University of Sussex
Business, Management & Economics

Economics Department Working Paper Series

No. 30-2011

The Evolution of Gender and Racial Occupational Segregation across Formal and non-Formal Labour Markets in Brazil – 1987 to 2006

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Abstract: This paper provides a unique analysis of the evolution of gender and racial occupational segregation in Brazil from 1987-2006. Drawing on a novel dataset, constructed by harmonizing national household data over twenty years, the paper provides extensive new insights in the nature and evolution of occupational segregation over time, while also providing important new insights into the forces driving these changes. The results presented here expand upon existing research in the developing world in several directions. First, the new dataset constructed for this study allows the analysis to cover a longer time period than has previously been possible. Second, the analysis explores both gender and racial segregation side by side. Third, all of the analysis is conducted for the labour market as a whole, and disaggregated into the formal, informal and self-employed labour markets. Fourth, the paper decomposes the key driving forces that lie behind trends in occupational segregation. The paper presents three major findings: first, gender segregation is always considerably greater than racial occupational segregation, but racial segregation has been more persistent over time and has several features that make it comparatively worrisome; second, while occupational segregation is declining by both gender and race, the decline has been greater in the formal labour market. Third, the decomposition of segregation measures over time reveals that changes in the internal gender and racial composition of occupations have driven improvements over time. These important differences between formal and non-formal labour markets provide preliminary insights into the possible importance of formal labour market policies and institutions in shaping outcomes.

Keywords: Brazil, Gender, Race, Occupational Segregation, Informality.
JEL Classification: J15, J16, J71, O17, O54.

Acknowledgements: This paper draws on two chapters of my PhD thesis. I thank Gustavo Bobonis, Jairo Castro, Richard Dickens, Patricia Justino, Julie Litchfield, Rafael Osorio, Wilson Prichard and Barry Reilly and participants at the 2011 AIEL conference in Milan and at 2011 PhD conference at the University of Sussex for useful comments and suggestions. All errors are my own.

1. Introduction

Occupational segregation represents one of the core themes in the labour economics literature (e.g., Anker 1997, Reardon and Firebaugh 2002, Fryer 2010, King 1992, Charles and Grusky 1995 and Watts 1998), but despite the centrality of occupational segregation to any understanding of labour market outcomes, studies of occupational segregation have been surprisingly rare in developing countries. This paper seeks to address this gap in the literature by providing the most detailed existing analysis of the evolution of gender and racial occupational segregation in Brazil, covering the years from 1987-2006.

One reason for the absence of such studies in developing countries has been the lack of sufficiently detailed and complete data. The first empirical contribution of this study correspondingly lies in the introduction of a harmonized reclassification of occupations drawn from the Brazilian national household surveys (the *Pesquisa Nacional por Amostra do Domicilios* (PNAD)) from 1987 to 2006. This new data set addresses the absence of a systematic and consistent classification of occupations over time in the PNAD, and makes it possible to explore labour market trends over a longer period than has previously been possible, while using categories that also facilitate international comparison.

Having constructed this new harmonized occupational classification, this paper contributes to our understanding of occupational segregation in Brazil, as well to the broader literature, in several ways. First, drawing on the new data, it assesses changes in Brazilian occupational structure, and the magnitude of occupational segregation,[1] over time, providing more accurate and complete findings by employing several alternative measures of occupational

[1] In this study we focus on horizontal (or nominal) occupational segregation, which captures disparities in occupational attachment. That is, it captures the extent to which different population groups are over represented in certain occupations, and relatively absent from others. This is distinct from vertical (or hierarchical) occupational segregation, which captures disparities in the positions (and thus the pay) received by different population groups *within* individual occupations (Semyonov and Jones 1998, Blackburn et al 2001, Blackburn and Jarman 2005). That is, vertical segregation captures the extent to which certain population groups may be overrepresented in more senior or high paying positions within individual occupations. It is important to be extremely clear about definitions, as these definitions of horizontal and vertical segregation sometimes differ within the economics literature. Finally, it is important to note the distinction made by Merkas and Anker (1997): if horizontal segregation refers to differences in employment across occupations, and vertical segregation refers to different positions within occupational groups, then when there is a sufficiently detailed number of occupations used in the analysis, these two concepts tend to become equivalent.

segregation. Second, the analysis addresses both gender and racial[2] segregation side by side, in order to highlight commonalities and differences in both levels and trends over time. Third, all of the analysis is conducted for the labour market as a whole, and disaggregated into the formal, informal and self-employed labour markets, highlighting important differences and the potential importance of formal labour market policies and institutions in shaping outcomes. Fourth, the analysis is also conducted disaggregated by several key characteristics of the labour force, in order to identify specific demographic, educational, sectoral and spatial patterns. Finally, the last section employs a technique proposed by Deutsch et al (2009) in order to decompose the causes of declining segregation into, respectively, changes in the gender or racial composition within individual occupations, changes in the overall occupational structure and changes in the sub-population shares of the entire workforce.

A central goal of the paper is to not only describe trends over time, though this is valuable in its own right, but also to gain preliminary insights into the *driving forces* behind these trends. This paper nonetheless makes two novel contributions in this direction. First, by disaggregating the analysis into the formal and non-formal labour markets, we gain indirect insight into the possible impact of anti-discrimination legislation (ADL) and other labour market policies and institutions. The formal sector provides scope for regulated labour markets to function, and as such different outcomes with respect to gender and racial occupational segregation across the formal, informal and self-employed sectors are likely to reflect the impact of this regulation. While the findings are only indicative, the evidence is consistent with the view that labour market rules have contributed to lower levels of occupational segregation, as segregation has decreased faster in formal labour markets. Second, the decomposition methodology employed in the final section of the paper finds that it is changes in the internal composition of occupations that have driven improvements over time among all sectors, rather

