and Mexico are similar in two aspects. In the case of the State as an employer, that is, employing the workers precariously or not, both countries' public jobs are usually not precarious, although outsourcing in public sector is increasing in the last years (Druck *et al.*, 2018). Similarly, both countries have been facing a decrease in labor organization and collective bargaining in the recent years, revealed in the decrease of unionization (Campos, 2017).

The most important aspect to underline is the role of the State as a legislator. This is especially important because we want to see which were the impacts on the labor market precariousness of the 2012 labor reform in Mexico, and which might be the consequences of the 2017 labor reform in Brazil. Both Mexican and Brazilian reforms affected, in some sense, one or more of four dimensions which make labor more precarious. The main difference is that Mexico did the reform in 2012, so its effects are already perceived in the country's labor market, whereas in Brazil the reform happened in 2017 and the effects may not be yet fully capture by the data available. Our hypothesis is that Brazil will follow the Mexican path once the effect of the reform begins to unfold fully.

The underlying objectives of these types of reforms are to reduce labor costs, flexibilize hiring and dismissal conditions, and increase the participation of new employment forms (e.g., temporary, home office, short-term). In the following we present how these labor legislation reforms opened the possibility for an increase in precariousness by highlighting how could they affect the dimensions of precarious work. Table 4 sums up the main changes in the 2012 Mexican and 2017 Brazilian labor reform, in an effort of linking these changes to each dimension of labor market precariousness.

Dimension	Mexico	Brazil
Degree of certainty of continuing work	Regulation of new working forms: Outsourcing Trial periods Initial capacitation contracts Seasonal jobs	Regulation of new working forms: Outsourcing Intermittent contracts Partial contracts Autonomous work Temporary jobs
Control over work	Individualization of the wage relation; New promotion criteria, reducing the role of seniority; Multitasking	Increasing working hours
Social protection	Easiness of declaring a strike as illegal; Reduction of the sickness payment.	Limitation to the access to the Labor Justice; Increasing the role of the individual agreements
Income level	Wage by productivity	Reducing of overtime payment; Payment by productivity; Increasing of the flexible part of wages.

Table 4: Main changes in labor reforms and their relation with labor market precariousness dimensions. Source: elaborated by the author.

In terms of degree of certainty of continuing work, both labor reforms decrease it through the regulamentation of fixed term employment contracts, such as trial contracts in Mexico and intermittent contracts in Brazil, among others. With respect to control over work, in Mexico, the regulation of multitasking, that is, the possibility of the employers to assign workers complementary tasks to its original job description reduces their control over work, while in Brazil worker have come to lose control through the flexibilization of the working hours.

The greatest menace to workers' protection in Brazilian labor reform came from the reduction of the possibility of judicialization of labor disputes. In Mexico, on the other hand, the attack on workers' capacity of protect themselves came from new criteria to define a strike as illegal. Finally, in both cases, the whole idea of the reforms is to reduce wage costs, but specifically, in Mexico, the reduction of back pay[2] and of sick pay, together with the possibility of hourly wages, are the major threats to the reduction of labor related income directly, whereas in Brazil, unstable income may come by increasing the importance of non-fixed parts of wages, such as payment by productivity and individual wage bargain, which might open space to a wage reduction through negotiation, surpassing even collective agreements.

3. Labor market precariousness index

3.1. Approaches on measuring labor market precariousness

The literature on indices for measuring precariousness may be divided in two approaches. The first approach is what we call "simple sum". In that stream of methodology, the researcher first defines the variables which comprise the idea of precarity. After that, she defines thresholds to consider individuals as precarious and assigns new values to the variables (the value of 1 if the individual has the precarious characteristic, and 0, otherwise). The results from the "simple sum" methodology usually fall into two extreme index values, where the individual is considered precarious either if she has at least one of the characteristics or if she holds all the characteristics simultaneously. This can be achieved either by summing up the values, thus the index ranges from 0 - absence of precarious characteristics - to k, being k the number of dimensions of precarity taken into consideration, or by multiplying the values, which yields a further binary index (1, if precarious, 0, otherwise). The justificative for the "simple sum" approach is that one cannot properly weigh the importance of each dimension to precariousness. In other words, all variables would be equally important in explaining precarity.

Gallo (2003) proposes an index in its simplest form, that is, considering as precarious a worker that does not have access to social security and/or is employed with a non-permanent contract. Dealing with this binary "index", the author was able to fit a logistic regression to evaluate how socio-demographic and economic-productive factors affect precarity in the Mar del Plata region in Argentina. Campos (2010) broke down precarity into three dimensions -

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[2] Here, "back pay" refers to wages and benefits an employee claims she is entitled to receive after a wrongful dismissal. Previous to the reform, the worker had the right to receive the salary corresponding to the dismissal day up to the day the Labor Court promulgates the sentence. The reform limited the value to the amount corresponding to 12 months.

fixed-term contracts, insufficient income, and absence of protection - to build up a state-level index for Mexico between 1995 and 2010 which consisted in the sum of the proportion of workers with the precarious characteristics in each state.

With a set theory-based approach, Olsthoorn (2014) proposes two integrated indicators for specific aspects of precarious employment: one for income insecurity (using wages, supplementary income, and unemployment benefits as variables) and another for job insecurity (using non-permanent contract and duration of unemployment as variables). The approach consisted in, first, define thresholds for each one of the variables. The worker is deemed precarious regarding the income if he is below the thresholds for each one of the characteristics, and similarly for the precarity regarding the job. Further, it integrates both indicators to build up a labor precariousness index for the Dutch labor market and test his hypothesis through probit models.

Finally, García-Pérez *et al.* (2017) propose a new methodology to measure precarious employment using Spanish data from 2006 to 2010 with a multidimensional approach. They used as dimensions of precariousness the earning of low wages, presence of fixed-term contracts, and part-time work. The authors first defined a threshold for each dimension, attributing 1 if the individual possesses the precarious characteristic, and 0 otherwise. Then, they sum up the values to construct a second threshold in two ways, that is, the individual will be precarious only if he either has all the characteristics (index equals to three) or he has at least one of them (index equals to one). The justificative for this approach is that it allows to measure both the incidence - that is how many precarious jobs exist - and the intensity - the average number of precarity dimensions - by group.

The second stream of literature deals with indices constructed by some sort of weighted sum. Likewise, the researcher must, at first, define the variables composing the precariousness index. After that, he must define the weights. This can be done in two ways: it can be either defined through some already calculated parameter (like the inverse of the population not having that specific precarious characteristic, such as in Mora (2012)); or through factorial analysis. In the factorial analysis, the factorial weight of each variable with respect to some of the factors are used as weights. The assumption is that one or more factors represent the precarity as a latent variable, and, thus, the factorial weights can be seen as the correlation of that dimension with the precarity, thus allowing for a meaningful weight.

Building a bridge between the two streams of literature, Mora (2012) analyzes some of the main methodological problems originated from an attempt of building a multidimensional precariousness index. Using the Mexican National Survey of Occupation and Employment for

the second quarter of 2008, the author compares the results of three strategies to build a precariousness index. After defining the variables composing the index and the respective thresholds, the author proposes three indices: one consisting in the arithmetic mean of the variables; another one using the inverse of the proportion of the working population which do not have the precarious characteristic as weight; and, finally, a factorial analysis, with the factorial weights being used to build the index. The results for the indices were similar, which led the author to opt for the simpler one (the arithmetic mean).

Similarly, Oliveira (2006) applies factorial analysis to construct an index based on the factorial weight of each of the dimensions taken into account - all of them related to the degree of job security - with respect to the first statistical factor (the factor capturing the highest shared variance among the observed variables included in the factorial analysis) obtained to study the evolution of precarious jobs among Mexican young workers in the year 2000.

3.2. Methodology

Our main objectives in this paper are to evaluate how did labor precariousness evolved in Brazil and Mexico throughout the period between 2012 and 2019 and to test whether labor market conditions, structure, and labor legislation affect precarity. We propose a labor precariousness index in order to provide a way to measure the incidence of precarious work in aggregate terms, i.e., how precarious is a specific sector of the labor market. In our case, we are going to consider federated state-level data (Salas, 2014).

The index will be constructed through principal component analysis (PCA). PCA is a statistical technique that distributes the variation of a multivariate dataset across components, allowing for the explanation of the variability of the observed data through a reduced number of linear combinations (Jolliffe, 2011).

Our problem is that we cannot measure labor precariousness directly. In fact, precarity is a "rather elusive concept, difficult to capture in survey questionnaires" (Kiersztyn, 2017). Thus, we assume it is a latent (unobserved) factor underlying a set of variables. In other words, we suppose the existence of the unobserved variable "labor precariousness" which consists in the explanatory variable of several observed indicators (Kolenikov *et al.*, 2004).

The observed indicators are proxies for degree of certainty of continuing working, control over work, social protection, and sufficient income, found in the databased. Considered simultaneously, they compose the definition of precarious work we are aiming at. They must attend three criteria to be considered into the composition: (i) they must be theoretically related to the latent variable; ii) they must be highly correlated among themselves, but not perfectly

correlated; iii) the variables cannot be more correlated with any other variable (latent or not) than with precariousness. Further, we must assess the measure of sampling adequacy for factor analysis for each variable through the Kaiser-Meyer-Olkin (KMO) test. The KMO test returns values between 0 and 1, where values closer to 1 indicates a more adequate set of variables for factor analysis (Hair et al., 2006).

After defining the k variables composing the index, we are going to compute an aggregate (state-level) index. We will derive this index using principal component analysis (PCA) (Hair et al., 2006). Using these k variables, we define for each i state of the country at the time $t = 1$ a vector of size k, in which each coordinate is the proportion of the working population that has the k-th characteristic previously defined, centered to mean zero and scaled to unit variance. Then, we compute the correlation matrix A_k among the variables under analysis:

$$A_k = \begin{bmatrix} 1 & \rho_{12} & \cdots & \rho_{1k} \\ \rho_{21} & 1 & \cdots & \rho_{2k} \\ \vdots & \vdots & \ddots & \vdots \\ \rho_{k1} & \rho_{k2} & \cdots & 1 \end{bmatrix} \tag{1}$$

Where all the diagonal elements equal one - for the correlation of a variable with itself equals one - and the elements outside the diagonal are the correlations between the variables. By solving $\det(A_k - I) = 0$ -- where I is the identity matrix of dimension k – we find the eigenvalues λ. The index will be constructed through the dot product of the eigenvector associated with the highest eigenvalue of the covariance matrix (i.e., the one which captures loss of the data variance), and the vector of variables $\boldsymbol{x}$. This is called the first principal component of the covariance matrix. The procedure grants k principal components, the first accounting for the maximum possible proportion of the variance of the variables studied, the second accounting for the maximum of the remaining variance, and so on. Because the eigenvectors are orthogonal among themselves, the principal components are uncorrelated (Hair et al., 2006).

We are going to work with the assumption that the first factor we obtain, i.e., the first principal component, express the labor precariousness. The first factor accounts for most of the variance of the data. Since the data is composed by observations on the four dimensions of precariousness, the factor accounting for the most of this variability is a reasonable index for labor precariousness[3].

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[3] Appendix A shows the results for the KMO test and a summary of the first principal components factor loadings and share of variance explained for both countries.

In order for the procedure to be robust, all variables must be positive correlated with this first principal component, that is, they should be all positive correlated with the "labor precariousness". In the PCA, the elements of the eigenvectors correspond to the correlations between each variable with the corresponding component to which that eigenvector belong (Hair et al., 2006). For that reason, we are going to use the elements of the eigenvectors as weights to build the index, as shown in Equation (2).

Thus, for each state i for a time period t we define an index such that:

$$PRE_{it} = \boldsymbol{a}'_{it}\boldsymbol{x}_{kit} = a_{11}x_{1it} + a_{12}x_{2it} + \cdots + a_{1k}x_{kit} = \sum_{j=1}^{k} a_{1j}x_{jit} \qquad (2)$$

In this sense, we ensure that the variables which are more correlated with the first principal component – summarizing the "labor precariousness" – get more weight to the final index. With this approach, we are able to evaluate the importance of each variable for explaining the degree of precariousness in each country weighted by its correlation with the labor precariousness.

Although several factors may influence the individual variables composing the index, the positive correlation of the factor loadings with the first principal component assures that any impacts on a single variable is transmitted to the index, weighted by its relative importance in the composition. Furthermore, the choice of variables is theoretically grounded on Rodgers' (1989) definition of precariousness which bases the concept adopted here. Since it is a multidimensional concept, PCA comes up with a proper statistical measure to synthetize the phenomenon dimensions into a single number (Fávero and Belfiore, 2017). Finally, given this is precisely our goal, the choice of the first principal component –as the index of labor precariousness – have both the features of being able to be condensed into a single number, and of capturing the single most important source of variability in data, thus reducing the loss of information usually carried out by indexes.

To make comparisons over several periods, we use the first eigenvector (corresponding to the largest eigenvalue) estimated for the time and repeat the process for the subsequent years. The idea is to make the index comparable through time in relation to some base year, in order to see if precariousness decreased or increased since this determined period. Therefore, we are assuming that the correlation between the indicators and the labor precariousness do not change significantly through time, especially since we are working with a short period of analysis.

3.3. Data

The data sources used to calculate the index are the National Survey of Occupation and Employment (Encuesta Nacional de Ocupación y Empleo, ENOE) for Mexico and the Continuous National Household Sample Survey (Pesquisa Nacional por Amostra de Domicílios Contínua, PNAD) for Brazil. Both are quarterly surveys, but we are using the respective data which allowed us to reconstruct the databases as annual surveys. Thus, for the Mexican base, we are using the data for the first quarter, which encompass the amplified survey. For the Brazilian case, we are using the first interview of each household in each year. We chose this approach due to lower variability among quarters in the same year, adding not much information to the analysis.

Both databases contain information about individuals and households and can be disaggregated by state. It also contains information on demographic and occupational characteristics. The following shows the elements which compose the definition of precarious work and the corresponding variable in the Brazilian and Mexican databases (Table 5):

Dimension of precarity	Description	Precarity condition
Degree of certainty of continuing work	Jobs with a short-time horizon have a higher risk of job loss	Temporary contract; non-registered for Brazil; unwritten contract for Mexico
Control over work	Control over working conditions, wages, or the pace of work	Less than 40 or more than 48 hours
Social protection	Extension of workers' protection by law, collective organization or customary practice	Lack of access to social security
Income level	Low income jobs may be associated with poverty and insecure social insertion	Wage per hour less than two minimum wages

Table 5: Elements composing the definition of precarious work. Source: elaborated by the author based on Rodgers (1989).

The first variable relates to the uncertainty in continuing work, the most common proxy being temporary contracts. Here, we are also going to consider workers with temporary contracts as those with a higher uncertainty in continuing work. Nevertheless, we add to the definition the workers without labor registration in Brazil and without written contracts in Mexico, because the two mechanisms provide a degree of security of continuing work in these countries once they imply in higher dismissal costs for the employers.

The second variable - working hours in a week - tries to approximate the workers' capacity of controlling the pace of the work. The worker is considered to possess a precarious

characteristic if he usually works fewer than 40 or more than 48 hours a week because it deviates from the typical weekly working hours. The third variable deals with the absence of social protection. We are considering the lack of access to social security as a precarious characteristic because it means that the worker will not be able to fully access some welfare benefits, such as health or pensions (depending on the country). Finally, the fourth variable corresponds with insufficient income and it is considered under a precarious condition the worker that receives an hourly wage less than two times the country's minimum wage per hour.

3.4. Results

The idea is to analyze how the precariousness evolved in Brazil and Mexico during the period between 2012 and 2019 in a federated-state basis. The index allows the comparison within countries through the time period, but not a direct comparison between the countries, that is, the index is not suitable for between countries comparison. The countries' surveys have sufficiently different approaches for constructing the variables, so a comparative analysis should be seen with caution. Besides, the factor loadings from the factorial analysis are specific for each database. For this reason, the analysis is restricted to compare how the precarity evolved, that is, if it increased or decreased in the states within each country.

Table 6 shows the results for the KMO test and a summary of the first principal components factor loadings and share of variance explained for both countries. The table shows that the datasets have good measures of sample adequacy, being suitable for principal component analysis. Furthermore, the first principal components capture most of the variance for both countries, which indicates that they may be adequate summary measures for labor precariousness given the dimensions previously defined.

Dimension	Variable	Measure of sampling adequacy[i]		First principal component[ii]	
		Brazil	Mexico	Brazil	Mexico
Degree of certainty of continuing work	Temporary contract; non-registered for Brazil; unwritten contract for Mexico	0,76	0,63	0,5160	0,5199
Control over work	Less than 40 or more than 48 hours	0,98	0,86	0,4716	0,4946
Social protection	Lack of access to social security	0,76	0,64	0,5164	0,5437
Income level	Wage per hour less than two minimum wages	0,96	0,63	0,4946	0,4352
Overall sample adequacy[iii]		0,84	0,68		
Standard Deviation[iv]				1,8990	1,7474
Proportion of variance[v]				0,9015	0,7634

Table 6: Principal component analysis summary: i) Kaiser-Meyer-Olkin criterion with respectives meaures of sampling adequacy; ii) factor loadings of the first principal component (FPC); iii) overall measure of sample adequacy; iv) standard deviation of the FPC; v) proportion of total variance explained by the FPC.