[2] We employ the commonly recognized and understood term "racial" segregation to denote segregation based on differences in skin colour. However, while we employ this term for the sake of simplicity, the term "skin-colour based" segregation is arguably more accurate, as the Brazilian population is generally held not to be classifiable into ethnicities. Brazil is a multi-racial society, among which the dominant population groups have historically included *brancos* (whites), *pretos* (black people), *amarelos* (Asians), and *pardos* (brown people, including *mulatos*, *caboclos*, *cafuzos*, *mamelucos* and *mestiços*), while since 1992 indigenous people's have been split from *pardos* and considered an independent category. Given this complexity, we adopt Telles' approach and consider all non-white populations together, in part because the distinction between the black and brown categories is somewhat subjective, and frequently reflects the perceptions of white individuals (Telles 1992, Telles and Lim 1998). In addition, the white and non-white categorization suits our approach due to the need for a binary variable when employing standard methodologies for occupational segregation analysis.

than declining segregation simply being driven by the entry of women and non-whites into the labour force. Moreover, across both gender and racial segregation, changes in the occupational structure have contributed to increasing levels of segregation, though this effect is concentrated entirely in the non-formal labour markets.

The paper is structured as follow. Section 2 reviews existing studies that investigate occupational segregation and informality, particularly in the Brazilian context. Section 3 describes the construction of the new data set, based on the harmonized classification of occupational codes over twenty years. Section 4 provides a brief overview of key changes in the Brazilian occupational structure over time. Section 5 presents the analysis of gender and racial occupational segregation by applying several well-known segregation measures. Section 6 presents the decomposition of changes in both gender and racial occupational segregation over time, while the final section concludes.

2. Literature Review

While occupational segregation is among the core topics of labour economics surprisingly little systematic empirical research has been conducted on this topic in developing countries, while few have sought to carefully compare gender and racially based segregation, and none have drawn clear connections between informality and broader trends in occupational segregation. A careful review of the literature reveals 25 studies that measure occupational segregation in individual countries, of which the majority focus on gender occupational segregation[3] and only three look at developing countries.[4] The only studies to look jointly at gender and racial segregation focus on developed countries (Albelda 1986, King 1992 for U.S. and Neuman 1994, 1998 for Israel). In addition to these individual country studies, a smaller

[3] For U. S. see Albelda (1986), Blau and Hendricks (1979), Baunauch (2002), Cotter et al (2003), Hutchens (1991, 2004), King (1992) and Watts (1995); for United Kingdom see Hakim (1992, 1993) and Watts (1998); for Australia see Lewis (1982), Moir & Selby-Smith (1979) and Karmel & Maclachlan (1988); for Ireland see Reilly (1991); for Israel see Neuman (1994, 1998), for Switzerland see Deutsch et al (1994) and Fluckiger and Silber (1999), for Brazil see Oliveira (2001), for Spain see Mora & Ruiz-Castillo (2003), for Mexico see Calonico and Nopo (2007), for Colombia see Castro and Reilly (2011). Among previously cited works, Albelda (1986), King (1992) and Neuman (1994, 1998) also explore racial occupational segregation. In addition we find two studies only on racial segregation in the US, such as Boisso et al (1994) and Maume (1999).

[4] Calonico and Nopo (2007) on Mexico, Castro and Reilly (2011) on Colombia, Oliviera (2001) on Brazil.

number of studies adopt a cross-country perspective (Blackburn et al 1993, Charles and Grusky 1995, Melkas and Anker 1997, Semyonov and Jones 1999, Anker et al 2003, Deutsch et al 2005 and Deutsch and Silber 2005), of which only two consider experiences in developing countries[5].

Focusing specifically on Brazil, theoretical and empirical research looking at wage discrimination is extensive (see among others, Soares 2000, Arcand and Hombres 2004, Arias et al 2004, Arabsheibani et al 2003, Carvalho et al 2006), but the only empirical study of occupational segregation is, to the best of the author's knowledge, Oliveira's (2001) study finding that gender occupational segregation, measured by the Duncan Index, declined by three percentage points between 1987 and 1999 when measured at the 3-digit level of occupational classification. There is a clear opportunity to update Oliveira's work over a longer period of time, and to move beyond it in looking at racial segregation, and in disaggregating the analysis into the formal, informal and self-employed sectors.

The decision to disaggregate the analysis into the formal and non-formal sectors reflects the greater risk exposure faced by those in the informal sector, and the potential to highlight the factors contributing to different patterns of occupational segregation across sectors. Given this focus on informality, it is useful to briefly review existing research looking at the evolution of the Brazilian informal sector.

Arriving at a precise definition of informality is challenging both conceptually and empirically. The first conceptualization of informality is attributable to Hart (1971, 1972) and it mainly used to the concept of informality as small business mostly characterized by rudimentary technologies. Conceptually, the informal sector can be seen in productive terms, as offering employment to micro-entrepreneurs, families engaged in small businesses, precarious and unskilled workers, or it can be viewed though a more legalistic lens, as a site for unregulated and illegal activities that evade taxation (Gasparini and Tornarolli 2007). These two definitions imply a need to distinguish between informality and the shadow economy, that is, between small businesses and other illegal and tax-avoiding activities (Cacciamali 1982, 1983).

Alongside these conceptual issues is the question of how, methodologically, to identify informal workers. Some early studies of Brazilian informality focused on wage workers without labour contracts, self-employed individuals, employers earning up to a certain portion of the

[5] Deutsch et al (2005) on Costa Rica, Ecuador and Uruguay, and Anker et al (2003), who analyze cross-country variation in occupational segregation, including both developed and developing countries.

minimum wage, unpaid family workers, and domestic service workers (see Jatoba 1987 and Gatica 1989 cited in Carneiro 1997), while other studies adopted a definition of informality based on the payment of social security contributions (see Cacciamali 1988, Telles 1992). In a more recent paper, Henley et al (2009) compare three different definitions of informality: i) contract status, based on the possession of a signed labour card; ii) social security status, based on contribution to a social security institution; and iii) formal sector activity, based on employment within a firm with more than five employees. They find that only 40% of cases are classified as informal across all three definitions of informality, highlighting the importance of clear definitions.

Despite these definitional challenges, most empirical studies in Brazil have defined informal workers as those workers without signed work cards, the *carteira de trabalho* (Carneiro 1997, Soares 2004, Ulyssea 2006). However, even this definition leaves important issues unresolved. The first relates to the treatment of the self-employed, as different studies have opted to exclude them, include them in the informal sector or treat them as a separate component of non-formal labour markets, as is the case here (Maloney 2004, Almeinda and Carneiro 2007). The second related to employers, for whom identifying formality or informality is very difficult, as they do not possess the *carteira de trabalho*. The ILO considers employers with less than five employees to be in the informal sector, and this definition is adopted by Bosh et al (2007) in their study of the Brazilian informal sector. However, this threshold varies from country to country (see the discussion in Bosh et al, 2007), information on the number of employees might be missing and some small firm employers may be formal according to other metrics, such as the payment of social contributions.

While there are both conceptual and methodological issues related to establishing a universal definition of informality, there is consensus that the Brazilian informal market is large, with estimates placing it at 50% of more of the total labour force (e.g. Urani 1996, Carneiro 1997, Soares 2004, Bosch et al 2007, Ramos and Ferreira 2005). Much of this literature further argues that the informal sector has been rising over time, with Bosch et al (2007) in particular arguing that it has increased by 10% during the 1990s. However, Ramos and Ferreira (2005) argue that this worrisome increase in informality in Brazil is primarily confined to urban areas and the manufacturing sector, while attention to the nation as a whole provides a more mixed pattern. Equally important, the recent work of Bosch et al (2007) argue that the informal sector

is closely intertwined with the formal sector labour market, though providing an attractive alternative for more flexible and unregulated business outside of government regulations (see also Carneiro 1997, Fiess et al 2008). Consistent with this view, they find that both formal and informal labour markets are highly pro-cyclical and strictly interrelated, as most transitions from the formal to the informal sector occur *within particular industries*, rather than resulting primarily from structural changes in the importance of different economic sectors (see also Maloney 1999, 2004).[6]

Along with capturing broad trends, several authors seek to explain the determinants of these trends, though disentangling causality is inherently difficult. Bosch et al (2007) conclude that the primary driver of the growing informal sector that been institutional reforms affecting the labour market, including union power, firing costs and overtime rule, while trade liberalization has a played only a very minor role. Several other authors broadly echo this finding, arguing that stronger enforcement of labour protection in the formal sector may reduce hiring and encourage informality (Carneiro 1997, Holk 2002, Ulyssea 2010). Goldberg and Pavcnik (2003) similarly find no impact of trade variables on trends in the informal sector, while Paes de Barros and Corseuil (2001) argue, contrary to Bosch et al (2007), that there is no evidence that labour market regulations have driven changes in levels of informality. Ultimately, these studies generally find that tighter regulation in the formal sector is an important reason for informality. On the other hand, they also do not address other factors that may also shape trends in the informal sector, such as reforms in the public health sector or the huge migration of workers from rural areas to urban/metropolitan areas, primarily in the South-East of Brazil.

Finally, and of greatest interest to this paper, several studies have highlighted key features of the informal sector that appear to reflect an important connection between informality and occupational segregation. Telles (1992) and more recently Ulyssea (2010) note that the informal sector continues to be dominated by women and non-whites, and particularly by non-white women, though they both note the comparative lack of attention to issues of race in studies of the Brazilian informal sector. These patterns are most clearly revealed in the experience of domestic service workers, who are primarily women, disproportionately non-white and remain largely informal (Abramo 2004). Finally, Telles (1992) notes that educational attainment plays a

[6] The limited role of structural changes in justifying the explosion of the informal sector is also acknowledged in Ramos and Ferreira (2005).

particularly important role in the ability of women to enter the formal labour market, with uneducated women overwhelmingly employed in the informal market, while the same pattern does not hold true for men. These very cursory findings from the literature provide an initial inspiration for the decision here both to consider gender and racially based segregation side by side and to consider the formal and non-formal labour markets separately.

3. The Construction of the new Classification of Occupational Codes

Most studies of occupational structure, occupational segregation and informality in Brazil are based on the *Pesquisa Nacional por Amostra do Domicilios* (PNAD), but these studies are plagued by the existence of a major break in the data on occupations, owing to a radical change in the way that occupations have been classified especially since 2001. The result is that it has been difficult or impossible to conduct studies of the evolution of occupational segregation in Brazil over a protracted period of time and including recent developments.[7] In order to overcome this problem, this study is based on a novel re-classification and harmonization of the occupational codes from successive PNAD surveys, thus allowing for the analysis of trends in occupational structure and segregation over a longer period, and in greater detail, than has previously been possible. The most detailed and compatible existing re-classification of occupational codes using the national household survey (PNAD) is attributable to Osorio (2008), who constructed 46 occupational codes at the 2-digit level over the period 1986 to 2006. Nonetheless, our effort is more accurate than previous re-classification efforts, including those studies that have employed different surveys, for example, Barros et al (1997), Lovell (1994, 2000, 2006), Lago (2006).[8]

[7] While Oliviera (2001) considers occupation segregation over a relatively protracted period, from 1981 to 1999, this was only possible because the study focused on years prior to the radical change in the PNAD classification of occupational codes (Oliveira, 2001). The same is true for Machado et al (2003), who look at trends over the period 1981-2001 (again stopping before the break in the PNAD data in 2001) by aggregating over 300 occupational codes at the 3-digit level into 67 groups at 2-digit level.