For Brazil, Fig. 2 shows the evolution of the precariousness index from 2016 (the immediate year previous to the reform) and 2019 to assess post-reform outcomes. The results below show a division between the Northern, less developed states, with higher precariousness indices, and the Southern, more developed states, that present relatively lower precarity (Fig. 2). Figure 3 shows that most of the Brazilian states presented an increase in the precariousness index, which lead to an increase for the weighted average index value for the country as a whole.
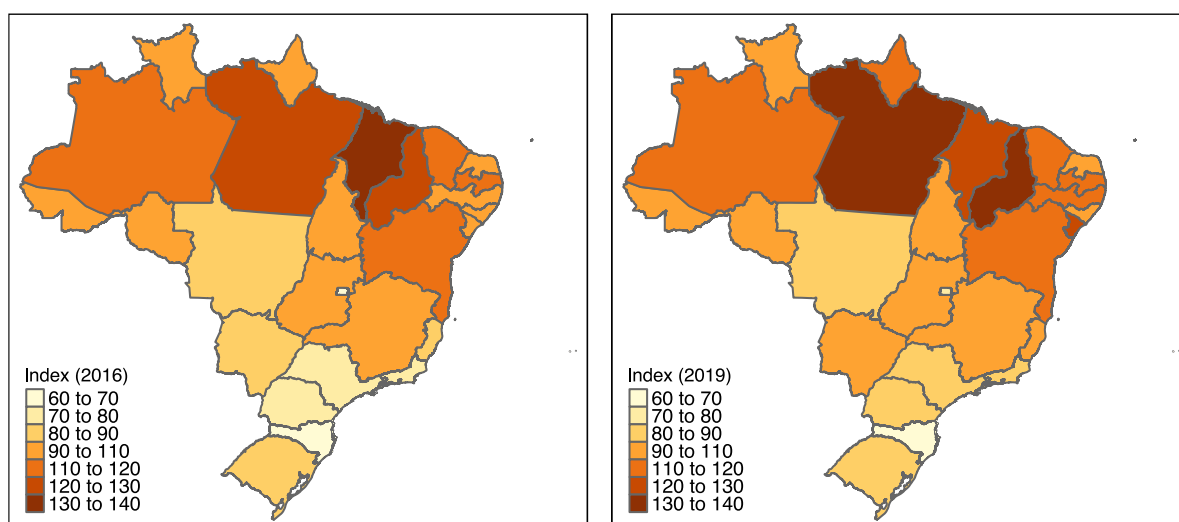

Figure 2: Labor precariousness index by state – Brazil: 2016 and 2019. Darker colors indicate states with higher precariousness indices.
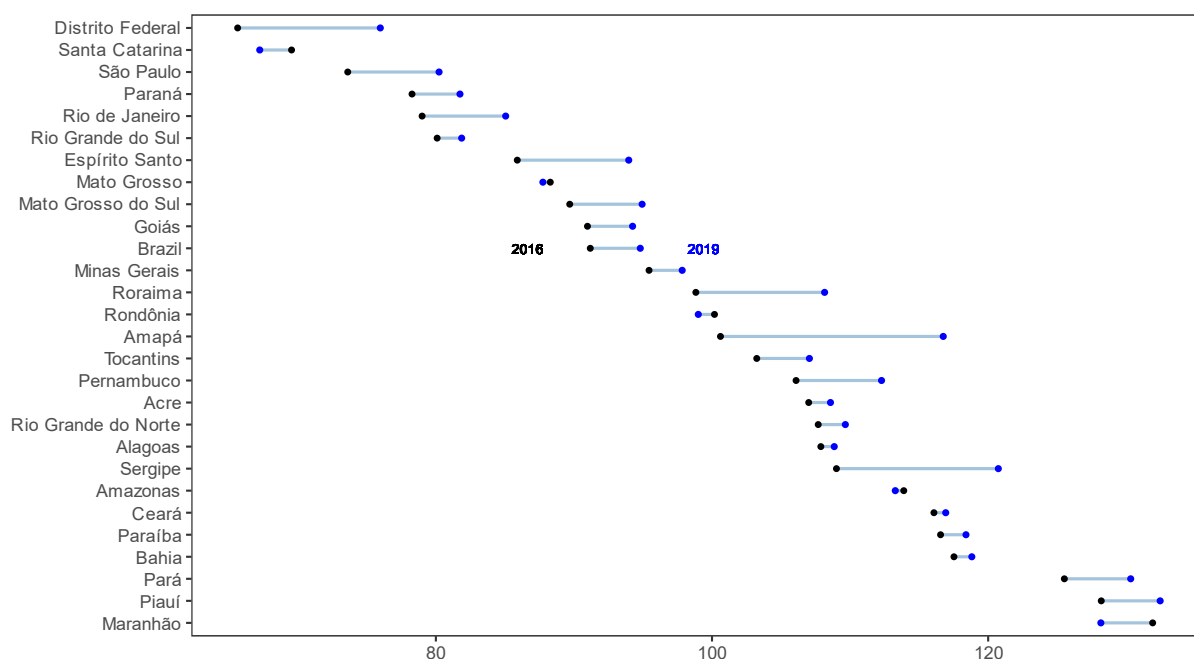
Figure 3: Labor precariousness index by state – Brazil: 2016 (black) and 2019 (blue). Rightmost values indicate states with higher precariousness indices.

Table 7 displays the index values for all years between 2012 and 2019 and includes the variation from 2012 to 2016 and from 2016 to 2019. Prior to the 2017 reform, Brazilian states were able to sustain a decreasing precariousness index even in a context of economic stagnation and unemployment. One possible explanation may be that although labor market conditions were not favorable, the framework of labor legislation was still able to protect workers from precarity.

However, 2017 seems to be a turning point for the Brazilian labor precariousness index lowering trend. While the weighted average index for the country decreased 5,63% in 2016 with respect to 2012, the variation between 2016 and 2019 was of 3,97%. That is to say, precariousness has been steadily increasing since 2017, with some states even being worse than 2012.

It is important to highlight the increase in the precariousness index in two regions. An important characteristic of the Distrito Federal – where the Brazilian capital is situated – is the high incidence of public servants, occupation commonly associated with security. However, the index increased 15,74% since 2016, raising the concern on how the reform may have been affecting the public jobs. The second region to be highlighted is São Paulo, the country's richest state, and where most of the jobs are based. In the state, the index escalated roughly 6 units in 2017 with respect to 2016 and has risen to the point that 2019 figure is greater than the one in

2012. The results reveal that neither the state with high prevalence of public jobs nor the country's most developed regional labor market are far from increasing precariousness.

Federated State	2012	2013	2014	2015	2016	2017	2018	2019	2012-2016	2016-2019
North										
Acre	109,53	112,00	106,66	108,69	107,00	112,25	109,43	108,58	-2,31%	1,47%
Amapá	107,54	104,94	104,21	108,66	100,61	110,02	102,77	116,75	-6,44%	16,03%
Amazonas	110,91	111,11	110,82	109,84	113,89	112,43	112,23	113,27	2,68%	-0,54%
Pará	127,41	127,30	123,61	127,68	125,52	128,05	125,97	130,32	-1,48%	3,83%
Rondônia	105,32	100,15	96,82	97,70	100,18	97,42	97,61	99,01	-4,88%	-1,17%
Roraima	104,34	105,99	104,70	105,36	98,83	101,27	102,57	108,15	-5,29%	9,44%
Tocantins	112,36	115,94	105,30	102,43	103,24	104,66	104,10	107,05	-8,12%	3,69%
Northeast										
Alagoas	109,18	111,26	107,52	111,29	107,88	110,34	105,91	108,85	-1,19%	0,90%
Bahia	124,97	120,85	117,81	118,75	117,52	119,83	119,74	118,82	-5,96%	1,10%
Ceará	122,46	121,03	119,99	118,52	116,07	116,65	117,99	116,93	-5,21%	0,74%
Maranhão	133,10	131,35	133,55	135,82	131,91	130,47	128,80	128,16	-0,89%	-2,84%
Paraíba	126,66	126,49	119,70	117,94	116,55	116,54	118,06	118,39	-7,98%	1,58%
Pernambuco	112,58	108,78	103,57	106,11	106,09	110,95	108,86	112,28	-5,77%	5,84%
Piauí	133,75	128,31	129,39	131,30	128,19	128,73	126,59	132,46	-4,16%	3,33%
Rio Grande do Norte	116,01	115,88	111,53	108,67	107,69	111,94	110,68	109,66	-7,17%	1,82%
Sergipe	123,35	118,30	113,31	113,50	109,01	114,49	113,93	120,74	-11,62%	10,76%
Southeast										
Espírito Santo	93,49	90,54	87,56	88,47	85,90	90,03	94,90	93,97	-8,12%	9,40%
Minas Gerais	98,20	96,68	94,31	95,50	95,44	98,13	99,86	97,84	-2,81%	2,52%
Rio de Janeiro	86,87	82,95	78,78	78,91	79,00	84,56	84,26	85,06	-9,05%	7,66%
São Paulo	77,88	74,85	72,53	73,84	73,62	79,59	82,91	80,23	-5,47%	8,99%
South										
Paraná	85,51	80,94	77,39	79,16	78,27	83,22	82,31	81,75	-8,46%	4,44%
Rio Grande do Sul	87,30	85,57	80,66	81,62	80,09	81,91	83,33	81,87	-8,26%	2,22%
Santa Catarina	74,81	71,67	66,76	69,31	69,55	70,70	69,18	67,24	-7,04%	-3,31%
Central-West										
Distrito Federal	71,89	71,92	68,71	67,81	65,64	72,56	74,85	75,98	-8,68%	15,74%
Goiás	97,15	95,50	90,14	90,58	90,98	95,29	94,17	94,25	-6,35%	3,59%
Mato Grosso	93,98	91,07	87,25	92,45	88,29	89,37	90,44	87,75	-6,06%	-0,61%
Mato Grosso do Sul	94,62	91,77	91,89	93,97	89,70	92,16	90,15	94,94	-5,20%	5,84%
Brazil	**96,62**	**93,99**	**91,08**	**92,39**	**91,18**	**94,70**	**95,35**	**94,80**	**-5,63%**	**3,97%**

Table 7: Labor precariousness indices for Brazilian states and weighted average for the country 2012-2019. Rightmost columns show variation from 2012-2016 and 2016-2019 in percent.

The situation is similar for the Mexican states. In a situation analogous to the Brazilian one, the historically less developed states – in the Mexican case, the South – present a higher level of precariousness, while the Northern states – more developed, bordering the United States

– possess significantly lower precariousness indices (Fig. 4). Additionally, almost all Mexican states presented an increase in the precariousness index since the implementation of the reform in 2012 (Fig. 5).
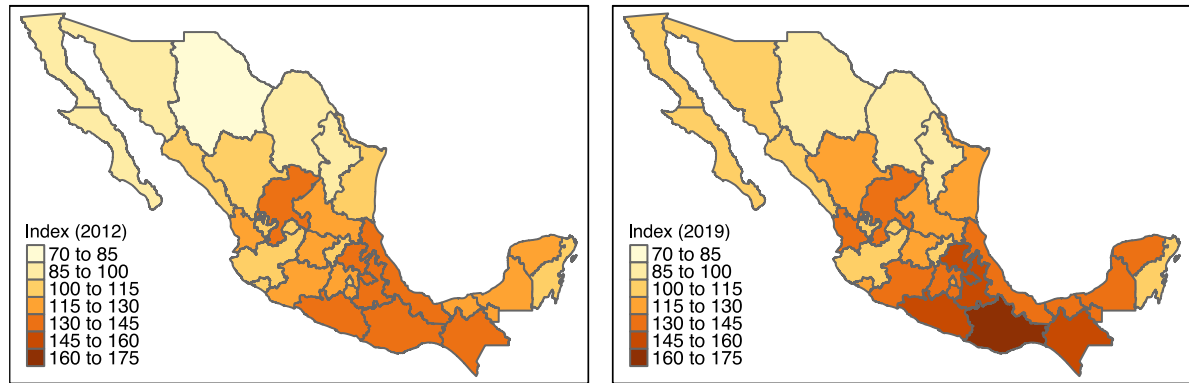
Figure 4: Labor precariousness index by state – Mexico: 2012 and 2019. Darker colors indicate states with higher precariousness indices.
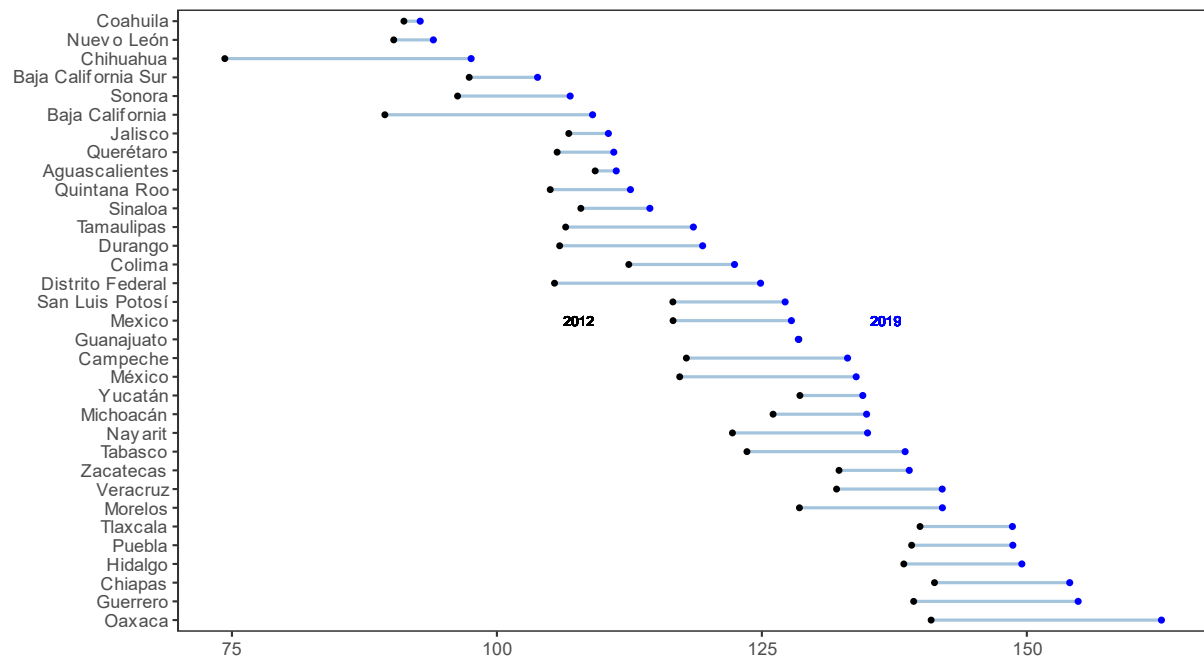
Figure 5: Labor precariousness index by state – Mexico: 2012 (black) and 2019 (blue). Rightmost values indicate states with higher precariousness indices.

Table 8 shows how the increase in precariousness has been pervasive among Mexican states since 2012. The weighted average index for the country increased 9,58%, a noteworthy result when comparing to Campos (2010) estimation of precarity reduction in Mexico from 1996 to 2008, with a slight increase in the 2009/2010 biennial.

Northern state displayed the highest increase in precariousness, reaching even a 31,27% of increment in Chihuahua in the period. Among central states, Distrito Federal – where Mexico City is located – presented the highest increase in the index, of 18,44%. Again, the situation is

parallel to the Brazilian one, where precariousness seems to rise even in the richest states and in where federal entities are located.

Federated State	2012	2013	2014	2015	2016	2017	2018	2019	2012-2019
North									
Baja California	89,43	87,54	88,41	87,54	90,77	86,10	95,83	109,03	21,92%
Baja California Sur	97,39	95,03	99,31	98,26	98,33	94,18	100,94	103,84	6,63%
Chihuahua	74,33	80,87	78,90	79,54	76,03	75,59	85,22	97,57	31,27%
Coahuila	91,23	86,69	79,44	82,08	85,79	87,42	91,20	92,76	1,69%
Durango	105,92	108,76	110,83	112,69	113,14	110,25	121,38	119,41	12,74%
Nuevo León	90,26	86,71	86,38	84,19	83,41	82,99	89,06	94,00	4,14%
Sinaloa	107,92	108,45	109,67	109,90	109,95	106,39	111,33	114,43	6,03%
Sonora	96,29	89,20	97,79	96,32	99,09	99,53	104,18	106,91	11,03%
Tamaulipas	106,49	103,77	103,34	100,73	104,02	106,03	109,29	118,54	11,32%
Center									
Distrito Federal	105,44	109,52	110,12	114,29	111,78	113,40	119,81	124,88	18,44%
Guanajuato	128,49	129,78	127,63	131,76	131,75	132,05	130,11	128,44	-0,04%
México	117,25	119,04	119,01	122,69	122,71	123,79	130,14	133,90	14,20%
Morelos	128,54	131,30	132,40	133,61	136,26	135,99	139,24	142,04	10,50%
Querétaro	105,68	104,07	103,39	106,65	105,10	108,91	109,98	111,03	5,06%
San Luis Potosí	116,60	118,96	117,90	120,43	121,90	121,47	123,07	127,19	9,08%
Zacatecas	132,28	129,67	130,24	132,26	135,17	133,46	137,31	138,91	5,01%
West									
Aguascalientes	109,27	110,36	109,45	107,14	107,24	108,48	111,96	111,26	1,82%
Colima	112,44	111,96	114,06	115,61	116,04	115,84	119,51	122,42	8,87%
Guerrero	139,32	139,17	141,31	142,26	142,28	140,95	150,07	154,84	11,14%
Jalisco	106,78	107,47	103,48	103,64	103,36	104,75	108,79	110,52	3,50%
Michoacán	126,06	126,11	130,83	132,22	134,56	134,39	135,34	134,88	7,00%
Nayarit	122,22	120,67	122,17	125,42	122,84	126,51	129,86	134,97	10,43%
East									
Hidalgo	138,39	139,12	136,76	137,19	137,81	146,86	147,36	149,53	8,05%
Puebla	139,13	140,11	140,52	143,08	143,03	144,43	147,97	148,68	6,86%
Tlaxcala	139,92	139,28	140,30	143,54	142,40	142,67	143,81	148,64	6,23%
Veracruz	132,05	129,83	131,47	135,30	137,63	138,10	142,79	142,02	7,55%
South									
Campeche	117,88	118,16	118,87	117,40	121,68	125,66	132,18	133,08	12,90%
Chiapas	141,29	140,93	145,29	143,29	144,72	147,89	153,57	154,05	9,03%
Oaxaca	140,97	144,66	144,78	148,44	151,51	153,16	159,50	162,70	15,42%
Quintana Roo	105,03	104,99	102,50	104,88	104,72	107,64	109,32	112,60	7,21%
Tabasco	123,59	122,45	123,74	121,84	124,15	130,13	133,87	138,52	12,08%
Yucatán	128,59	127,21	123,65	123,88	123,61	124,17	131,65	134,52	4,61%
Mexico	**116,62**	**116,93**	**117,13**	**118,52**	**119,00**	**119,74**	**124,52**	**127,79**	**9,58%**

Table 8: Labor precariousness indices for Mexican states and weighted average for the country 2012-2019. Rightmost column shows variation from 2012-2019 in percent.

Therefore, we have seen two paths in the evolution of precariousness in both countries. Mexican situation reveals that ever since 2012 precariousness has rising significantly among the states. For Brazil, however, the turning point seems to be 2017, since before the country's regions were facing a declining index, but from 2017 onwards precariousness has increased. Remarkably, 2017 represents the implementation of Brazilian labor reform. The data here presented thus raise the question on which is the role of the labor reforms in those countries in explaining the upward evolution behavior of the index.

Concluding remarks

The study of precarious work in Latin American should not have the same starting point as in Europe. In other words, while in Europe it is commonly assumed the dismantling of the standard employment relationship as the starting point of the precarization process, in Latin America labor markets were already populated by precarious workers since the beginning. The number of workers in precarious jobs have always been large in Latin America, so it is not a new process in the region.

In this paper, we followed the concept proposed by Rodgers (1989) who defined as "precarious" the work with high risk of dismissal in the short-run, low employee control, absence of social protection, and insufficient income. These dimensions were approximated by, respectively, having a temporary, unregistered, or unwritten contract, working less than 40 or more than 48 hours per week, lack of access to social security, and per hour income less than two times the minimum regulatory wage.

From these variables we proposed the creation of a labor precariousness index using the statistical technique of principal component analysis. The use of this technique was important because it addresses the multidimensional characteristic of the phenomenon of labor precariousness. We assumed the first principal component as "labor precariousness" and used the correlation between the variables and this factor as weights in the construction of the index.

Our objective was to see how labor precariousness evolved in Brazil and Mexico between 2012 and 2019. Results showed that precariousness has decreased in Brazilian states from 2012 to 2016 but has been increasing since the implementation of the reform in 2017, whereas it has increased in Mexican states since 2012. We raise the possibility that the 2012 Mexican labor reform negatively affected this country's labor market, turning it more precarious than the Brazilian one, which was not reformed until 2017, but that began to descend

into more precariousness since the implementation. These results may raise a concern about the future of Brazilian labor market with the 2017 labor reform, since it contains similarities in terms of objectives with the Mexican reform. From the evidence showed so far, we begin to question to what extent the Brazilian reform has influenced the increasing precariousness level in the country.

Paper 2 – Flexibility and precariousness: an assessment of the 2012 Mexican labor reform through an agent-based model

Introduction

The task of measuring labor market precariousness in underdeveloped countries goes through the challenge of recognizing the multidimensionality of the phenomenon and, consequently, the way of capturing it. The next step – and the objective of this paper – is to propose a model to study the main drivers of the evolution of work precariousness.

The previous paper of the thesis tackled the multidimensionality challenge by proposing and evaluating a labor market precariousness index. It summarizes into a single number the four constitutive dimensions of a precarious labor market: reduced degree of certainty of working, low worker control over job characteristics, scarce (or absent) social protection, and insufficient income. The results show that, between 2012 and 2019, precariousness increased among Mexican regional labor markets. The implementation of a labor reform in 2012 may be at the heart of the explanation of these results. The reform was targeted at, among other things, reducing dismissal costs and "flexibilizing" wages. Further, the results revealed that, other things being equal, the level of precariousness has been increasing in the Mexican states since the implementation of the reform in 2012.

Nevertheless, the exploratory analysis is not able to completely evaluate the share of the increase in the labor market precariousness due to the 2012 labor reform. When the objective is to estimate the distinct impacts on a response variable of changes in institutional parameters, even the econometric approach might be limited.

Considering the data required (and unavailable) to advance the analysis based on an empirical approach, the problem we propose to investigate in this paper is how a more flexible institutional setup may have affected the country's level of precariousness by proposing a theoretical model. To achieve this objective, we develop an agent-based model (ABM). ABMs are computer-simulated models containing a set of heterogenous agents acting autonomously in a decentralized context, representing a complex evolving system (Tesfatsion, 2003). ABMs are theoretical models based on (economic) agents' interactions, at the micro level, which give rise to macro-level emergent properties, without the requirement of strict rational behavior and long-run equilibrium conditions (Heckbert *et al.*, 2010). This micro-macro approach is able to characterize both bottom-up and top-down feedback mechanisms and allows for path-dependent trajectories to develop over time. ABMs have been frequently used for policy

evaluation purposes, offering an adequate framework for the analysis of qualitative change and transformation processes (Fagiolo and Roventini, 2017).

Our goal is to evaluate the role of labor market flexibility in explaining the rising precariousness in Mexico. To achieve it, we build a model focused on the dynamics of a flexible labor market. The hypothesis is that the flexibility carried out by the reform led to the rise of precariousness in Mexico in the 2010s. The model keeps track of worker-level wage, time in employment (tenure), and the associated distributions, important elements to evaluate labor market precarity. It can also robustly reproduce the main stylized facts of this market and the macroeconomy.

We propose the use of an Agent-Based Model (ABM) as a theoretical model of the reality to guide the investigation of the problem of how labor reforms may affect precariousness in the labor market. ABMs permit the modeling of the heterogeneous behavioral patterns of individual agents and allow the analysis on how their interactions develop into emergent properties in the aggregate level (Namatame and Chen, 2016). In other words, agent-based models allow researching the microfoundations of emergent phenomena observed only at the aggregate level (Siegfried, 2014).

We created a model is loosely based on the labor-augmented "Schumpeter meeting Keynes" (K+S) model (Dosi, *et al.*, 2019a). It works as a laboratory for the analysis of institutional regimes and policies, taking into account the main changes in labor legislation reforms and evaluating how they may impact precariousness. Our model has the advantage of being a simpler model but still able to robustly reproduce a significant number of stylized facts of the modern economies and labor markets. Besides, it explicitly accounts for termination fee payments by the firms, an important element of worker income in developing countries and a significant cost to firms.

The general results from models like K+S suggest negative effects of labor market flexibilization policies (Dosi, *et al.*, 2017; Dosi, *et al.*, 2018; Dosi, *et al.*, 2019b). However, to the best of our knowledge, the effects on labor market precariousness, as proposed here, have not been studied yet using the ABM approach.

The working hypothesis here is that, in more flexible labor markets, firms became more prone to fire workers to accommodate production to changes in expected demand. This may lead to two sets of impacts. First, by increasing turnover, it directly influences average time in unemployment. Then, indirectly, together with the flexibilization of wages, it affects wage level and income distribution. The increasing number of unemployed workers pushes down the wage level and expands inequality.

Besides this introduction, this paper is organized as follows. Section 1 contains a literature review on agent-based models of the labor market. It provides a general review on the methodology and why ABMs are convenient to explain complex phenomena. Further, it lists the main findings of these models concerning precariousness-related aspects. Section 2 describes the model itself, with the timeline of the events and the behavioral equations. Section 3 and 4 discusses the results, first presenting an empirical validation of the model, with the reproduction of some key stylized facts, and, then, highlighting the relation between flexibilization and precariousness in Mexico. The paper ends with some conclusions.

1. Literature review

In the year of 1995, Mexico faced an economic crisis, with a fall of 6,2% of the GDP. The subsequent years were of a fast economic recovery related with the external sector. After the North American Free Trade Agreement (NAFTA) in 1994, the Mexican economy became even more strongly linked to the U.S. The strong growth of the United States in the mid-90s stimulated the recovery of Mexico's economy (Ramirez, 2003).

The country shifted from an oil-based economy to a productive structure centered around export-oriented manufactories. NAFTA, together with a devaluation of the domestic currency, allowed for a higher participation of Mexican products in North American markets, in such way that the external sector was the main driver of economic growth at the time (Moreno-Brid *et al.*, 2005)

The expansion of manufacture linked to exports were accompanied by productivity gains, mostly through capital investment. Consequently, the low-skilled workforce previously allocated in the traditional manufacture was expelled to the service sector (Cárdenas, 2015). The modernization of the productive structure caused, as a consequence, the displacement of a significant portion of the labor force to informality, mostly present in services (Aleman-Castilla, 2006).

Mexico's economic activity followed a sustained, albeit low, growth path during the 1990s and beginning of the 2000s. The growth pace and the productive structure were insufficient to generate enough formal employment to absorb the surplus labor force (Loría and Salas, 2019). At the same time, the intensification of migratory flows of Mexican workers to the US allowed for low unemployment rates (Canales, 2002).

In the mid-2000s, Mexican manufacture lost space to China in the world commerce. In the aftermath of the 2008 crisis, a spike in the unemployment rate was followed by an increase

if informal employment, along with a slowdown of the economic growth (Cárdenas, 2015). In this context, the dominant diagnosis for the slow growth relied on the low labor productivity due to high informality (Loría and Salas, 2019). The ultimate cause for informality was to be found on the labor legislation, full of rigidities that were considered to prevent the generation of formal employment in the context of the modernization of the productive structure (Cervantes and Acharya, 2013).

Policy makers at that time came up with a reform of the labor law as a solution for the problem of informality, low productivity, and slow economic growth. The reform of the Federal Labor Law came into being in 2012 with the following goals: i) increase flexibility in hiring and firing to adequate the labor market to the new forms of production and contracts; ii) regulate trial and initial training contracts to promote formal employment and the entrance of young people into the labor market; iii) limit penalties suffered by the firms in wrongful dismissal and restrain access of workers to Labor Justice, to stimulate hiring, reduce litigious disputes and diminish the economic burden for firms in the act of firing (Romero and Acevedo, 2017).

The supporters of the reform expected that the decrease in informality would lead to labor productivity gains. By increasing the productivity, the economy would accelerate the economic growth. This, alongside with the regulation of new work forms, would increase formal employment and tackle informality, inducing the economy to a virtuous cycle (Fernández and Lima, 2015).

Criticism on the reform centers around the hypothesis that flexibility does not assure formal employment generation. On the contrary, flexibilization would open space for precarious forms of insertion in the labor market, because, even though the new work forms are regulated as "formal" they do not assure good job positions (Loría and Salas, 2019).

In fact, after 2012, Mexico saw an increase in temporary workers that, in turn, reduced the average time in employment (Mendoza-González *et al*, 2020). Workers were uncapable of achieving enough experience, and the prevalence of temporary positions reduced the certainty in continuing working. Together with a limitation of the access to the Labor Justice, and the reduced social protection after wrongful termination, workers faced a weakening of their bargaining power in the labor market, explaining real wages effective decline (Moreno-Brid *et al.*, 2019).

Therefore, throughout the 2010s, Mexico experienced a combination of low but steady economic growth with reduced unemployment rates. However, informality and temporary contracts played increasingly prominent roles in employment generation (Cervantes and

Acharya, 2013). Insertion into a labor market with such characteristics may be considered more precarious than in the previous period, since the jobs available featured higher insecurity and flexibility, together with lower wages and social protection (Romero and Acevedo, 2017).

One difficult task is to isolate the effects of the flexibilizing reform from other endogenous and exogenous factors affecting the labor market during the same period. To tackle this problem, the construction of a theoretical model would be useful to understand the underlying mechanisms of the labor market, disentangling the multiple cause-consequence processes. By building a theoretical model of a flexible labor market – an abstraction of the Mexican one after the reform – we could shed light on the role of flexibility in generating the labor market outcomes above mentioned. For this purpose, we have a range of possible methodologies and approaches.

The conventional labor market models usually consider that an aggregate matching function, acting as a mechanism linking workers looking for jobs to firms demanding labor force, determines real wages and employment level in a context of uncoordinated, time-consuming, and costly trade for both sets of agents (Blanchard and Diamond, 1989). Search frictions and asymmetric information may prevent idle workers to match open job posts, resulting in equilibrium unemployment. Increases in the efficiency of the matching function could speed up the labor market capacity for fully matching workers and vacancies, eventually pouring into full-employment equilibrium (Pissarides, 2000).

Indeed, firms searching for workers, on the one side, and workers searching for jobs, on the other, constitute the labor market. However, either set of agents can be hardly described as atomistic particles taking decisions based on rational expectations under complete information, seeking to globally maximize the respective objective functions subject to the matching mechanism (Lawson, 2003). Rather, they may be more likely described as heterogenous individual agents endowed with bounded rationality, locally interacting in a limited information environment (Simon, 1990). Models which consider such evolving and complex nature of economics have generated more powerful explanatory results than traditional ones (Fagiolo and Roventini, 2017). From the complex networks of interaction between dissimilar agents depicted by the former models, reasonably coherent aggregate (macro) properties emerge (Kirman, 2010). Therefore, upper-level phenomena, like work precariousness, may be understood as stemming from the interactions of the labor market agents (Kalleberg, 2009). Furthermore, such models can be empirically validated against the main stylized facts of the labor market. Most importantly, since the ultimate goal of a model is to assess causality, that is, to see how labor reforms may impact precariousness, ABMs provide a "robust identification of causal

mechanisms" (Boero *et al.*, 2015) by means of evaluating simulated histories which differ among themselves only by changing specific parameters or agents' behavioral rules.

To the best of our knowledge, few ABMs in the literature take into account labor market specific features, relegating it to a position of a byproduct of the macroeconomic dynamics. Ballot (2002) proposed an ABM reproducing the dynamics of the labor market when agents change or learn in response to shocks, such that market coordination may evolve in an endogenous way. The authors' goal was to display "a modeling technique that enables the labor economist to derive macro consequences from micro foundations in a rigorous way, while developing a rich underlying micro behavior, taking heterogeneity into account" (Ballot, 2002, p. 54).

Fagiolo *et al.* (2004) proposes a model which sought to provide a joint explanation of what the authors called the "most important aggregate regularities" of the labor market, namely, "[i] the process through which firms and workers meet (…), [ii] how this matching process affects wage setting and employment dynamics (…), and [iii] the extent to which unemployment and output interact over the business cycle". The authors showed the usual aggregate regularities may emerge from the decentralized interactions of uncoordinated and heterogenous agents with adaptive behavioral adjustments. These aggregate regularities – represented by the Beveridge, Wage, and Okun curves – emerge from the interplay between labor and product markets, while changes in institutional, behavioral, and technological parameters provide changes in the shape and shifts on these curves, in line with empirical evidence. When building the labor market agent-based model, the ability of reproducing these aggregate regularities becomes important to validated it.

In the "Schumpeter meeting Keynes" family of models[4] (starting with Dosi *et al.*, 2010), Dosi *et al.* (2017a) compare different labor market institutional regimes to determine how the mechanisms of wage determination, firing, labor protection, and productivity growth impact on labor market and macroeconomic dynamics. More specifically, the authors seek to investigate changes posed by a more "flexible" labor market, once it might lead to a faster inter-firm reallocation of labor, on the one hand, but, on the other, it would render the economic system more fragile. Results show that flexibilization harmfully affects not only workers – by increasing inequality, easing termination of employment, and reducing social protection – but also the entire economy, once it raises the likelihood of crises and dumps economic growth.

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[4] For a full summary of the results of these models, see Dosi *et al.* (2019a).

Following its predecessor, Dosi *et al*. (2017b) analyzed the effects of a regime change towards labor market flexibilization. The introduction of flexible labor institutions increased unemployment and inequality, in both functional and personal terms, while worsening overall macroeconomic performance. Feedbacks arise from flexibility to inequality and unemployment.

Still on the question of labor market reform, Dosi *et al.* (2018) compare the effects of supply-side active labor market policies – such as promoting job search matching, and providing training for the unemployed – with passive ones, like unemployment benefits (automatic stabilizer). In this set-up, supply-side polices alone cannot fully mitigate the negative effects of flexibilization reform. Rather, sustaining aggregate demand, by means of the maintenance and expansion of unemployment benefits, may more effectively counteract inequality rise and preserve economic growth.

To sum up, the three models from Dosi et al. point out to the conclusion that labor reforms aimed at flexibilizing the labor market may have, as unintended consequences, the worsening of macroeconomic performance and the increase of inequality. Nevertheless, none of the works directly address the issue of labor market precariousness.

In order to be validated, an ABM must be able to reproduce relevant stylized facts from the economic system it models (Fagiolo *et al.*, 2019). Table 1 summarizes a literature review of the stylized facts our model seeks to reproduce.

Index	Stylized Fact
SF1	Right-skewed market-share distribution
SF2	Tent-shaped firm output growth distribution
SF3	Productivity heterogeneity among firms
SF4	Right-skewed wage distribution
SF5	Wage distribution peak around a minimum income in developing countries
SF6	Right-skewed time in employment
SF7	Turbulent GDP growth rate and endogenous crises
SF8	Persistent unemployment
SF9	Wage curve
SF10	Okun curve
SF11	Beveridge curve

Table 1: Stylized facts the model aims at reproducing. Source: elaborated by the author

(SF1) Right-skewed market-share distribution: Coad (2009), in a review of the literature on the firm size distribution, demonstrates that the positively skewed nature of aggregate firm size distribution is a robust finding, on most of the empirical literature.

(SF2) Tent-shaped firm output growth distribution: as shown by Coad (2009), recent empirical research observed that the Laplace distribution provides a good fit for the empirical distribution of firms' growth rates, distinguishable by its "tent shape" in a log-log plot. Bottazzi and Secchi (2006) suggest that positive feedback mechanism assures that previously successful firms are more likely to capture growth opportunities, thus concentrating growth in a few firms.

(SF3) Productivity heterogeneity among firms: Bartelsman and Doms (2000), using a longitudinal micro-level data, document the dispersion of productivity among firms and the persistence of their differentials through time. According to Nelson (1981), large and persistent productivity differentials arise due to differences in the outcomes of technological intents.

(SF4) Right-skewed wage distribution: Neal and Rosen (2000) show that the shape of wage distribution tends to be skewed to the right and display long (right) tails, with the top percentile of earners accounting for a disproportionate share of total earnings. Explanations of this behavior vary, from differences in individuals' initial endowments, learning abilities, and investment in skills.

(SF5) Wage distribution peak around a minimum income in developing countries: When analyzing the distribution of wages for several developing countries, Rani *et al.* (2013) showed distribution spikes around the minimum regulatory wage. Even though these countries present a large informal sector, with employers not legally abiding by labor legislation, earnings distribution reveals that a stipulated minimum income provides a reference for employers and workers in the wage setting process.

(SF6) Right-skewed time in employment: Neumark *et al.* (1999) show that tenure distribution is right-skewed and this pattern is consistent over the years, in such way that long periods in the same job becomes infrequent.

(SF7) Turbulent GDP growth rate and endogenous crises: One of the key empirical regularities of modern capitalist economies is that output does not grow steadily, but in turbulent cycles through time (Goodwin, 1967). The cycles are recurrent, but not periodic (Stock and Watson, 1999).

(SF8) Persistent unemployment: Ever since Keynes (1936), involuntary unemployment has been acknowledged as a characteristic feature of the capitalist economies. The state of expectations governs effective demand which, by its turn, determines the level of employment. Therefore, full employment is rarely achieved.

(SF9) Wage curve: Blanchflower and Oswald (1990), among others, found evidence for a negative relation between unemployment and wage, the so-called wage curve, on both US and UK data. A higher unemployment rate would mean a greater number of workers trying to enter

the labor market. Entrant workers would accept lower wages, decreasing the rate at which wages would grow.

(SF10) Okun curve: Huang and Yeh (2013) found evidence of an Okun curve for the US states and a panel of countries, whereas Moraes and Feistel (2015) provided estimates for Brazil. Based on the work of Okun (1970), the Okun curve states an interplay between labor market and economic activity, posing a negative relation between output growth and unemployment growth. A decrease in unemployment means an increased absorption of labor force by firms. The faster the number of employed workers increases, the higher is the output growth rate.

(SF11) Beveridge curve: Elsby *et al.* (2015) provides a survey on the literature concerning the Beveridge curve, highlighting the empirical findings for the US, and selected developed countries. The Beveridge curve postulates a negative relation between the rate of unemployment and the rate of vacancies, defined in terms of total employment. The rationale behind it is that if the economy presents a higher number of vacancies, it is easier for a worker to find a job, thus reducing unemployment rate.

2. The model

We build an agent-based model with heterogenous firms and workers interacting in both goods and labor markets, acting under a boundedly rational set of behavioral rules. The model inherits some of "Schumpeter meeting Keynes" (K+S) (Dosi *et al.*, 2019) family of models' features and resembles in many aspects the Competitive regime proposed there. The objective is to setup a model able to reproduce the stylized facts of the contemporary developing economies for further evaluation of the impact of institutional changes, introduced by labor market reforms, on work precariousness.