[8] The Brazilian national commission for classification, the *Commisão Nacional de Classificação* (CONCLA) has also prepared a re-classification that recoded the official national classification of occupations (CBO-94), and the official classification of occupations used by the Census, in order to make both compatible with the international classification standard ISCO-08 (also discussed in Muendler et al, 2004). However, the official national classification of occupations by CONCLA does not address the disruption of the time series by changes in the occupational codes for the PNADs starting in 2002.

The methodology for this reclassification is described very briefly here, due to the lack of space.[9] The key challenge in this reclassification has been to ensure sufficient homogeneity within each occupational grouping. To this end, key features of each occupational group have been analysed and taken into account, and we have paid special attention to the mean of main job earnings and both the means and modes of the maximum level of education attained. A key element in understanding this process, which is stressed in Muendler et al (2004), is that in re-classifying occupations, we have transformed the more profession-based Brazilian classification system CBO-94 into the more skill-oriented international system ISCO-08. The resulting re-classification of Brazilian occupational codes is consistent over time and compatible with international standards, containing 80 occupational codes at 3-digit level, 26 occupational codes at 2-digit level and 10 occupational codes at 1-digit level (see the complete re-classification in Table A1 in the appendix). The major occupational groups at 1-digit level are, in order: Legislators, senior officials, and managers; Professionals; Technicians and associate professionals; Clerks; Service workers and shop and market sales workers; Skilled agricultural and fishery workers; Craft and related trades workers; Plant and machine operators and assemblers; Elementary occupations, and; Armed forces.

4. Background: The Evolution of Brazilian Occupational Structure

While our focus is on the evolution of occupational segregation over time, it is useful to begin with an overview of broad changes in occupational structure, as well as how these new estimates compare to earlier research. What follows focuses, in particular on highlighting differences based on gender and race, as well as across the formal, informal and self-employed sectors. Throughout the analysis, we consider the entire national labour market, i.e. all five regions of Brazil and both urban and rural areas. As noted earlier, this is important, as conditions are somewhat variable across the country and, as such, analysis of specific regions or metropolitan areas risks capturing trends that do not reflect the situation of the entire nation. Of course, this national focus risks obscuring important differences across sub-groups or regions, and the analysis thus concludes with a discussion of these differences.

[9] Additional information is, of course, available from the author.

As was already noted, we divide the entire labour market into the formal, informal and self-employed sectors. The formal sector comprises private sector employees with signed labour cards, domestic workers with signed labour cards and civil servants. The informal sector comprises private sector employees and domestic workers without a signed labour card. Given that our sample covers both urban and rural areas, agricultural workers both with and without signed labour cards are included in the formal and informal sectors respectively. We choose to keep self-employed workers separate from informal workers due to differences in composition and trends amongst these two non-formal sectors. We exclude military forces and employers.[10] Finally, our sample excludes workers who are not remunerated or for whom the wages variable is missing. As the exclusion of 'zero wage' observations is likely to result in an underestimate of the non-formal sectors, we perform a robustness check to see if accounting for these zero wages observations has a significant effect on our estimates of informality and segregation.

4.1 Distribution of Workers between the Formal and Non-Formal Sectors

Dividing the Brazilian employed labour force into the formal, informal and self-employed sectors reveals two broad messages. First, the informal and self-employed sectors cover more than half of the entire sample across all twenty years. Second, the distribution of workers across these three sectors has remained nearly constant over time (Figure 1). The formal sector has increased by only 1.23 percentage points during the last two decades, moving from 45.53% in 1987 to 46.76% in 2006. On the other hand, both the informal and self-employed sectors have declined by 0.6 percentage points. The absence of an increase in informal sector activities at the national level is in line with previous research by Ramos and Ferreira (2005). While several other studies have reported rising informality, this rise, as generally acknowledged in several empirical studies,[11] is a more restricted phenomenon that refers mainly to private employees in metropolitan areas, especially in the South-East region. Part of the explanation for the differential trend when looking at the national level is the fact that our sample accounts for

[10] While we could have followed Bosh et al (2007) in using the ILO threshold to distinguish formal and informal sector employers (with those with less than five employees considered informal), this method appears to be problematic in this case, as the data reveals that at least 50% of small firm employers pay social security contributions and, as a consequence, should not be considered informal workers.

[11] See, for example, Carneiro (1997) and Bosh et al (2007). Carneiro (1997) report a rise of informality by looking at the metropolitan area of Sao Paulo. Bosh et al (2007) claim that the informal sector has increased by 10 percentage points between 1985 and 2002 by considering only private sector in six metropolitan areas.

agricultural and domestic workers, both of whom have experienced an increase in the "degree of formalization" of their occupations over time.[12]

[Figure 1 about here]

Turning to trends by gender and race, Figure 2 reveals that although male and white workers have traditionally dominated the Brazilian labour market, the presence of women and non-white workers has consistently increased over time, by 5.74 and 6.59 percentage points respectively. Looking specifically at women, despite the huge increase of women in the entire labour market, they are still generally underrepresented in Brazilian labour market and are more present in the informal sector (Wajman and Rios Neto 2000, Soares and Izaki 2002, World Bank 2002a, 2002b). In the case of race, the increasing share of non-white workers in the labour force has resulted in their exceeding the share of white workers starting from 2003. Despite this rapid increase in the share of women and non-white individuals in the labour market, it is important to note that both groups continue to be strongly overrepresented in the informal sector relative to formal sector employment.

[Figure 2 about here]

While women have entered the labour force rapidly, the experiences of white and now-white women have been very different (Figure 3). White women have overwhelmingly joined the formal sector, with their participation in the informal sector actually declining, while non-white women continue to be sharply overrepresented in the informal sector. Along the same lines, we see an increasing representation of non-white workers in both non-formal sectors, mainly driven by non-white women in the informal sector (roughly six percentage points) and non-white men in the self-employed sector (roughly five percentage points).

[Figure 3 about here]

[12] In our dataset, the share of formal agricultural workers increased from 12% to 18% between 1987 and 2006, while formal domestic workers increased from 19% in 1992 to 27% in 2006 (see Fonseca & Rayp (2011) on the formalization of agricultural workers and Berg (2010) and ILO (2010) on the formalization of domestic workers).