In the present model, firms freely adjust (hire and fire) workforce to accommodate for the planned production. Wages are flexible and indirectly respond to unemployment and market conditions. Firms have the final say in determining wages through an asymmetric bargaining process. Finally, unemployment benefits act as an income cushion for unemployed workers, and a floor for wages. Figure 1 shows the model schematic structure.
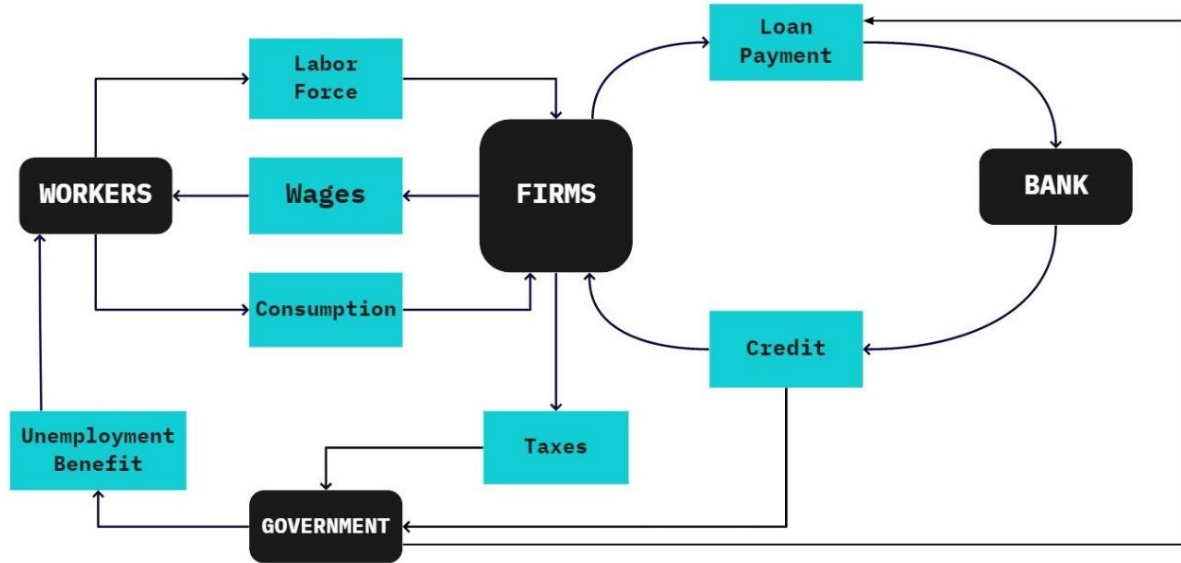
Figure 1: The model schematic structure displaying the interactions among the agents

The model is composed by two sets of agents: a fixed number of F_0 consumer-good firms (denoted by the subscript j), and of L_0 workers (subscript ℓ), in addition to a single bank, and a monopolist capital-good (machines) supplier. Firms produce a homogenous, non-durable good under a Leontief production function considering only labor and capital as inputs. They invest in R&D to increase productivity and set desired production based on (myopic) expected demand, determining the mix of labor and capital needed to achieve the desired level of production. Consequently, aggregate desired production determines labor and capital demands. At this point, firms may decide to invest to increase the stock of capital – delivered just in the next period by a monopolist machine supplier with perfectly elastic supply – and to adjust vacancies to fulfill the required labor force for production.

Workers search for jobs only when unemployed and, then, randomly apply to (potential) vacancies, with probability proportional to firm size. Job applications line up in queues at firms. Each firm offers a wage sufficient to satisfy enough workers in the own queue, according to the labor demand, if any. Labor market clearing in not ensured: some or all firms may not get all the workers they desire and workers may remain unemployed even if there are still open vacancies at firms they did not apply to. Workers' wage requests are determined by previous individual labor market status. Such asymmetric bargaining favors firms in the wage determination. Although incurring in dismissal costs, firms may freely fire to accommodate production changes.

At each period, all workers hired by a given firm receive equal wages. Heterogeneity arises due to tenure, as workers remaining at the same firm receive wage increases linked to productivity gains, and unemployed workers may accept lower wages to be reallocated. For this reason, as a worker remains in the same job, her future termination fee also increases.

After the matching and hiring takes place, firms produce and sell production to workers in the goods market. Effective production may be lower than the desired level if there is labor shortage at firms. Unemployed workers receive unemployment benefits from the government. Fired workers also receive a termination fee paid by firms.

Prices of goods are determined by each firm applying a mark-up over costs. Mark-ups evolve according to the market share dynamics: growing firms increase mark-ups, and vice versa. Market shares, in turn, are determined by a replicator equation (Metcalfe, 1994). Therefore, the more competitive firms expand and the less fit ones shrink, and eventually leave the market. Competitiveness is inversely correlated with price and unfilled demand.

Firms with near-zero market share or bankrupt leave the market. The number of firms is fixed, so that any leaving firm implies a new one entering. Entrants enter with the most productive technology available and capital stock (output capacity) equals to the average size of the market.

The government levies taxes on firms' profits and pays unemployment benefits. The bank lends money to firms and government and receives interests and amortizations. Firms have access to the credit market at a fixed interest rate whenever profit-to-debt ratio is above a fixed threshold. Government and bank do not employ workers.

In each simulation period, the following events take place, in order:

1. Firms plan desired production based on expected demand and current capital stock;
2. Firms define the desired labor and (next-period) capital stock;
3. Job-seeking workers send applications to firms;
4. Wages are set and job vacancies are partly or totally filled;
5. Firms pay wages and termination fees, and government pays unemployment subsidies;
6. Goods market opens and market shares are allocated according to the relative competitiveness of the firms;
7. Firms compute profits, pay taxes and repay (part of) debts;
8. Exit takes place and new firms enter;
9. Aggregate variables are computed and the cycle restarts.

Innovation, expectations and planning of the production

Each period firms will invest a share ι of its available funds in R&D. Firms have a probability proportional to its real R&D expenditure (in wage terms) of having a successful technological update. If R&D is successful, the firm will draw a value $b \in [b_1, b_2]$ from a Beta distribution which will increase the new productivity A_t:

$$A_{j,t} = \left(1 + b_{j,t}\right)A_{j,t-1} \tag{1}$$

Firms plan the desired production $Q_{j,t}^d$ based on the expected demand $D_{j,t}^{e\,5}$:

$$D_{j,t}^e = D_{j,t-1} + N(0, \sigma_R^2) \tag{2}$$

We assume that the (myopic) expected demand at time t is a function of the demand actually faced by the firm at time $t-1$, that is, the firm expects to maintain its current level of demand plus a random component drawn from a normal distribution with zero mean and variance σ_R^2.

Firms will try to hire the amount of labor necessary to satisfy its desired production $Q_{j,t}^d$, constrained by the available stock of capital $K_{j,t}$, and the firm total factor productivity $A_{j,t}$ (the current "technology"):

$$Q_{j,t}^d = \min\left(A_{j,t}K_{j,t}, D_{j,t}^e\right) \tag{3}$$

$L_{j,t}^d$ is the number of laborers the firm needs to hire to the (constrained) desired production $Q_{j,t}^d$:

$$L_{j,t}^d = \frac{Q_{j,t}^d}{A_{j,t}} \tag{4}$$

Therefore, labor demand may be constrained by both expected demand and available capital stock. Firms employ the minimum number of workers to achieve the desired production.

Investment decision

The desired capital stock for $t+1$ is a function of the expected demand $D_{j,t}^e$ in t. If the desired production is constrained by the capital stock, firms will invest to increase it. Desired capital stock for next period is thus defined as:

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[5] For the sake of simplicity, we choose to not consider the role of inventories. In the context of this model, the consumption-good produced is perishable; therefore, if not sold, the production vanishes, and stock is not formed.

$$K_{j,t+1}^d = \frac{D_{j,t}^e}{A_{j,t}} \tag{5}$$

The expansion investment (physical units), if any, is defined by the difference between the desired capital and the current stock, accounting for the constant capital depreciation rate δ:

$$EI_{j,t} = \max\left(K_{j,t+1}^d - (1-\delta)K_{j,t}, 0\right) \tag{6}$$

Investment must be financed either with internal or external funds, depending on the firms' accumulated profits and access to credit. Investment expenditure (monetary terms) is given by:

$$I_{j,t} = p_t^k \, EI_{j,t} \tag{7}$$

We assume a totally elastic market for capital. The price of capital evolves according to the variation in total capital purchases:

$$p_t^k = p_{t-1}^k \left(\psi_1 \frac{\sum_{j=1}^{F_0} I_{j,t-1}}{\sum_{j=1}^{F_0} I_{j,t-2}} \right), \qquad \psi_1 \in [0,1] \tag{8}$$

Firms can invest the amount $I_{j,t}$ provided they have enough money or access to credit to finance it. If so, the stock of capital is updated:

$$K_{j,t} = (1-\delta)K_{j,t-1} + EI_{j,t-1} \tag{9}$$

The new stock of capital is enough to fulfill the desired production given the current productivity $A_{j,t}$, because the capital demand by the firms considers replacing depreciation and adds the difference necessary to achieve the desired output.

Searching, matching, hiring, and firing

At any time, firms offer the number of vacancies $v_{j,t}$ to satisfy desired labor demand $L_{j,t}^d$ minus the number of workers already employed:

$$v_{j,t} = L_{j,t}^d - L_{j,t-1} \tag{10}$$

Firms fire workers if vacancies $v_{j,t}$ are negative. Each unemployed worker has a parameter a_ℓ which defines the number of firms she applies to. Let $\mathcal{F}_{\ell,t} = \{F_1, \dots, F_{a_\ell}\}$ be the application set of the worker ℓ at time t. Firms in set $\mathcal{F}$ are drawn randomly with probability proportional to market shares. Thus, each firm j will form a queue, that is, a set of workers that applied to it.

When applying for jobs, workers post the requested wages to firms. Wage requested $w_{\ell,t}^{r}$ is a function of workers' previous status. Let w_t^u be the value of the unemployment benefit the worker would receive if unemployed, $w_{\ell,t-s}$ the wage received at time $t - s$ (last time employed). Worker requested wage $w_{\ell,t}^{r}$ is:

$$w_{\ell,t}^{r} = \max\left(w_t^u, w_{\ell,t-s}\right) \tag{11}$$

The wage offered by firms $w_{j,t}^{o}$ is the minimum wage that satisfies enough workers in the queue, according to $w_{\ell,t}^{r}$ and $v_{j,t}$. Therefore, it is the highest wage among the $v_{j,t}$ cheapest (available) workers in the queue. The set of workers the firm can hire is given by the workers in its queue that satisfy $w_{j,t}^{o} \geq w_{\ell,t}^{r}$. The set of workers actually hired is a subset of this set because workers apply to more than one firm at a time. So, a firm will hire $v_{j,t}^{f}$ workers, the number of fulfilled vacancies, $v_{j,t}^{f} \leq v_{j,t}$. Therefore, $L_{j,t} = L_{j,t-1} + v_{j,t}^{f}$ is the total of labor available to firm j at time t, and $\mathcal{L}_{j,t}$, the corresponding set of workers.

Employed-worker wage raises proportionally to changes in firm productivity:

$$w_{j,t} = w_{j,t-1}\left(\psi_2 \frac{A_{j,t}}{A_{j,t-1}}\right), \qquad \psi_2 \in [0,1] \tag{12}$$

As firms pay the same wage $w_{j,t}^{o}$ to all workers hired in t, intra-firm wage inequalities arise only because of tenure. Firms produce with labor only, so total cost is the sum of the wages paid in each period. For the workers hired at t, firms pay wages at $t + 1$, so (wage) cost at t is:

$$W_{j,t} = \sum_{\ell \in \mathcal{L}_{j,t-1}} w_{\ell,t-1} \tag{13}$$

One key novelty of the model is the explicit inclusion of firing costs, or the payment of a termination fee by firms. Let $\mathcal{E}_{\ell,t}$ be the set of time periods in which worker ℓ was employed (at the same firm) up to time t, and $w_{\ell,t}$, the wage she received at each time t. The termination fee is as a fraction λ, a parameter, of his past wages:

$$TF_{\ell,t} = \begin{cases} \lambda \displaystyle\sum_{t \in \mathcal{E}_{\ell,t}} w_{\ell,t}, & \text{if fired in } t \\ 0, & \text{otherwise} \end{cases} \tag{14}$$

Let $w_{\ell,t}^{PV}$ be the present value of workers' ℓ future wages (in perpetuity) at time t assuming a fixed interest rate r and current wage $w_{l,t}$:

$$w_{\ell,t}^{PV} = \frac{w_{\ell,t}}{r} \tag{15}$$

To decide which workers to fire, firms compute the net firing cost $NFC_{\ell,t}$ as the difference between the present value of future wages and the termination fee.

$$NFC_{\ell,t} = w_{\ell,t}^{PV} - TF_{\ell,t} \tag{16}$$

Assuming workers have homogeneous skills, the higher the NFC of a worker, the more beneficial is to the firm to fire her. Therefore, firms order workers by decreasing value of NFC and fire workers up to the amount desired, excluding workers whose NFC's are negative.

Effective production and effective demand

Given the amount $L_{j,t}$ and $K_{j,t}$ of labor and capital employed, effective production is computed according to a Leontief production function:

$$Q_{j,t} = A_{j,t} \times \min(L_{j,t}, K_{j,t}) \tag{17}$$

Considering the wages to be paid and effective production, firms compute unit cost:

$$c_{j,t} = \frac{W_{j,t}}{Q_{j,t}} \tag{18}$$

Firms set the consumer-good price applying a mark-up over unit cost:

$$p_{j,t} = (1 + mk_{j,t})c_{j,t} \tag{19}$$

Mark-up evolves with respect to the firm's previous market shares according to parameter $\eta \in [0,1]$:

$$mk_{j,t} = mk_{j,t-1}\left(1 + \eta\frac{ms_{j,t-1} - ms_{j,t-2}}{ms_{j,t-2}}\right) \tag{20}$$

The sale of individual firm production is determined by aggregate demand. We assume that workers fully consume their income[6]. For this reason, aggregate desired consumption is the sum of wages earned by employed workers[7], unemployment benefits and termination fees earned by the unemployed.

Let L_{t-1} be the number of employed workers in period $t - 1$, $\mathcal{L}_t$, the set containing these workers, and L^s, the total workforce size – a fixed parameter – such that $L^s - L_{t-1}$ is the total unemployment in $t - 1$. The desired aggregate consumption C_t^d depends on the demand of both employed and unemployed workers, plus the termination fees TF_t:

$$C_t^d = \sum_{\ell \in \mathcal{L}_t}\left(w_{\ell,t-1} + TF_{\ell,t}\right) + w_t^u(L^s - L_{t-1}) \tag{21}$$

Effective consumption is bounded by the total production of the firms (in money terms):

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[6] This restriction does not affect aggregate results, as long as the workers' propensity to consume of income is higher than that of capitalists, which is zero in our case (Dosi *et al.*, 2018).
[7] Capitalist consumption is zero and profits are fully reinvested.

$$C_t = \min\left(C_t^d, S_t\right), \qquad S_t = \sum_j p_{j,t}\, Q_{j,t} \tag{22}$$

Firm competitiveness $E_{j,t}$ is a function of price $p_{j,t}$ and unfilled demand $ud_{j,t}$[8]:

$$E_{j,t} = -p_{j,t} - ud_{j,t} \tag{23}$$

The weighted-average competitiveness is computed as:

$$\overline{E}_t = \sum_j E_{j,t}\, ms_{j,t-1} \tag{24}$$

Firms' expected market shares evolve through a "quasi" replicator dynamic:

$$ms_{j,t}^e = ms_{j,t-1}\left(1 + \chi \frac{E_{j,t} - \overline{E}_t}{\overline{E}_t}\right), \qquad \chi > 0 \tag{25}$$

Effective consumption C_t is distributed among the firms based on expected market shares $ms_{j,t}^e$. Each firm tries to sell the production corresponding to its expected market-share, that is, a fraction $ms_{j,t}^e$ of C_t. Each worker tries to consume her disposable income fully. The cycle goes on iteratively until either all demand is satisfied, leaving an excess supply, or all supply is sold, remaining an unsatisfied demand. Therefore, actual demand faced by the jth firm at time t is given by $D_{j,t}$ resulting from this process, and the corresponding effective market share is:

$$ms_{j,t} = \frac{D_{j,t}}{C_t} \tag{26}$$

Profits, tax, net worth and loans

Firms' gross profits $P_{j,t}$ are given by:

$$P_{j,t} = p_{j,t}\, D_{j,t} - W_{j,t} - TF_{j,t} \tag{27}$$

Where $p_{j,t}D_{j,t}$ are the sales, $W_{j,t}$ are the wages paid, and $TF_{j,t}$ are the termination fees paid. Firms pay tax on gross profits, where ϕ is the tax rate:

$$Tax_{j,t} = \begin{cases} \varphi\, P_{j,t}, & \text{if } P_{j,t} > 0 \\ 0, & \text{otherwise} \end{cases} \tag{28}$$

Firms take credit to invest or when they face a negative cashflow. If the firm takes credit, it will be recorded as a loan in its balance sheet. Let $B_{j,t}$ be the open balance of unpaid loans contracted up to time $t - 1$. At each period, firms repay part of the debt $LP_{j,t}$ until fully amortizing it after τ periods:

---

[8] We normalize (relative) prices and unfilled demands such that $p_{j,t}, ud_{j,t} \in [0, 1]$.

$$LP_{j,t} = B_{j,t} \left(r + \frac{1}{\tau} \right) \tag{29}$$

Where r is the fixed interest rate the bank charges on all loans. Firms can take credit down to a profit-to-debt ratio of Λ higher than a stipulated threshold ω:

$$\Lambda_{j,t} = \frac{P_{j,t}}{B_{j,t}} \tag{30}$$

Evolution of a firm net worth $NW_{j,t}$ is thus updated by adding the profit net of investment, less the tax, and the loan payment:

$$NW_{j,t} = NW_{j,t-1} + P_{j,t} - I_{j,t} - Tax_{j,t} - LP_{j,t} \tag{31}$$

Entry and exit

At the end of each period, firms with (almost) zero market share (below threshold μ), or bankrupt, exit and a new breed of firms enters the markets. Firms go bankrupt if net worth NW is negative and profit-to-debt ratio Λ is below threshold ω. The number of firms is fixed, so entry is conditional on exit.

Entrant firm h has the same productivity of the largest firm i, $A_{h,t} = A_{i,t-1}$. It contracts a loan sufficient to invest in a fixed fraction ϕ of the largest firm's capital stock, $K_{h,t} = \phi K_{i,t-1}$. In the first period, entrant demand expectation equals the initial capital, $D_{h,t}^e = K_{h,t}$.