4.2 Labour Market Trends, Disaggregated by Characteristics of the Labour Force

In addition to these broad trends, more nuanced messages emerge by considering different populations groups disaggregated by key characteristics (age, education, economic sector, region, and urban/rural).[13] Due to the constraints of space we selectively highlight the most important insights that emerge, rather than presenting each individual piece of the analysis.

Looking first at employed female labour force, we find growing participation among young and adult women with respect to their male peer group, but also find that the share of elderly women in the labour force has risen rapidly, as women now remain in the labour market longer (Wajnman et al, 2006). With respect to years of education, women have always represented more than half of the total educated labour force: well educated women are much more likely to be engaged in the labour force. The presence of women is predominantly in the tertiary sector and especially in the social services, trade and hospitality and financial services sectors. Finally, female participation has increased primarily in the South and South-East regions, and primarily in urban areas.

Non-white workers have increased across all age groups, and particularly among young workers, with young non-white workers becoming more than half of the labour force after 2000. Non-white workers represent the predominant share of the illiterate labour force, at an average of 70%, but their share of the more educated workforce is also, encouragingly, increasing.[14] The presence of non-white workers is predominantly in the primary sector, followed by the secondary sector, while non-white participation is increasing homogeneously across all three sectors over time.[15] The North and North East regions record the largest share of non-white workers, while non-white workers also represent the majority of the rural labour force over time. The fact that

[13] We define three main age groups: young (aged 15-29), adult (aged 30-49) and elderly (aged 50-65). For educational attainment the employed labour force is divided among illiterate workers, workers that achieved compulsory school level only and more educated workers with more than a compulsory school degree. We consider a standard three sector grouping of economic activities (primary, secondary and tertiary sectors) as well as a detailed breakdown of different economic activities: a) agricultural, forestry and fishing activities (hunting is included as well), b) mining, c) manufacturing, d) services related to electricity, gas and water provision, e) construction, f) trade activities and services related to hospitality and tourism, g) transport and storage activities, h) financial services (including insurance services) and real estate and, finally, i) social services (including health and education). Finally, with respect to geography we consider the five main regions of Brazil (North, North-East, South-East, South and Central-West) as well as the division between urban and rural areas.

[14] Among those that have attained only compulsory school, the share of non-white workers has increased from 47% to 59%, while their share of the workforce with more than compulsory education has similarly increased, from 20% up to 34% (the rise of educational attainment among non-white Brazilian is also documented in Osorio, 2008).

[15] At a more detailed level of disaggregation, non-white workers are most heavily represented in agricultural activities and the construction and mining sectors (mainly non-white men) followed by trade and hospitality and social services (mainly non-white women).

the share of non-white workers in the North and North-East has remained relatively constant, despite the aggregate rise of non-white participation in the labour market, may be evidence of migration across regions during this period.[16]

4.3 Trends in Occupational Distribution

If we turn to looking at the occupational distribution – that is, investigation of the professions in which members of different population groups are primarily employed – a number of further insights emerge. First, although there has been an increase in female and non-white participation in the labour market, the occupations in which these groups are primarily employed have, somewhat surprisingly, remained relatively stable over time (Figure 4). That is, a large part of the increase in female labour force participation has been directed at the same economic sectors in which they have historically been employed, primarily in the tertiary sector. For non-white workers we see somewhat greater change in the occupational distribution, with significant movement into the secondary and, particularly, tertiary sectors, but here too this movement has been largely into areas in which that have traditionally been employed. The result is that new female and non-white workers have largely been employed in the tertiary sector, consistent with the rapid growth of the tertiary sector as a share of the overall labour market (Baer 2008: chap. 18, World Bank 2002b).

[Figure 4 about here]

Second, we find that women tend to be more concentrated in a few occupations (e.g. teaching associates, personal service workers), while non-whites are more homogenously distributed in the occupational structure. Interestingly, we find that female dominated occupations are generally more-skilled (such as teaching) than male dominated professions (such as extraction and building trade workers). Along the same lines, non-white dominated occupations are generally less skilled occupations than those that are white dominated. That said, we also find that while women tend to be concentrated in particular occupations, those

[16] Brito and de Carvalho (2006) and Gomes Braga (2006) explore the features of internal migration in Brazil, and report evidence of migration toward urban areas and toward the southern regions particularly during the 1990s. On the other hand, new work by Pochmann (2007) reports a different trend in recent years, as new regions, such as Amazonas, Mato Grosso e Goiás (among other, primarily in the Central-West and North regions) have replaced the South and the South-East regions as the primary recipients of internal migrants.

specific occupations are quite different between the formal and informal sectors, with, for example, large numbers of women in the informal employed as housekeepers or manufacturing workers, while in the formal sector women are concentrated among teachers and clerks.

Third, we, not surprisingly, find some evidence that non-formal employment tends to be concentrated in a relatively smaller number of occupations than formal sector employment. This is suggestive of less diversified informal and self-employed sectors, but the difference with the formal sector is less than we might have expected. The absence of a larger difference is in line with the hypothesis, proposed by Bosch et al (2007), that informality does not simply exist in marginal sectors, but frequently expands across all sectors of the labour market.

Finally, we find that the concentration of individual population groups within particular occupations is declining over time, even within those occupations that remain highly segregated. For example, female dominated occupations, such as personal services, have seen the increasing entry of male workers, while financial services, which are highly male dominated, have witnessed growing female participation. This trend towards greater homogeneity in the representation of female and non-white labourers in the labour force is an important issue to which we return later to the analysis of the driving forces behind changes in segregation over time.