Government, financial sector and national accounts

Government collects a fixed tax φ on firms' gross profits and use this revenue to pay for unemployment benefits. Government is not credit restricted, meaning that it can take loans from the bank at a fixed rate r every time its expenses – the payment of public debt plus the payment of unemployment benefits – are higher than the tax revenue. Public debt as a share of nominal GDP has a stable trajectory over time. The real and the nominal Gross National Product are computed according to the usual national accounting identities:

$$GDP_t = \bar{p}_0 \sum_j D_{j,t} + \bar{p}_0^k \sum_j EI_{j,t} \tag{32}$$

$$GDP_t^{nom} = C_t + \sum_j I_{j,t} \tag{33}$$

3. Model validation

Macroeconomic agent-based models built with the purpose to be used as a policy and institutional "laboratory" need first to be able to robustly reproduce the relevant stylized facts for the phenomena under study[9]. Therefore, the goal of this section is to assess the model's ability to replicate a range of important regularities at firm-, worker-, and aggregate-level. Table 1 provides the set of stylized facts aimed for the model to reproduce.

The following results come from a Monte Carlo experiment based on 100 simulation runs, discarding the first 250 periods. Graphs showing normalized values were achieved through the mean centering of variables, as per below formula:

$$X_i^{\text{std}} = \frac{X_i - \bar{X}}{\bar{X}} \tag{34}$$

Figure 2A shows the distribution of market-shares and indicates that firms' market-shares have a right-skewed distribution (SF1). Also, the model is able to reproduce a tent-shaped distribution of firm output growth (SF2) (Fig. 2B). Firms' heterogeneity regarding productivity levels (SF3) is shown in Figure 3C. The heterogeneity is persistent through time and occurs due to the cumulative feature of idiosyncratic innovation and a feedback mechanism between profits, and R&D investment.

Workers' wages are right-skewed (SF4), indicating a concentration on lower wages and a right tail, with fewer workers receiving the higher incomes (Fig. 2D). The model also shows that the presence of a guaranteed form of minimum income (the unemployment benefit) act as an attractor for the wages (SF5) (Fig. 3A). Time in employment presents a right-skewed distribution (SF6), given a high turnover in the labor market, with fewer workers remaining at the job for longer periods (Fig. 3B).

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[9]On the importance of empirical validation, see Pyka and Fagiolo (2007), Fagiolo and Roventini (2017), Fagiolo *et al*. (2019).
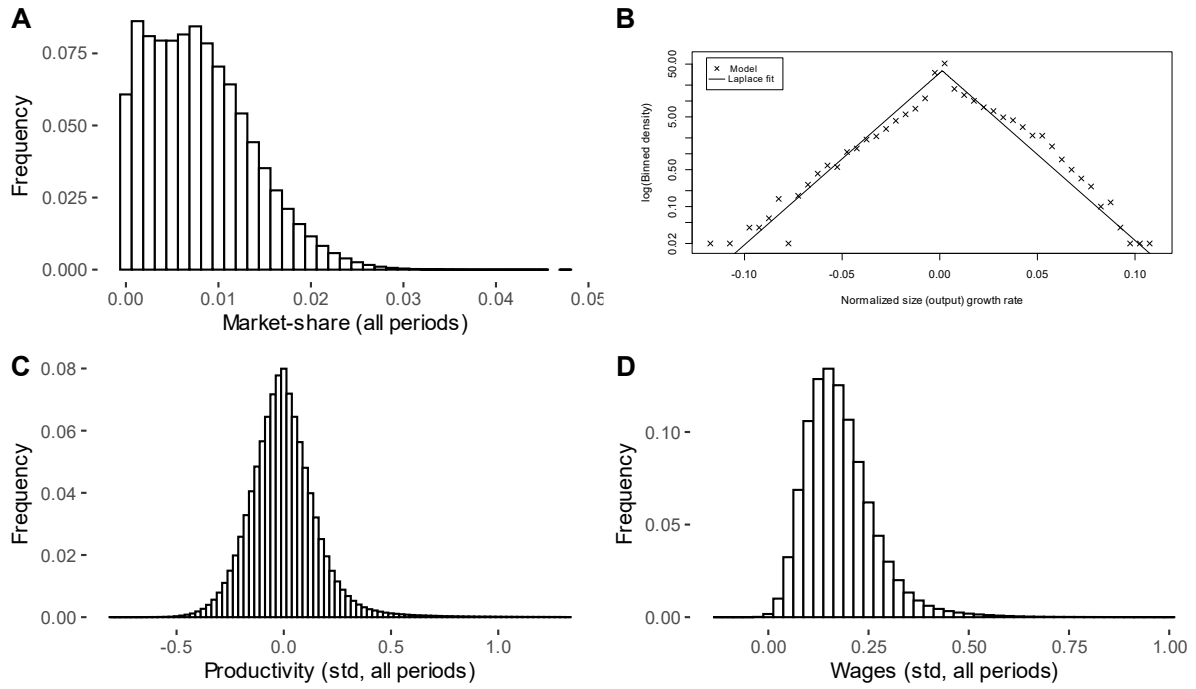
Figure 2: Histogram of pooled market shares in the goods market (A); histogram and Laplace-distribution fit of pooled normalized output growth rate (B); histogram of pooled normalized total-factor productivity (C); histogram of pooled normalized real wage (D). 100 Monte Carlo simulation runs.

Regarding the macroeconomic side of the model, GDP exponentially grows over time, albeit in a turbulent fashion (SF7) (Fig. 3C). GDP growth rates present a right-skewed distribution (Fig. 3D), indicating a higher probability of the economy of presenting growth periods, but also with less frequent endogenous crises (SF7). In terms of labor market, its main stylized fact is persistent unemployment (SF8): market is not cleared even with a positive trend of production growth (Fig. 4A).
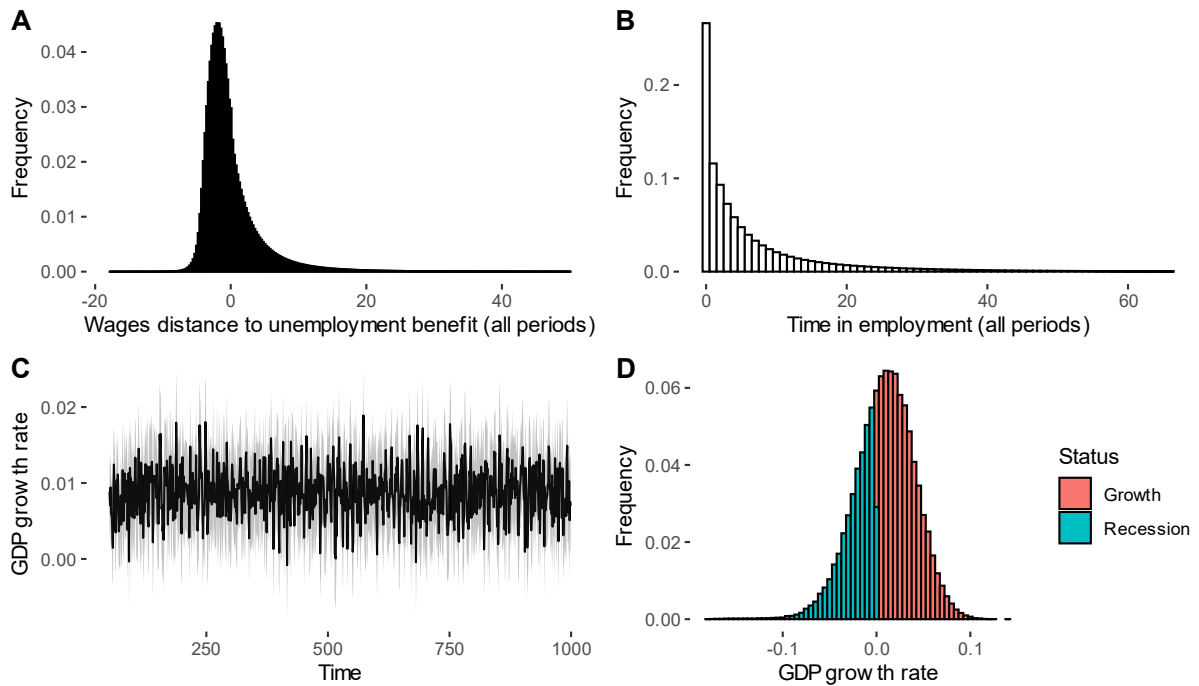
Figure 3: Histogram of pooled wages distance to unemployment benefit (%) (A); histogram of pooled time in employment (B); time-series for the GDP growth rate (C); histogram of GDP growth rate (D). 100 Monte Carlo simulations runs.

Fagiolo *et al.* (2004) point out to three important labor market aggregate regularities that this model also reproduces: i) the Wage curve (SF9); ii) the Okun curve (SF10); iii) and the Beveridge curve (SF11). The Wage curve states that increases in wages are negatively correlated to unemployment rates, as shown by the downward slope curve in Figure 4B. The interplay between economic activity and the labor market is shown by an Okun curve posing a negative relation between output and unemployment growth (Fig. 4C). Finally, the Beveridge curve postulates a negative relationship between the rate of unemployment and the rate of vacancies, defined in terms of total employment, expressing the easiness of finding jobs when more vacancies are available (Fig. 4D).
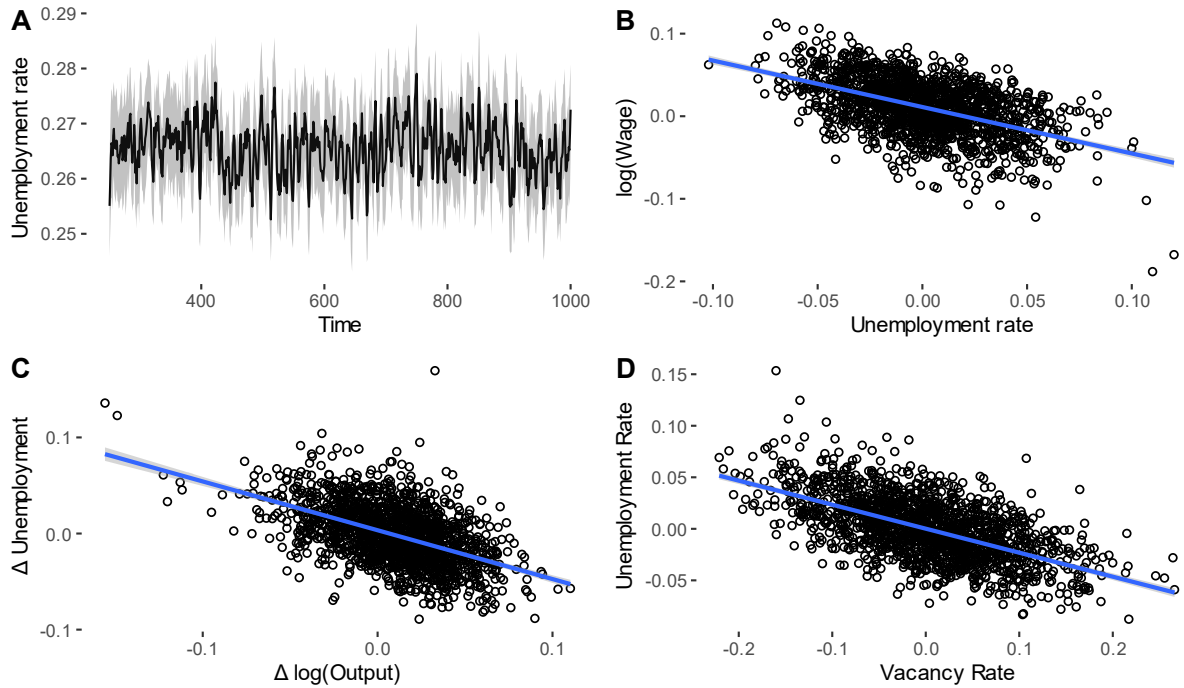
Figure 4: Time-series for the unemployment rate (A); Wage curve (B); Okun curve (C); Beveridge curve (D). 100 Monte Carlo simulation runs.

4. Post-reform Mexican labor market: flexibility and precariousness

The model was built to understand the effects of a flexible labor market on variables linked to work precariousness, mainly time in employment and wages. Mexican labor market, after 2012 reform, revealed two country-specific stylized facts. Firstly, temporary-job introduction led the expansion of employment, and the reduction of time in employment (Fig. 5A). Secondly, real wages decreased (Fig. 5B) (Romero and Acevedo, 2017).

In Mexico, flexibility in hiring and firing, along with reduced dismissal costs induced higher employment after 2012 (Mendoza-Cota, 2017). Nevertheless, temporary jobs gained terrain in the labor market, being the main factor for employment growth (Mendoza-González *et al*, 2020). The share of temporary workers over total labor force increased in the first few years after the reform (Fig. 5C) shifting tenure (time in employment) curve downwards (Fig. 5A). This inverse correlation seems to apply also to the sharp reversion observed in 2018-2019. Figure 5D gives support for the idea of a negative correlation between the changes in the share of temporary workers and mean tenure in the post-reform Mexican labor market.
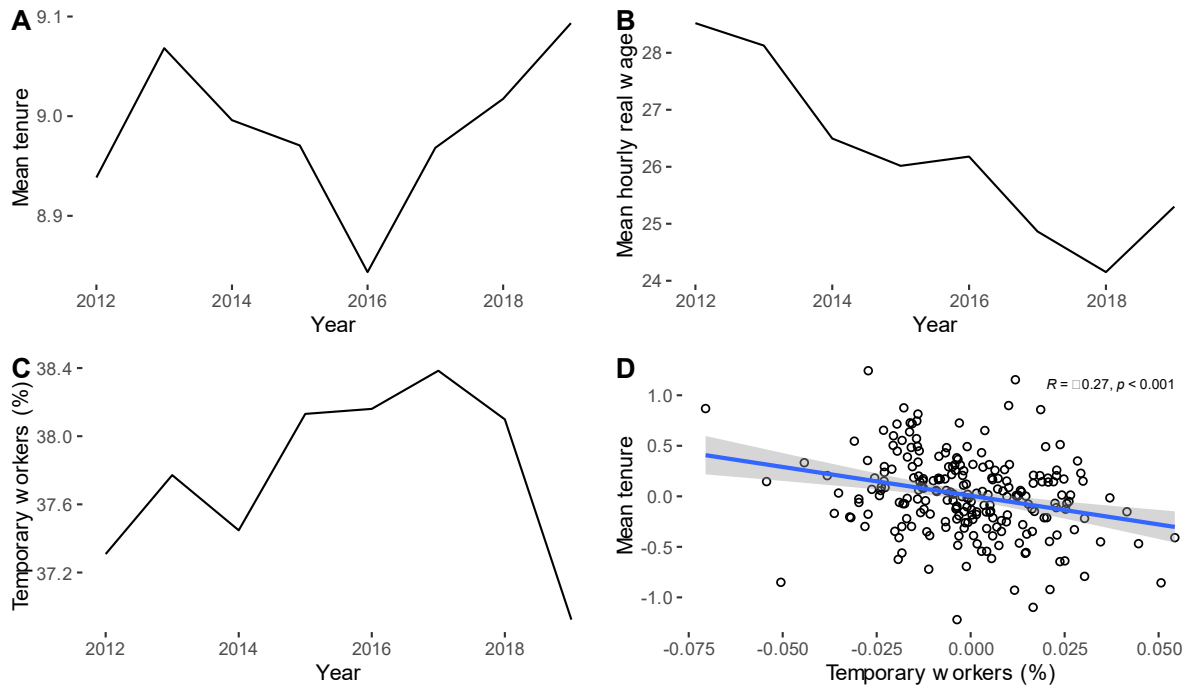
Figure 5: Time-series for mean tenure (A); mean hourly real wage (B); and percentage of temporary workers over total workers (C); scatterplot relating the yearly variation in the share of temporary with yearly variation of tenure (2013-2019) (D). Wages in 2019 prices deflated by the Consumer Price Index (*Índice Nacional de Precios al Consumidor* – INPC). Source: ENOE/INEGI

The flexible labor setup configured in the model reveals how the increasing work precariousness process may be disentangled. With reduced restrictions on firing and hiring, firms in our model have more freedom to adjust the workforce. Mexican labor reform achieved it through the expansion of non-standard forms of employment, mainly temporary jobs. As the model shows, the easiness in reallocating the workforce induces higher turnover rates, thus fewer workers remain in employment for a longer period. The consequence is a decrease in tenure and an increase in worker uncertainty about continued work. Unemployment rate oscillates due to successive attempts of firms to adjust their labor force to their production needs. But such attempts, in aggregate terms, tend to "backfire" in the short term, as demand is directly affected and prevent firms to fulfill the sales expectations. However, average unemployment remains stable, arising from a high turnover in the labor market.

In our model, workers leaving and entering the labor market continuously pressures wages down. The required wage by an unemployed worker is the minimum between the unemployment benefit and her last wage when employed. Since employed workers receive wage increases over time, the queue of job applications is filled with workers typically requiring a lower wage than the firms' average wage.

Wage flexibilization in Mexico was achieved by increasing the employers' power when arbitering wage composition (Romero and Acevedo, 2017). In the model, the "last word" of

firms in the wage determination mimics the employer strength in bargaining. Previous status in the labor market is determinant for the workers' bargaining power. Every time a worker enters the market, after a period unemployed, she has a disadvantage in the wage negotiation. In this context, the model reproduces the labor-capital struggle in a unlevel playing field. On the one hand, unilateral wage determination allows firms to pay the minimum wage necessary to achieve the amount of labor desired. On the other hand, high turnover rates pressure workers' wage requests down, given unemployment becomes more frequent.

Concluding remarks

The objective of this paper was to propose an agent-based model (ABM) able to reproduce the main stylized facts of the contemporary economies and, more specifically, of the labor market. Our goal was to create an empirically-validated model to act as a laboratory for further research on how "flexibilizing" labor reforms would impact work precariousness in a country. More specifically, we sought to reproduce the dynamics of flexible labor market in the modes of the Mexican after the labor reform of 2012 to assess the effects of the flexibilization on labor precariousness, focusing in variables important to explain precarity such as time in employment and wage level.

In the model, agents are persistently heterogenous. Both innovation and demand drive firms' output growth, revealing the interplay between the Schumpeterian and Keynesian engines of growth. The model replicates several stylized facts found in the literature. Aggregate output rises exponentially, although inconstantly, alternating periods of growth and recession along the business cycle. The overall regime of growth, and the transmission of productivity gains, allow wages to rise persistently too. This leads to wage differentiation, and a positively-skewed wage distribution. Even though long-term growth is steady, aggregate unemployment is persistent and pro-cyclical, with an active labor market and permanent hiring and firing. Three important regularities of the labor market – the wage, Okun, and Beveridge curves – also simultaneously emerge.

The model was created from the scratch and is loosely inspired by the "Schumpeter meeting Keynes" (K+S) family of models It introduces with two major additions. First, it is a simpler model but still able to robustly reproduce a significant number of stylized facts of the modern economies and labor markets. In this sense, it is also useful as a "laboratory" for policy analysis as well as it has a higher reproductability. Furthermore, the enhanced labor market

dynamics allows for a more comprehensive analysis without imposing higher complexity on the other parts of the model.

Second, while in the K+S model fired workers just receive an institutional unemployment benefit, our model explicitly accounts for termination fee payments by the firms, an important element of worker income in developing countries and a significant cost to firms. In addition, the presence of termination fees is a key characteristic of both Mexican and Brazilian labor markets, and has been one of the targets of the labor reforms aimed at flexibilizing firing and reducing labor costs.

The model was set up with a high degree of labor market flexibility, with firms being able to easily adjust the labor force to the production needs. This results in a right-skewed time in employment, indicating that workers remain few periods in the same job. Since tenure is strongly linked to wage increases, income gains are therefore slowed down.

This setup assisted us understanding the short-term effects of the 2012 Mexican labor reform. The increase in use of temporary workers, enabled by the reform, gave the employers more freedom to allocate the workforce. Therefore, turnover rates rose, and hourly wage decreased because of lower employee tenure. The two outstanding impacts were the reduced degree of certainty in continuing working, and the constrained capacity of earning a sufficient income, leading to a higher degree of work precariousness.

Nevertheless, the analysis proposed here is limited to provide a guideline on what would be the mechanisms emerging from a labor reform targeting a more flexible labor market. Being the model now empirically validated, the next step is to assess how institutional changes – like labor reforms – may generate state transitions on the dimensions of labor precariousness and other macroeconomic indicators.

Paper 3 – An agent-based model for evaluating the impact of the 2017 Brazilian labor reform on precariousness

Introduction

In this paper, we propose a model to evaluate how 2017 Brazilian labor market reform may have impacted the level of job precariousness. Our goal is to study the potential of labor flexibilization reforms in the aggravation of the dimensions composing the definition of precariousness[10]. More specifically, we wish to study the possible long-term consequences of institutional changes on the Brazilian labor market, whose starting point is significantly worse than that of developed countries. We employ an agent-based model aimed at simulate the response to institutional changes of heterogenous workers interacting in the labor market.

The recent debate on labor reforms emerged in Europe as a response to the long-standing economic slowdown in the region. Existing industrial relations and the collective bargaining framework shaped how labor legislation reform should take place in order to tackle unemployment by flexibilizing labor relations. Additionally, the rise of conservative politicians' influence gave political support for the implementation of the reforms. However, the European countries that first relaxed employment protection legislation experienced an increase in unemployment rates, differently on what was expected (Adascalitei and Morano, 2015).

Similar factors drove developing countries' labor reforms, that is, adjustment of labor markets, propping up aggregate demand, and ascension of right-wing politicians. Within this context, Brazil went through a labor reform in 2017 aimed at increasing labor market flexibilization and reducing labor costs through: i) demeaning the importance of collective agreements, privileging individual bargaining; ii) generalization of new contract forms, such as temporary, part-time, trial, and intermittent jobs, reducing the certainty of continuing in work; iii) reducing the role of Labor Justice and organized labor; and iv) increasing flexibility in wage determination, among other points.

The justification for the reform pointed to the necessity of modernizing labor relations, reduce informality, fight unemployment, and spur economic growth. Nevertheless, a few years after the reform, Brazilian economy remains stagnated, whereas informality and unemployment have risen (Cardoso and Azaïs, 2019). New working forms seem to point not to a modernization

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[10] Following Rodgers (1989), the dimensions of precariousness are: i) low certainty of the continuity of the employment relation; ii) less worker control over his own working conditions, wages, and pace of work; iii) absence of social protection; iv) insufficient income.

of labor relations, but rather to a backlash towards loss of labor rights and increasing precariousness.

Recent research tried to estimate the impact of labor reform on Brazilian labor market indicators (Krein *et al.*, 2019; Teixeira, 2019; Bridi, 2020; Romero *et al*, 2020). These works have shown that evidence is dubious, but favors the idea that the reform may harm the situation of precariousness indicators in the long run. However, it may be yet too early to empirically evaluate the effects of the reform. For this reason, we propose a theoretical model able to shed light upon the question on which might be the long-run impact of the labor reform on precariousness.

In face of insufficient empirical evidence, we study the possible consequences of deregulating reforms on labor market with an agent-based model (ABM). Our hypothesis is that deregulating reforms exacerbate precariousness of underdeveloped countries' labor markets in, at least, three dimensions: i) reducing the degree of certainty of continuing working by reducing average time in employment and increasing long-term average unemployment; ii) threatening workers' personal income security by decreasing the average income; iii) increasing income inequality among workers and between workers and employers. Additionally, we also would like to check if labor flexibilizing reforms may also have impact on macroeconomic indicators, such as GDP and productivity growth and volatility.

Macroeconomic agent-based models are computational representations of an economy composed by autonomous agents whose micro-level decisions and interactions generate micro- and macro-level consequences. Agents are initially heterogenous and may (or may not) persist heterogenous throughout the simulated history. Agents act under uncertainty adopting simple behavioral rules. Macro-level emergent properties arise from the interactions of the micro-level agents, as in the case of the real economy. The complexity of the interactions between agents and the corresponding feedback mechanisms implies that ABM's are not bounded to any sort of equilibrium premises.

We validate our model's results by the comparison of statistical properties of the simulated data with "real world" stylized facts. After validation, the model becomes logically suitable for the type of experiment we propose.

The base model used in this paper is loosely inspired by the labor-augmented "Schumpeter meeting Keynes" (K+S) family of models (Dosi *et al.*, 2019a). The model was empirically validated in another paper in this thesis, being able to reproduce several micro- and macro-level stylized facts. The impact of the labor reform on precariousness will be evaluated through the introduction of a policy regime change along the simulated history, and the

comparison of the relevant labor market indicators with a counterfactual no-reform regime. Our goal is to evaluate whether the labor reform i) reduce average time in employment; ii) decrease average wage level and growth; iii) increase unemployment rate; and iv) induce higher personal inequality and a reduction of the wage share on the aggregate income.

The paper is divided as follows. Section 1 provides a literature review on the arguments for the labor reforms and the recent research on its impacts in Brazil. Section 2 describes the model and its structure, emphasizing the modelling of the institutional changes introduced by labor reforms. Section 3 analyses the policy experiment results. The paper ends with some Conclusions.

1. Literature review: labor reforms' motives and consequences

Recently, labor market reforms have become an important discussion topic for developing countries. Two reform objectives usually proposed are to cope with high informality[11] and to modernize labor relations (Filgueiras, 2019). High informality characterizes developing countries' labor markets, where workers have limited opportunities for formal insertion (Loayza, 2009). For that reason, several workers become self-employed or are informally hired in small firms, characteristically under low productivity and wages (Salas, 2002). Labor reform proponents, with the discourse of "promoting formalization", use legislation reforms to regulate precarious insertions – such as self-employment – without considering that former informal workers may not have better working conditions other than be formally under the law now.

Another argument advocates for a "modernization" of labor relations. Most Latin American countries established labor legislation just by mid 20th century, largely inspired by the European welfare state, where previously the lack of a proper legislation let workers unprotected (Cook, 2010). Labor legislation was introduced in these countries in a context of fast growth, industrialization, and urbanization. They seek to provide security and stability to the urban workers of the time (Castel, 1998). However, the protective legislation framework was adopted in the semi-urban realities of Latin American countries at the beginning of the industrialization process. For current labor reform proponents, distortions have compromised

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[11] The 90th International Labor Conference (2002) of the International Labor Organization associates the term "informal economy" to economic activities done by business and workers which are not – legally or practically – covered or sufficiently covered by formal agreements. Informality may rise due to lack of regulation, where the economic activities performed are not covered by the law. Also, it may happen by ignorance of the law, explicit illegality, or lack of proper application of the law by the authorities. In this sense, a labor reform would be useful to simplify the legislation, pushing more workers and business to formality.

the development of such labor markets until the present, and impaired firms' ability to generate jobs and to pay better wages[12]. Additionally, proponents argue that a set of out-of-date rules does not suit fast changing labor relations of the 21st century, which pledge for more flexibilization (Edwards and Lustig, 2001).

Frequently, labor reform proposals emerge during period of crisis, promising to reduce unemployment, to induce hiring, and boost economic growth without imposing further burden over companies. Proponents state that the deregulation of labor markets has a direct positive impact on firms' hiring decisions. If, for example, hiring costs are reduced and the process of hiring and dismissing workers becomes less expensive, firms would have an incentive to hire more workers even during periods of crisis (Cook, 2010). Yet, reform proponents promise to generate employment without direct expenditure by the government in job promotion programs, thus not impacting public budget. This is important for developing countries given they frequently do not have space to expand public expenditure. On the contrary, the increase in firms' hiring – leading to reduced unemployment – would increase overall demand, reactivating the economy and boosting economic growth. In turn, renewed economic growth would positively impact public budget by the increased consumption and tax revenue, once more workers are now receiving income and firms are selling more (Kaplan, 2008).

Nevertheless, the (limited) evidence on the positive impacts of deregulation of labor market is disputed in the literature. Several studies have found no statistical correlation between employment protection legislation and unemployment rates (ILO, 2015; Silva, 2018). On the same direction, the impact of deregulation on labor market indicators is dubious for Adascalitei and Morano (2015).

Some studies present a negative correlation between employment protection legislation and employment rates. Nickel *et al*. (2005) revealed that employment protection increases unemployment through its impact on unemployment persistence. Feldmann (2009) found that stricter labor market regulations have increased unemployment all over the world. Bernal-Verdugo (2012) showed that increased labor market flexibility can have an important effect in reducing unemployment. Bouis *et al*. (2012) found similar results for the reduction of unemployment rates in the short-run after labor reforms.

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[12] Rogério Marinho – the leading Congressman for the Brazilian 2017 reform – spoke in a presentation that the "stereotype of the worker" thought in the conception of the country's labor legislation in the 1940's did not materialize and it is "absolutely inadequate for the Brazilian and whole world realities". He claimed that the reform is essential to "adequate the legislation to the realities of the transformations" of the Fourth Industrial Revolution. Source: https://bit.ly/3gbdRlN. Accessed in April 13th, 2021

Other studies argument that labor reforms have a negative impact on labor market indicators. Cacciatore *et al.* (2012) showed that, in the short-term, labor market reforms increase unemployment and decrease wage levels. Adascalitei *et al*. (2015) showed that countries that relaxed labor legislation between 2008 and 2014 experienced an average increase in unemployment of 3.7 percentage points, against an increase of 0.3 p. p. for other countries.

According to Teixeira *et al.*, (2017), the 2017 Brazilian labor reform (i) regulated new working forms, such as outsourcing, intermittent, temporary and partial contracts, and autonomous work; (ii) allowed the extension of the daily working hours; (iii) limited the access to the Labor Justice; (iv) increased the role of individual over collective agreements; (v) allowed the payment by productivity and the reduction of overtime payment; and (vi) extinguished workers' mandatory contribution to unions .

The impacts of the reform on the Brazilian labor market are not yet clear. Lúcio (2018) argues that its multiple impacts will be perceived only over time. Turnover may increase, as workers may be hired using the new working forms created by the reform. Direct agreement between employers and employees may restrain existing (collectively-agreed) protection rules. Additionally, atypical working hours may become more common among workers (Mourão, 2018).

Some authors tried to capture the short-term impacts of the 2017 reform. Trovão and Araújo (2018) identified the substitution of better paid positions for lower pay ones over the year after the reform. The authors argue for a long-term substitution effect, where the lower pay jobs allowed by the reform may gradually become the norm. Carvalho (2018) saw in the stagnation of the (high) unemployment rate an evidence against the argument that the reduction in labor costs would induce hiring. Unemployment remained high due mostly because of increased informality, when workers leaving formal jobs enter in informal relations.

Filgueiras (2019) provides a thorough analysis of labor market indicators after the reform. Formalization reduced, whereas unemployment remained stable. Informality increased, since in the lack of formal opportunities, workers in developing countries are more likely to rely on informal jobs to obtain income. Overall average wages were stagnant, with some labor market segments facing nominal reductions. Non-standard but now legal contracts, such as part-time and intermittent jobs, increased, along with atypical working hours. According to the author, the reform indeed offered incentives to the maintenance of informal labor relations. Reduced hiring costs did not induce formalization, because it is still even cheaper to not enter formal contracts.

2. The model

We build an agent-based model populated by heterogenous firms and workers behaving according to a set of boundedly rational behavioral rules, interacting on both goods and labor markets, with a small government and a stylized financial system. The model is loosely inspired by the labor-augmented "Schumpeter meeting Keynes" (K+S) family of models (Dosi *et al.*, 2019). It is characterized by the possibility of persistent unemployment even with long-term GDP growth, an endogenous process of technical change, competition among firms leading to market dynamics, search-and-match, non-clearing labor market, and a detailed process of the worker firing by firms.

The model is setup somewhat similarly to the "Competitive regime" of the labor-augmented K+S model to loosely represent the starting conditions of developing countries' labor markets. Firms freely adjust (hire and fire) workforce to accommodate for the planned production schedule. Wages are flexible and (indirectly) respond to unemployment and market conditions. Firms have the final say in determining wages through an asymmetric bargaining process. Finally, unemployment benefits act as a cushion for the unemployed workers and a floor for wages.

The previous paper of this thesis provides a full description of the model employed for the experiments proposed here. We were able to empirically validate the model by demonstrating that it reproduces most empirical stylized facts[13], constituting a proper "laboratory" to evaluate policy experiments. From that, we use the model to study if labor flexibilizing reforms may or may not affect precariousness-related labor market indicators, and achieve the promised macroeconomic objectives.

The stylized facts[14] attained by the model are: i) right-skewed market-share distribution; ii) competition leading to selection; iii) tent-shaped output growth distribution; iv) investment lumpiness; v) productivity heterogeneity among firms; vi) right-skewed wage and tenure distributions; vii) turbulent GDP growth rate; viii) persistent unemployment. Figure 1 presents the model overall structure[15].

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[13] In modelling the "nature of the growth process", Kaldor (1957) stated that "a satisfactory model (…) must also account for the remarkable historical constancies revealed by recent empirical investigations". In this sense, we follow Kaldor by putting forward a model which also reproduces "historical constancies" named stylized facts.

[14] For a complete description of the validation results, please refer to the previous paper of this thesis.

[15] For a full description of the equations of the model, see the previous paper in this thesis.
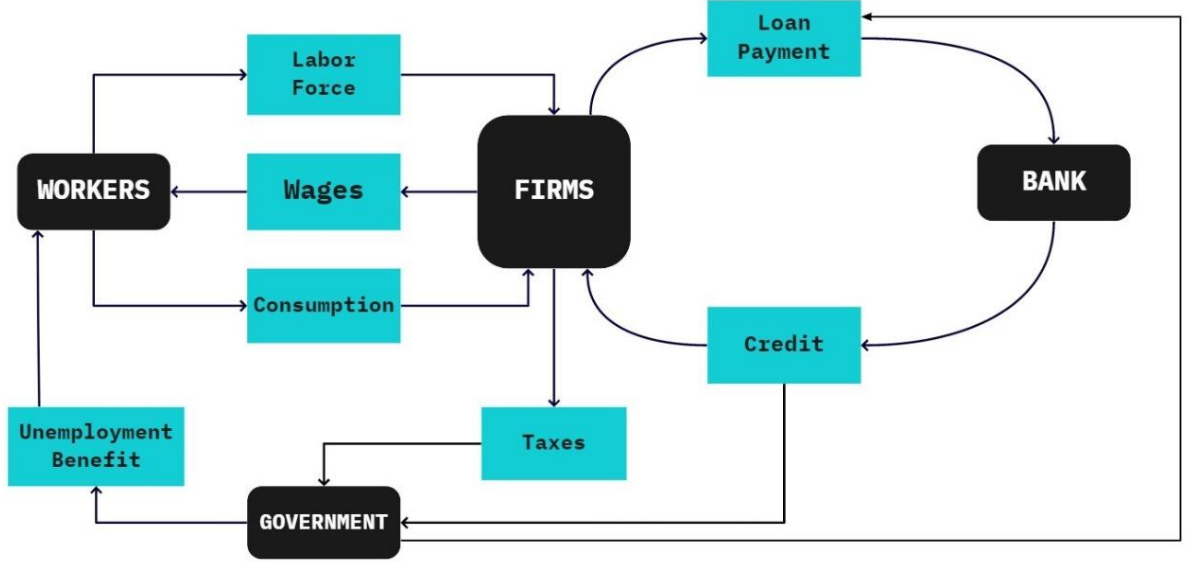
Figure 1: The model overall structure. Source: elaborated by the author.

The model is composed by four set of agents: a fixed number of F_0 firms (denoted by the subscript j) and L_0 workers (subscript ℓ), in addition to a government and a bank. Firms produce a homogenous and perishable good with a fixed-proportion of labor and capital, and invest in R&D to increase productivity. Firms set desired production based on expected demand, thus determining the mix of labor and capital needed to achieve desired output. Firms may decide to invest to increase the capital stock – which will only be delivered on the next period – and to offer or close vacancies to accommodate the required labor force in the period.

Workers randomly apply for jobs to a limited set of firms with probability proportional to firm's size and search only when unemployed. Firms offer a uniform wage $w_{j,t}^o$ sufficient to satisfy enough workers in the application queue, if any, according to the labor demand and the requested wages $w_{\ell,t}^r$. After the matching and hiring takes place, firms produce and try to sell output to workers in the goods market. Unemployed workers become eligible to unemployment benefits and fired workers receive a termination fee paid by firms.

Let $\mathcal{E}_\ell$ be the set of time periods in which a worker was employed (at the same firm) up to time t, $w_{\ell,t}$ be the wage she receives at each time $t \in \mathcal{E}_\ell$. The termination fee is as a fraction λ, a parameter, of his past wages:

$$TF_{\ell,t} = \begin{cases} \lambda \sum_{t \in \mathcal{E}_\ell} w_{\ell,t}, & \text{if fired in } t \\ 0, & \text{otherwise} \end{cases} \tag{1}$$

Prices are determined by a mark-up over unit costs. Mark-up evolves according to firm market share which, in turn, are determined by a replicator equation, where the more competitive firms expand, and the less competitive ones shrink. Firms with market share below

a threshold ω or bankrupt leave the market. The number of firms is fixed, so each exit corresponds to an entry. Entrants start with the most productive technology available and capital stock (output capacity) equals to the market average.

The government levies tax on firms' profits and pays benefits to unemployed workers. The bank lends money to firms and government, and receives interest and amortization on debt. Government and bank do not employ workers.

In each time step, the following timeline applies:
1. Firms plan desired production based on expected demand and current capital stock;
2. Firms define the desired labor and next-period capital stock;
3. Job-seeking workers send applications to firms;
4. Wages are bargained and job vacancies are partly or totally filled;
5. Firms pay wages and termination fees, and government pays unemployment subsidies;
6. Goods market opens and market shares are allocated according to the relative competitiveness of firms;
7. Firms compute profits, pay taxes and repay (part of) debt;
8. Exit takes place and new firms enter;
9. Aggregate variables are computed and the cycle restarts.