5. Measuring Occupational Segregation over Time

The analysis of the occupational segregation is undertaken by using three different indices of segregation: the Duncan index (I_D), the Karmel and Maclachlan index (I_{KM}), the Gini segregation index (I_G). Our motivation in applying this wide range of measures is twofold: first, to understand the extent to which the results may be dependent on the particular measures being employed, and, second, to gain a corresponding insight into which measure is best suited to our purpose.

The dissimilarity index, or Duncan index (Duncan and Duncan 1955), is certainly one of the most applied indexes of segregation and is given by the following formula:

$$I_D = \frac{1}{2}\sum_{i=1}^{n}\left|\frac{F_i}{F} - \frac{M_i}{M}\right| \qquad \text{with } i=1,2,\ldots,n \qquad (1)$$

where F_i and M_i are the number of female and male workers in the i^{th} occupation and F and B are the total number of women and men in the labour force.[17] The index is generally interpreted as measuring the proportion of the female workforce that would be required to shift between occupations in order to equalize female and male representation across occupations. The main weakness is the fact that redistributing the female workforce to reach zero segregation there would also imply a change in the occupational structure. Furthermore, this index assigns equal weights to each occupation independent of its relative size. Watts (1998) claims that the Duncan index fails to show occupation invariance, but it invariant to gender composition of the labour force.

There are several other measures of occupational segregation that have been proposed in the literature, of which we test two alternatives that address some of the criticisms of the Duncan index. A modification of the dissimilarity index has been developed by Karmel and Maclachlan (1988). The Karmel and Maclachlan index denotes the total labour force to be relocated *with replacement* in order to reach zero female-male segregation, while keeping the occupational structure and the overall female and male shares of the workforce constant.

$$I_{KM} = \frac{1}{2}\sum_{i=1}^{n}\left|a\frac{M_i}{T} - (1-a)\frac{F_i}{T}\right| \tag{2}$$

where $a = \frac{F}{T}$ is the share of female in the total labour force.

Finally, the Gini segregation index is defined by the following formula:

$$I_G = \frac{1}{2}\frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\frac{M_i M_j}{M\ M}\left|\frac{F_i}{M_i} - \frac{F_j}{M_j}\right|}{\frac{F}{M}} \tag{3}$$

As Silber (1989a, 1989b) notes, the G-segregation index is equal to the Gini Index of the female-male ratio, where the weights are the shares of each occupation in the total male workforce. Assuming a segregation curve which can be defined as a cumulative distribution of the proportion of women in every occupation, the index is given by twice the area lying between the segregation curve and the equi-distribution line given by the 45 degrees diagonal in a similar spirit to the Lorenz curve in the inequality literature.

[17] The formulas reported in this section refer to gender segregation. In order to compute the indices for racial segregation F and F_i have to be intended for non-white workers and M and M_i with white ones.

5.1 Occupational Segregation across Formal and Non-Formal Sectors

Turning to the results, each index is computed independently for both gender and racial segregation, as well as separately for the formal, informal and self-employed sectors. Table 1 provides the results of computing the different measures of occupational segregation, along with their bootstrapped standard errors.[18] All indices of segregation have been computed using our harmonized 3-digit occupational classification.[19] In order to assess the importance of changes in the segregation measures across sectors and over time, we calculate the statistical significance of the changes among formal, informal and self-employed sectors in any given year as well as over time, using five reference years (1987, 1992, 1997, 2002 and 2006). Tables A2 and A3 in the appendix report the test of mean differences, respectively, among sectors and over time using the standard parametric two sample *t*-test. Finally, in order to ensure that the results are robust, and not driven by the specific methodological choices involved in constructing the new classification of occupational codes, we conduct two robustness checks. The first compares the results to those that emerge when employing the original PNAD classification, while the second checks the impact of the exclusion of 'zero wage' observations from the analysis.[20] The robustness checks, though not reported in full here due to the constraints of space, confirm the credibility of the results.

[18] The standard errors are computed using the boostrapping technique based on 500 replications, following the approach illustrated by Efron and Tibshirani (1991, 1993). The bootstrap method estimates the distribution of the segregation measure by resampling with replacement in order to create multiple estimates of the statistics. These distributions are then used to construct confidence intervals around the original points and ultimately to establish standard errors (see also Boisso et al, 1994).

[19] Figures on occupational segregation by using occupational codes at 2-digit level are also available: the patterns are almost the same, but the extent of segregation is on average smaller. The more detailed are the occupational categorization the greater is the outcome from any measures of segregation.

[20] First, it is important to ensure that our findings represent actual changes in the distribution of workers across occupations, and are not an artefact of the methodology employed in constructing our new harmonized occupational classification. As a partial check against this possibility, our first robustness check compares our results presented in this section to results computed using the original classification: overall, the outcome of this comparison is reassuring. The second check refers to the exclusion of zero wage observations. The zero wage observations comprise missing wages and non-remunerated workers. Missing wages are on average only 1.4% of the entire sample and randomly distributed across occupations. Not remunerated workers represent instead an average of 9.5% of the sample. More importantly, not remunerated workers are non-random, and generally report employment in own-production, own-construction or as member of the household, mainly in the agricultural sector and are overwhelmingly women and primarily non-whites. In their earlier study of Brazilian informality, Ramos and Ferreira (2005) find that the exclusion of not remunerated workers from the analysis leads both to an underestimate of the size of the informal sector and to a change in the observed trend over time. Our findings are very similar, as we find that if we add not remunerated workers to the sample the overall estimate of the size of the informal sector increases as well as of occupational segregation - which is what we would expect given that the majority of not remunerated workers are female and non white.

[Table 1 about here]

The results are, encouragingly, broadly similar across the three indexes,[21] thus reinforcing our confidence in the results. For simplicity, what follows focuses on the widely used Duncan Index, and we can highlight three main findings. First, gender occupational segregation is always considerably greater than racial occupational segregation - roughly three times greater. In 2006 the Duncan index between female and male workers was 0.565, which is much greater than the Duncan index of 0.191 between non-whites and whites. This means that in 2006 more than half of female workers and one fifth of non-white workers would have needed to be reallocated in order to equalize workers' representation across occupations.