We simulate the model for 1000 periods, discarding the first 250, before the model "settles". Considering the stochastic components in the model, we perform a Monte Carlo experiment to evaluate the distributional properties of the results. We present the time-series results as the Monte Carlo averages of 100 simulation runs. Labor reform is implemented at $t = 350$. Model parametrization is presented in Appendix A.

3. Policy experiment: labor flexibilization reforms

3.1. Description of the reforms

We model the labor reform as a modification in the set of rules and parameters used by the model to emulate the institutional changes promoted by a real reform. The goal is to analyze how some variables will behave after the labor reform is introduced. We focus on three sets of variables, directly related to the evaluation of precariousness: i) duration of employment (tenure), as a proxy of the degree of certainty in continuing work; ii) wage level and growth

rate, related to workers' income security; and iii) personal and wage inequality. Also, we investigate whether the reforms would impact positively on GDP and unemployment.

We are going to evaluate the impact of two alternative labor reform formats. The first (LR1) aims at the reduction of labor costs, consisting in the reduction of the termination fee paid by the firm (parameter λ). The second (LR2) introduces the possibility of wage discrimination when hiring (variable $w_{j,\ell,t}^{o}$), representing an individual-level agreement between employer (j) and employee (ℓ).

Reducing the termination fee decreases the amount earned by workers at dismissal time. Figure 2 displays a schematic diagram of the process. The x-axis displays the number of workers fired, whereas the y-axis represents the term-fee costs. The **WC** downward-slope black line shows the total remaining wage cost after firing L workers. Let N' be the number of workers the firm desires to dismiss to accommodate production needs in a hypothetical situation. In the no-reform scenario (blue line **LR0**), if the firm decides to fire the N' workers, the termination fees amount to be paid would be larger than the wage costs to be saved. For that reason, firms would decide to fire $nL0 < N'$ workers. With the reduction of the termination fee seen as the light-blue line **LR1**, firms would fire $N' = nL1$ workers as desired, for now the amount to be paid in fees is equal or less the amount saved in wages[16].
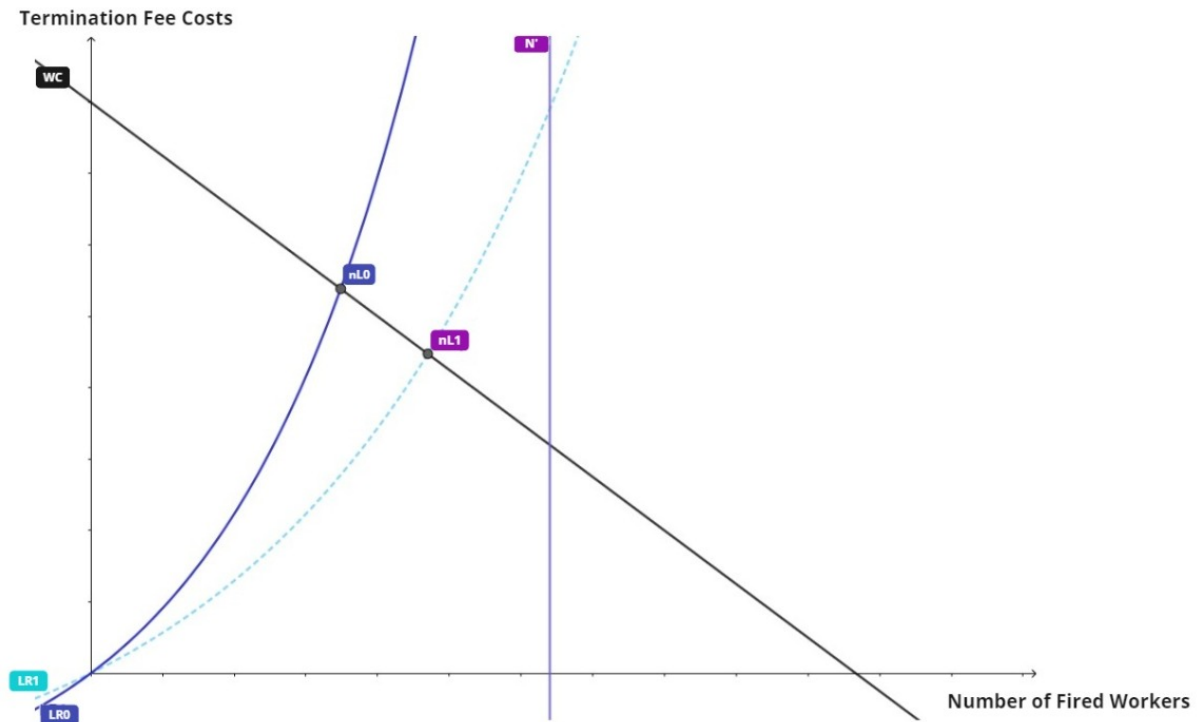

Figure 2: Schematic diagram of termination fee reduction (LR1) experiment. Source: author's analysis.

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[16] This does not imply that any reduction in the termination fees would guarantee that firms fire the number of workers they desire to fulfill production. The objective of the figure is to demonstrate how reducing termination fees incentives firms to fire more even for a "fixed" desired number of workers to fire.

After reform, the individual wage bargaining between employer and employee allows firms to pay different wages for workers hired at the same time (and for the same function) according to each worker requested wage. The previous mechanism of equalization of the new workers' wages, a proxy for collective negotiation, is replaced, potentially allowing firms to reduce payrolls. Figure 3 depicts schematically the change. The x-axis represents each worker in the application queue of a given firm, organized in increasing satisficing wages, whereas the vertical axis represents the individual offered wages. The horizontal line **LR0** shows the single wage offered in the benchmark scenario, while the curve **LR2** displays the effective wage offered to each worker in the queue. The intersection point *A* shows the wage paid to the last hired worker, the one which the highest requested wage. In the benchmark scenario, all hired workers would receive w^o, no wage differentiation would exist, and the firm total wage cost would be equivalent to the area under the horizontal line. With the reform, firms would be able to offer each worker the minimum amount required over the blue line **LR2**. This will give rise to wage discrimination and lower total wages than in the benchmark scenario. The brown area shows the new firm wage costs, lower than the previous cost, delimited by the area under the **LR0** line up to the point *A*.
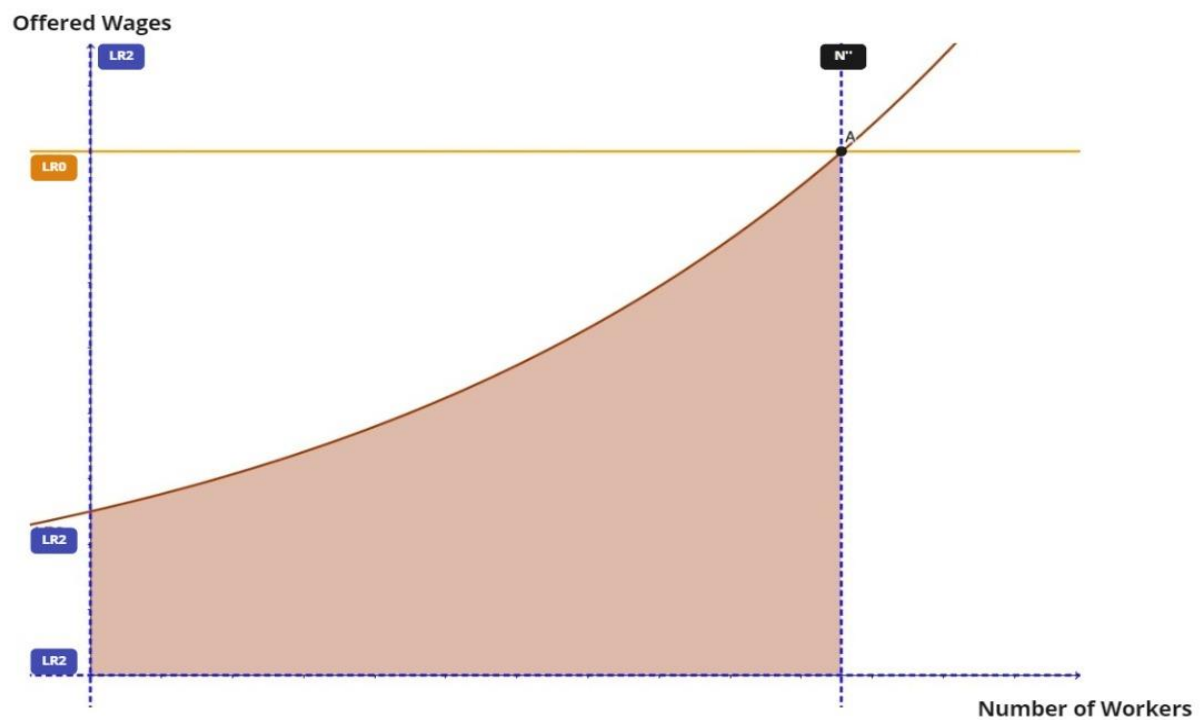

Figure 3: Schematic diagram of intra-firm wage differentiation (LR2) experiment. Source: author's analysis.

3.2. Comparison between reforms

The benchmark model configuration corresponds to a no-reform scenario which loosely mimics the dynamics of a developing country labor market. We compare two alternative labor reforms with the benchmark in terms of: i) tenure; ii) wage growth rate; iii) Gini index of employed workers' wages; iv) Gini index of all agents' incomes; v) GDP growth rate; vi) GDP volatility; vii) productivity growth rate; viii) unemployment rate; ix) cumulated income share[17]; x) wage share.

Table 1 shows the model results for the three scenarios, the ratio between them, and the Mann-Whitney-Wilcoxon U-test[18] to evaluate the statistical significance of the differences between the benchmark and the reform experiments. Significant differences were found for tenure, wage growth rate, Gini index, GDP volatility, unemployment, worker income share, wage share, total hired, and total dismissed for LR1. Tenure, wage growth rate, worker income and current wage shares decrease after the experiment, while Gini index, GDP volatility, unemployment, total hired and dismissed are significantly different. For LR2, wage growth rate and share significantly reduces, while the Gini indexes increase. Unemployment increases, together with total hired and dismissed. The effect of the reforms on the other variables were not significant.

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[17] "Cumulated income share" measures the net worth of workers over the net worth of firms.
[18] We use the Mann-Whitney-Wilcoxon U-test (instead a regular t-test) because we cannot assume normal distribution of the variables in the Monte Carlo experiment. p-values of the U-test are read the same way as in the case of a regular t-test.

	Benchmark (LR0)	Experiment 1 (LR1)			Experiment 2 (LR2)		
	MC Avg.	MC Avg.	LR1/LR0	U-test	MC Avg.	LR2/LR0	U-test
Tenure	6,8280	6,6710	0,9770	0,0000	6,8421	1,0021	0,4777
Wage Growth Rate	0,0110	0,0108	0,9808	0,0000	0,0098	0,8879	0,0000
Gini Employees	0,0201	0,0200	0,9978	0,3686	0,0231	1,1514	0,0000
Gini Index	0,8583	0,8630	1,0054	0,0000	0,8613	1,0035	0,0000
GDP Growth	0,0088	0,0088	1,0084	0,4005	0,0088	1,0073	0,5303
GDP Volatility	0,0318	0,0327	1,0276	0,0001	0,0318	0,9992	0,6913
Productivity Growth Rate	0,0088	0,0089	1,0114	0,1943	0,0088	1,0054	0,5740
Unemployment	0,2652	0,2752	1,0375	0,0000	0,2728	1,0287	0,0000
Cumulated income share	0,0578	0,0535	0,9255	0,0107	0,0581	1,0061	0,8757
Wage Share	0,7561	0,7533	0,9962	0,0487	0,7545	0,9979	0,0003
Total Hired	1.481,05	1.483,59	1,0017	0,0000	1.479,87	1,0117	0,0000
Total Dismissed	1.481,14	1.534,52	1,0360	0,0000	1.546,39	1,0441	0,0000

Table 1: Performance comparison among experiments: benchmark (LR0); termination fee reduction (LR1); intra-firm wage differentiation (LR2). Monte Carlo experiment averages for 100 runs. *p*-values for two-tailed Mann-Whitney-Wilcoxon test among experiments. H_0: no difference between experiments.

Figures 4 and 5 show the box and whisker (quartile) distribution plots for the Monte Carlo experiment for labor market and macroeconomic variables for both experiments. From them it is possible to evaluate not only the mean Monte Carlo values, but the whole distribution among experiments. The extrema whiskers indicate maximum and minimum points; lower and upper box indicate the first and third quartile, respectively; the central line display the median value.

LR1 had a more acute decrease in tenure (Fig. 4A) and increased inequality among all agents (Fig. 4E). LR2 major impact was on inequality among employees (Fig. 4D), with also a significant decrease in the wage growth rate (Fig. 4B). Regarding the macroeconomic variables, there is no evidence that labor reform spurs economic growth or productivity (Fig. 5A and 5C) once wage and termination fees reduction shrinks workers income, therefore not allowing to an increase in aggregated demand. GDP volatility increases marginally (Fig. 5B), but the increase is statistically significant, as shown by the U-test in Table 1.

Both LR1 and, particularly, LR2 affect wage growth negatively (Fig. 4B). The reduction in termination fees leads firms to increase firing. Once workers' required wages are directly proportional to the time in employment, wage demands reduce because they are staying longer out of a job. Therefore, when reentering to a job position, workers demand a lower wage in comparison to no-reform scenario.

Wage differentiation has a similar consequence of reducing wage growth by a different mechanism. The wage adjustment for employed workers is a function of their own wages. With lower wages, the baseline for readjustment is smaller, and, consequently, wage growth becomes slower.
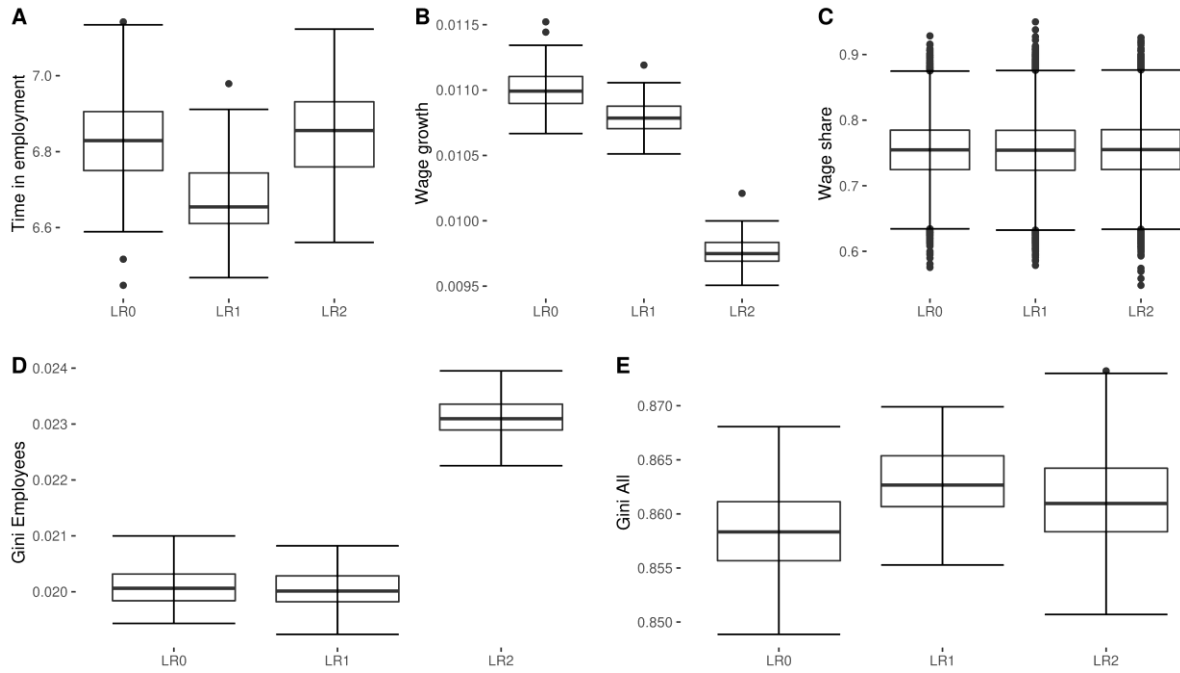
Figure 4: Performance comparison among experiments for labor market variables: benchmark (LR0); termination fee reduction (LR1); intra-firm wage differentiation (LR2). Monte Carlo experiment averages for 100 runs in period [500, 1000]. Bar: median | box: 2nd-3rd quartile | whiskers: max-min | dots: outliers
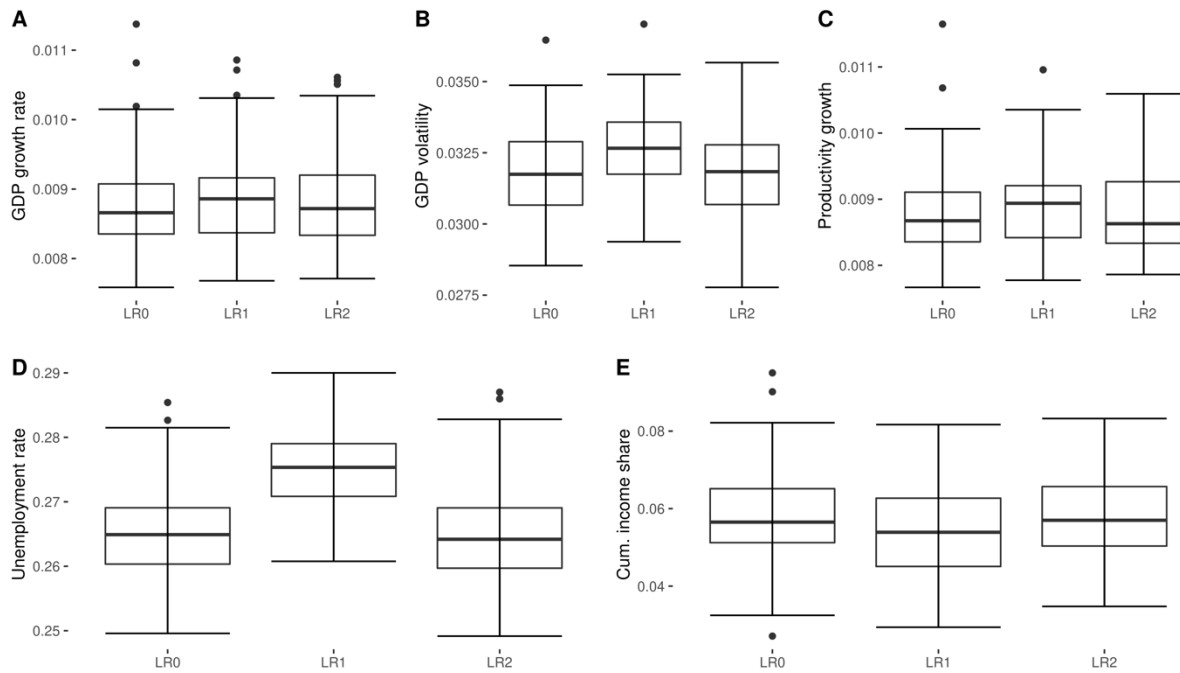