Second, gender segregation is generally more severe in the informal and self-employed sectors, as the Duncan index by gender in 2006 was 0.513 in the formal sector, while it was 0.653 for the informal sector. The same does not hold equally true for racial segregation, as levels of segregation in the formal and informal sectors were not statistically different from each other in 1987 and 2002, while during the 1990s racial segregation in the formal sector was, in fact, slightly higher than in the informal sector. That said, this trend has been significantly reversed since the beginning of the 2000s, when racial segregation in the informal sector began to exceed that in the formal sector. These results are all statistically significant and hold among each of the Duncan, Karmel & Machlachlan and Gini segregation indices (Table A2 in the appendix).

Third, overall levels of segregation are declining, though this decline has been much more pronounced for gender segregation, and in the formal sector rather than the informal sector. Using the Duncan index, gender segregation decreases overall by 6.5% between 1987 and 2006, while racial segregation declines by only 4.2%. Focusing on gender segregation, after a negligible increase in the early 1990s, we record a decrease in all of the segregation measures between the beginning of the 1990s and 2006, and these changes are always statistically significant (Table A3). This decline in gender segregation is focused in the formal sector (-7.7%) rather than in the informal sector (-5.5%). This declining trend for gender occupational segregation in Brazil is consistent with Tzannatos (1999) who finds that in developing countries

[21] Differences in segregation measures are mainly imputable to the properties of these indices and are acknowledged at the end of the section.

gender differentials in employment and pay are narrowing even faster than was the case in developed countries during the 1960 and 1970s, when they were experiencing rapid labour market changes (Watts 1998, Baunauch 2002). Racial segregation similarly decreases primarily in the formal sector (-8.2%) and is particularly sensitive to informality, as its decline in the informal sector is small (-3.1%). In fact, in the informal sector we see a somewhat surprising, and statistically significant, *increase* in racial segregation from the beginning of the 1990s, resulting in an overall decline in racial segregation in the informal sector between 1987 and 2006 that is not statistically different from zero (Table A3). While Table 1 reports the measures of occupational segregation every 5 years, Figure 5 plots the continuous evolution over time of the different measures.

[Figure 5 about here]

Finally, although the trends described so far are broadly common across all of the segregation indexes, it is also important to comment briefly on the differences in levels and trends across them. As regard to comparison among segregation indices, the Gini segregation index reports the highest figures among all indices. In 2006 the Gini segregation index was equal to 0.735 and 0.262, by gender and race respectively. Instead of looking at mean deviations as it occurs in the case of Duncan-type of indices, the Gini index uses mean differences to measure the dispersion of the occupational distribution. Thus, segregation appears a more severe problem when focusing on the compositional differences among all occupations, as the Gini index does, rather than focusing on how gender and racial ratio varies between each occupation and the overall workforce composition, as in the Duncan index.

By using the Karmel and Maclachlan index, the level of estimated segregation dramatically diminishes although the patterns are in line with the other indices. Again, the reason can be found in how these indices are constructed. The Duncan index detects the number of female workers that need to be moved without replacement allowing changes in the occupational distribution. The Karmel and Maclachlan index measures the number of female workers that should be shifted with replacement in order to obtain zero segregation without changing the relative size of each occupation and the overall size of the labour force (Watts, 1998). In Table 1, we notice that when the Duncan index is decreasing, the Karmel and

Maclachlan index decreases less or in some cases it even increases. This implies that, although the female-male differential has narrowed, the increasing number of women entering the labour market has meant that the proportion of workers needed to shift occupations to reach zero segregation has not changed or it has slightly increased (Karmel and Maclachlan, 1988).

5.2 Exploring Demographic, Educational, Sectoral and Spatial Patterns

As with the previous section, we conclude by exploring trends in occupations segregation disaggregated by key characteristics of the population (demographic, educational, sectoral and spatial). We calculate the Duncan index over time for each of the sub-groups of interest in order to disentangle differential trends in the data. The findings are presented in Figure 6 and we simply summarized the most important findings here.

In terms of demographic patterns, gender segregation is higher among older workers, while racial segregation is, somewhat surprisingly, higher among younger workers. With respect to educational patterns, gender segregation is lower among those with more education, but, racial segregation is, surprisingly higher among those with more education. This finding suggests that not only are non-whites a comparatively small share of the highly educated workforce, but they are unusually concentrated in some professions, and absent from others. That said, while segregation is higher among highly educated non-whites, we also see that after increasing rapidly from 1987-1993, segregation within this group has declined rapidly since the mid 1990s, while segregation among less educated groups has been stable, or slightly increasing, over time. We observe a similar trend among women, as gender segregation is not only lower among highly educated workers but it has also been declining rapidly, whereas segregation has declined only very modestly for less educated groups.

Moving to sectoral patterns, we find that segregation has increased in the secondary sector, particularly with respect to gender, while the opposite is true in the primary sector, where gender segregation has declined significantly. In the tertiary sector both gender and racial segregations have consistently declined over time. Within the tertiary sector women and non-whites have continued to make up the majority of the labour force, even as the overall size of the tertiary sector has grown rapidly, reflecting rapid new entry in this sector. The fact that segregation has been declining thus seems to reflect decreasing concentration within individual

occupations, as white men in particular also enter the sector and join traditionally female and non-white dominated professions.[22]

Turning finally to spatial patterns of segregation, we see that segregation has declined relatively homogenously across all regions. That said, there has been a particularly dramatic decline in gender segregation in the Central-West region, while racial segregation has been declining everywhere, but remains strikingly much higher in the South-East and South regions than elsewhere in the country. Finally, gender segregation is higher in rural areas while racial segregation is higher in urban areas.