Figure 5: Performance comparison among experiments for macroeconomic variables: benchmark (LR0); termination fee reduction (LR1); intra-firm wage differentiation (LR2). Monte Carlo experiment averages for 100 runs in period [500, 1000]. Bar: median | box: 2nd-3rd quartile | whiskers: max-min | dots: outliers

3.3. Experiment 1: lower termination fees

Figures 6 and 7 shows the detailed evolution of the variables' behavior after the simulated reform shock. While Figures 4 and 5 summarizes variable's distributions for the post-reform period, analyzing the Monte Carlo experiment time series is useful to understand the dynamics after the shock. We compare the evolution of the ratio of the variables between the reform and the benchmark. Values higher than 1 imply that the given variable is higher in the reform scenario in relation to the benchmark, the opposite being also true. We explain the evolution of the time series from the analysis of the inner microdynamics of the model, uncovering the causal chain of events derived from the set of behavioral rules.
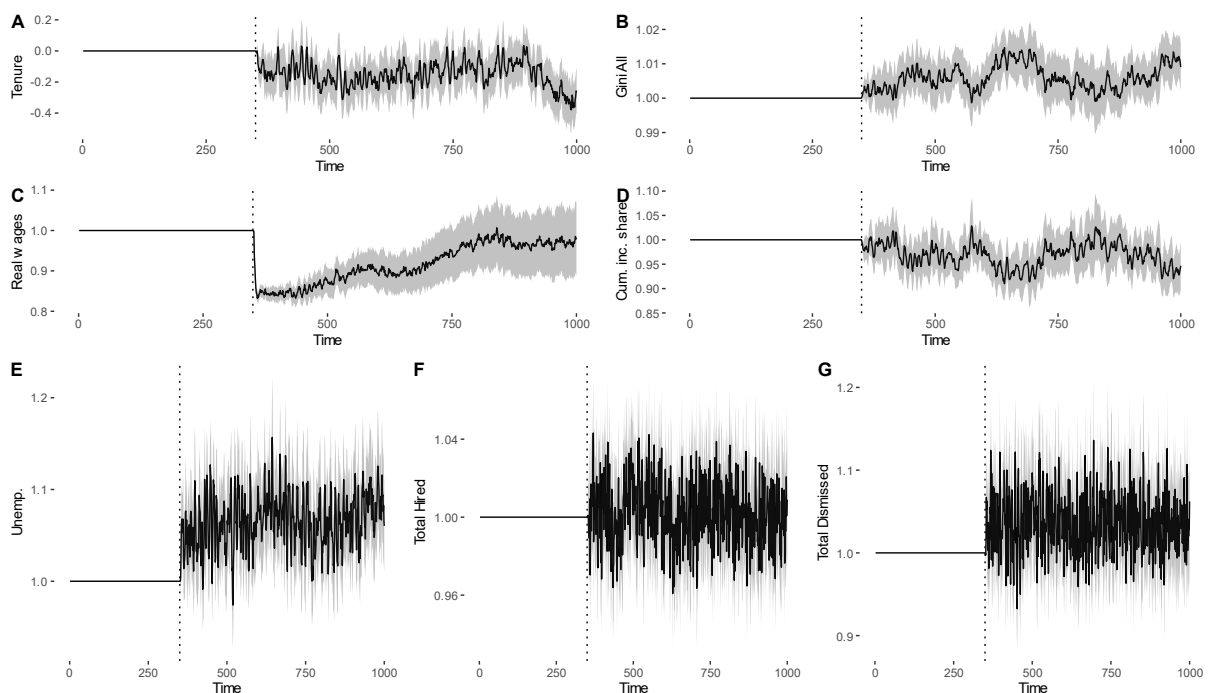

Figure 6: Comparison between labor reform reducing termination fees (LR1) and benchmark (LR0) values. The graphs show the values of the experiment scenario as a proportion of the benchmark. Differences in tenure[19] (A); ratio of Gini index among all agents (B); ratio of real wages (C); ratio of cumulated income share (D); ratio of unemployment rate (E); ratio of total hired (F); ratio of total dismissed (F). Monte Carlo experiment average from 100 runs. 95% confidence intervals in gray.

The reduction of labor costs – experiment LR1 – tends to mildly lower the time in employment (Fig. 6A) and induce sligthly higher personal inequality (Fig. 6B), with functional distribution shifting towards the employers[20]. Unemployment rate slowly rises as firing

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[19] For tenure we used the difference between the value in LR1 and in LR0 due to the frequent possibility of tenure equaling zero (meaning an unemployed worker), which would lead to a division by zero.

[20] By "wage inequality" we mean the differences in the wages earned among workers. "Income inequality" stands for the differences of overall income, including wages and other non-wage incomes (unemployment benefits, termination fees).

becomes cheaper (Fig. 6E). Given the decision of firing workers, firms preferably dismiss those with higher wages up to the point that the net present value of wages is equal to that of the firing cost. Since workers with higher tenure receive higher wages, firms tend to dismiss these workers. However, with the reduction of firing costs, even workers with lower wages and, therefore, lower tenure become more susceptible to dismissal (Fig. 6A).

The number of hirings increases after the reform (Fig. 6F), revealing that, in some sense, the reform increases the possibility of matchings. Nevertheless, the positive effect is largely offset by an even higher amount of dismissals (Fig. 6G), leading to an increase in unemployment (Fig. 6E). Because the higher turnover, wages initially decrease sharply (Fig. 6C), and also wage growth slows down. Cumulated income share fluctuates significantly (Fig. 6D), along with a small increase in the Gini index (Fig. 6B), as inequality tends to rise in the post-reform scenario.

From the analysis of the model's results, we conclude that the reduction of labor costs through lower termination fees induces two movements. First, it reduces worker income, as fired workers receive less at dismissal and real initial wages fall. Second, it induces firing, increasing unemployment and turnover rates. A larger unemployed workforce has lower power of bargaining for higher wages, thus leading to an overall wage decrease, at least in the medium-term after the reform.

3.4. Experiment 2: wage differentiation

When analyzing the time series of the main aggregate variables (Fig. 7), we confirm that the main effect of the wage differentiation reform (experiment LR2) is a major (permanent) increase in wage inequality among employed workers (Fig. 4D), as firms pay the minimum amount required by each worker, rather than a homogeneous (higher) wage.

Firms adjust employed workers' wages based on their previous wages. In the reform scenario, workers at the bottom of the wage distribution receive a lower wage than they would in the benchmark case. For this reason, the adjustments earned when employed are calculated over a lower baseline wage. Consequently, Gini index among employed workers rises.

Within the model, unemployment benefit has a direct link with the mean wage. Therefore, wages reduction also decreases the value of the benefit, thus reducing the income earned by the unemployed. Similarly, termination fees are directly proportional to the wages, given termination fees are a fraction of the "compulsory savings account" and, so, decrease proportionally with lower wages. In summary, dismissed workers are affected by both lower

unemployment benefit and reduced termination fees. For those reasons, income inequality, when also considering non-wage incomes, also rises (Fig. 7D).
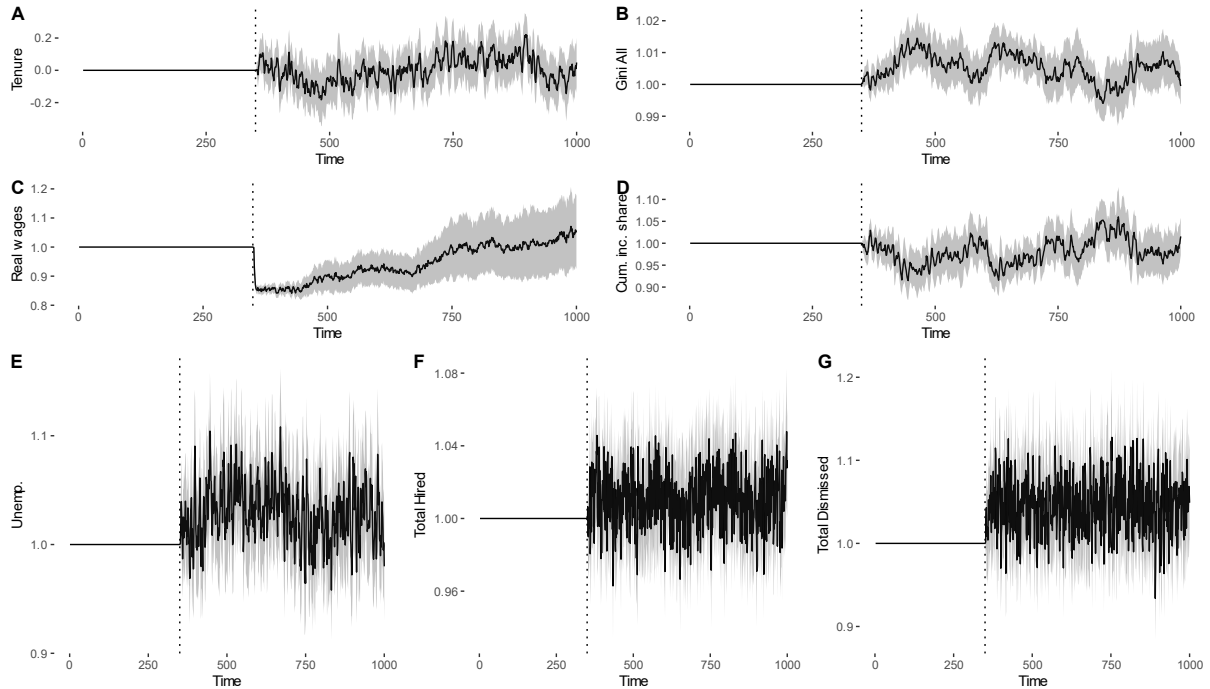

Figure 7: Comparison between labor reform allowing for intra-firm wage differentiation (LR2) and benchmark (LR0) values. The graphs show the values of the experiment scenario as a proportion of the benchmark. Differences in tenure (A); ratio of Gini index among all agents (B); ratio of real wages (C); ratio of cumulated income share (D); ratio of unemployment rate (E); ratio of total hired (F); ratio of total dismissed (F). Monte Carlo experiment average from 100 runs. 95% confidence intervals in gray.

The widened wage gap, together with the slow average real wage recovery (Fig. 7C), explains the stability of the wage and cumulated income shares (Fig. 4C and Fig. 7D) once workers with higher wages compensate for the income loss at the bottom of the distribution. This compensation effect also shows on the macro variables, which are not significantly different between experiments.

Some positive effects occur on both hiring (Fig. 7F) and dismissals (Fig. 7G), with the latter being slightly higher than the former, inducing mildly higher unemployment rates (Fig. 7E). Putting it all together, the reform does not generate aggregate benefits in both labor market and macroeconomic terms. On the contrary, it shows as a mechanism promoting higher wage inequality.

4. Analysis of the experiments: impacts on labor precariousness

The experiments (LR1 and LR2) put into action feedback mechanisms leading to the permanence of its negative impacts on work precariousness. Figure 8 summarizes the causal chain of this process, as depicted in the previous sections.
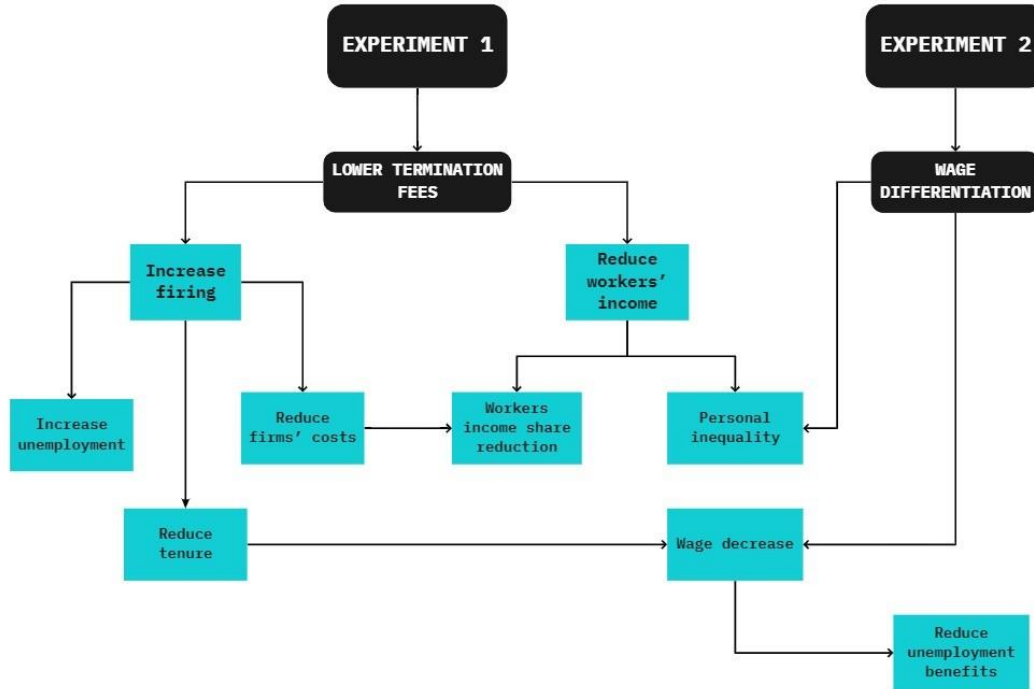

Figure 8: Feedback mechanisms into action after the labor reforms.

Three of the labor precariousness dimensions are aggravated by the first reform (LR1). Regarding certainty in maintaining an employment, the rise in unemployment makes it more difficult for workers to find jobs. For the employed, insecurity rises due to the expected reduction of job tenure. Competition for job positions in the labor market increases, thus reducing the wages growth pace. Finally, the wage level and growth are reduced, which lead to a substantial increase in income inequality. Alongside these negative effects, no significant impact was observed either on growth or productivity. In this sense, the overall effect of such a reform would be a general increase in the precariousness level in the countries' labor market, without any macroeconomic benefit.

Such scenario is made worse when we consider the impacts of the second reform (LR2). Workers, which otherwise would receive a floor wage equal to their pairs, start to receive lower payments, negatively influencing the path of wages. The lower baseline for wage adjustment widens the wage gap, implying in higher inequality as low-pay workers cannot catch. The first precariousness dimension aggravated is that of providing sufficient income.

Still, workers' negotiation power is weakened by reform, once the employer becomes able to pay a lower and uneven wage for hired workers, thus affecting workers' control over wage determination. Before the reform, low-pay workers could receive a higher wage because of the collective agreement. Now, they get just the minimum possible wage.

The reduction of wages also carries along the value of unemployment benefits and termination fees. Unemployed workers receive less income both from a reduction of the value of the benefit and of the fee paid at the dismissal, which thrives even higher inequalities.

Concluding remarks

In this work, we evaluated the impacts of the introduction of specific labor market reforms in closed economy. We used an empirically validated, theoretical agent-based model to see whether reducing worker dismissal costs and allowing for intra-firm wage differentiation would impact key labor market and macroeconomic variables. The analyzed labor market variables correspond to the dimensions of work precariousness.

The first experiment showed that termination fee reduction has two immediate effects: increases firms' incentives for firing and reduces workers' income. The former reduces tenure, the wage level, and the wage growth rate, and induces unemployment. Combined with the reduction of workers' income, personal inequality increases. The second experiment has as a direct consequence the expansion of wage and personal inequalities and the reduction of worker income. The reforms have not shown any significant consequences on most macroeconomic variables, meaning they are neither effective in promoting GDP or productivity growth nor smoother economic cycles.

Both experiments reveal how the reforms may impact precariousness dimensions. Reduced tenure and increased unemployment mean that workers in post-reform labor markets are more susceptible for dismissal and, therefore, have less degree of certainty in continuing work. Lower tenure and higher unemployment also induce workers to require lower wages, undermining workers bargaining power, reducing control in their capacity of determining wages. Consequently, reforms compromise average wage and wage growth. Because unemployment benefits have a link with wages, workers also have a protection mechanism diminished. In addition to wage reduction – increasing worker insecurity of achieving sufficient income – both personal and wage inequalities increase. By negatively affecting the four dimensions of precariousness, the experiments show that reforms may contribute to create a more precarious labor market, without producing positive outcomes even for firms.

Proponents advocating labor market reforms as the main mechanism by which better labor market and macroeconomic conditions could be achieved, in particular for the Latin American countries. However, even in the face of contesting evidence – either from the developed world experiences or simulated scenarios in the developing countries – labor flexibilizing reforms remain on the order of the day. The answer for this apparent inconsistency seems to lie on political economy: the objective behind the discourse is to allow for more appropriation of labor income in favor to capitalist class. The objective, however, is hardly achieved. Form the individual capitalist standpoint, reducing the labor costs by diminishing the termination fee and by differentiating the wages seem a direct instrument to attain the goal. However, in aggregate terms, the capitalist class yields no benefit in terms of output or productivity growth, with the collateral damage of deepening of the labor market precariousness.

Further research should consider the presence of a major informal labor market – a characteristic feature of Latin American labor markets – acting as a cushion for unemployed workers in periods of crises. In this sense, the most likely scenario would be that, after the reforms, unemployment in the formal market would be higher, but workers would migrate to informality as an alternative for (lower) income generation. Additionally, the role of minimum regulatory wage, should be taken into consideration, for the fact that it acts as guidance for wages in informal and (lower-end) formal markets. In the current model it is not possible to perform such analysis, opening opportunities for a new version.

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Appendix A

Symbol	Description	Initial condition
Variables		
Firms		
F_0	Number of firms	125
$Q_{j,0}^d$	Desired production	100
$K_{j,0}$	Capital stock	100
$mk_{j,0}$	Mark-up	0.3
$D_{j,0}$	Demand	100
$p_{j,0}$	Price	1
p_0^k	Price of capital	1
$\Lambda_{j,0}$	Profit-to-debt ratio	0
$B_{j,0}$	Loans	0
$A_{j,0}$	Productivity (technology)	1
Workers		
L_0	Number of workers	12,500
$w_{\ell,0}^r$	Wage required	1
w_0^u	Unemployment benefit	1
Parameters		
Industrial dynamics		
σ_R^2	Variance of random component of expected demand	1
η	Parameter weighing the impact of market-share over mark-up	0.02
χ	Parameter weighing the impact of competitiveness over market-share	1
ψ_1	Price-elasticity of demand of capital	0.8
δ	Depreciation rate	0.01
Labor market		
κ	Searching parameter (number of applications)	5
λ	Share of the wage considered in the computation of the termination fee	0.08
ψ_2	Elasticity of wages to productivity	0.8
Technology		
ι	Share of profits expend on R&D	0.01
$[b_1, b_2]$	Parameters of Beta distribution	[1.3, 98.7]
Government and bank		
r	Interest rate	0.01
ϕ	Profit tax rate	0.01
τ	Number of amortization periods	12
ω	Profit-to-debt threshold	0.025

Table 1: Initial conditions and parameters of the agent-based model