[Figure 6 about here]

6. Decomposition of changes in segregation over time

Having presented these broad trends, what remains is to seek to better understand the underlying forces that have driven these changes in occupational segregation over time. In particular, the analysis to follow seeks to understand whether declining occupational segregation is driven by more homogenous composition by gender and race within individual occupations, by changes in occupational structure (namely occupations' weights) or by changes in sub-population shares (gender or racial) of the entire labour force. This is particularly crucial given that the Duncan index, as well as other indices of segregation, is sensitive to changes in occupations' weights and to changes in gender and racial shares of the labour force. We thus employ the decomposition methodology proposed by Deutsch et al (2009), which combines the Karmel and Maclachlan (1988) decomposition and the concept of the Shapley value in order to distinguish between these three different sources of variation in occupational segregation (see also Shorrocks, 1999 and Sastre and Trannoy, 2002).

Segregation can change over time because of the changes in the internal gender or racial composition within each occupation. This source of variation is also termed 'net segregation' or variation in the 'internal structure' because it is independent of the variations that can occur 'in

[22] The tertiary sector covered 43% of the entire economy in 1987 and had grown to 67% in 2006. The female share of the tertiary sector has declined from 56% in 1987 to 52% in 2006, while the non-white share has increased, moving from 46.4% to 51%.

the margins'. The changes in segregation occurring because of 'variation in the margins' capture, respectively, changes in the relative weights of occupations or changes in the shares of sub-populations groups in the total labour force. The sum of these three sources of variation (i.e. the internal structure and the two components of the margins) is termed 'gross variation' in occupational segregation.[23]

Following Deutsch et al (2009) derivation, it is possible to decompose the change over time of a segregation index as follows:

$$\Delta I = I_v - I_p \tag{4}$$

where I_v and I_p represent, respectively, the indices for the final and initial periods of time. If we apply the concept of the Shapley decomposition following Deutsch et al (2009), the total variation, defining 'gross variation' of segregation over time, can be decomposed as follows:

$$\Delta I = f(\Delta m, \Delta is) = C_{\Delta m} + C_{\Delta is} \tag{5}$$

where $C_{\Delta m}$ and $C_{\Delta is}$ represent the two main components of the decomposition, the component of the change due to the variation in the 'margins' and the component of the change due to variations in the 'internal structure' (or 'net segregation') and they will be

$$C_{\Delta m} = \frac{1}{2} f(\Delta m) + \frac{1}{2}[f(\Delta m, \Delta is) - f(\Delta is)] \tag{6}$$

and

$$C_{\Delta is} = \frac{1}{2} f(\Delta is) + \frac{1}{2}[f(\Delta m, \Delta is) - f(\Delta m)] \tag{7}$$

The contribution of these components is then proved to be expressed also as follows:

$$C_{\Delta m} = \frac{1}{2}\{[I(s) - I(p)] + (I(v) - I(w)]\} \tag{8}$$

and

$$C_{\Delta is} = \frac{1}{2}\{[I(w) - I(p)] + (I(v) - I(s)]\} \tag{9}$$

where the set of matrices employed in the above equations are obtained by interacting both margins and internal structure of the segregation matrices from which the two indices I_v and I_p can be drawn. The two initial matrices are P and V and we need to compare them to derive matrix S which has the internal structure of P but the margins of V. In the same way, matrix W

[23] The Shapley decomposition by Deutsch et al (2009) is inspired by the decomposition technique proposed in Karmel and Maclachlan (1988). In fact, they have proposed to decompose the segregation index into the mix effects (gender, occupation and gender by occupation) and the composition effect, which are similar respectively to the variations due to the margins and to the internal structure proposed by Deutsch et al (2009). The important innovation of the Shapley decomposition is the absence of an interaction term or residual from the decomposition.

can be derived with the internal structure of matrix V and the margins of matrix P, simply by inverting the process.

In order to explain the derivation, let's start by considering the matrix P. This matrix has the ratio T_{ij}/T in its internal structure where T_{ij} is the number of individuals of occupation *i* and from the subpopulation *j* and *T* is the total number of workers. The margins of matrix P are defined by $p_{i\cdot} = T_i/T$ and $p_{\cdot j} = T_j/T$ which are respectively the horizontal margins (occupational structure) and the vertical margins (shares of the sub-populations).

To derive the matrix S, we need to multiply all element of P by the ratio $v_{i\cdot}/p_{i\cdot}$ and obtain an intermediate matrix X. Its elements need to be multiplied by the ratio $v_{\cdot j}/x_{\cdot j}$ to obtain a new matrix Y and so on, after several iterations, the matrix will converge to the matrix S with the internal structure of P and the margins of V (see Deming and Stephan, 1940).

As said, we could also start with the matrix V and by applying the same procedure we will end up with the matrix W that has the internal structure of matrix V and the margins of matrix P.

Now, the proposed decomposition is then able to decompose the variation in the margins into the component due to the variation in the occupational structure and the shares of the sub-populations. In other words, we will have that

$$C_{\Delta m} = C_{\Delta h} + C_{\Delta t} \tag{10}$$

where represent the contribution from changes in occupational structure and from changes in shares of sub-populations. Using the same procedure as before we can express these two components as follows:

$$C_{\Delta h} = \frac{1}{2}\frac{1}{2}[\{[I(l) - I(p)] + (I(s) - I(k)]\} + \{[I(v) - I(c)] + (I(f) - I(w)]\}] \tag{11}$$

and

$$C_{\Delta t} = \frac{1}{2}\frac{1}{2}[\{[I(k) - I(p)] + (I(s) - I(l)]\} + \{[I(v) - I(f)] + (I(c) - I(w)]\}] \tag{12}$$

In order to derive these components we need to define additional matrices (see Deutsch et al (2009) for the detailed construction of these matrices):

- matrix L with the internal structure of P, the horizontal margins of V and the vertical margins of P;

- matrix K with the internal structure of P, the horizontal margins of P and the vertical margins of V;
- matrix F with the internal structure of V, the horizontal margins of V and the vertical margins of P;
- matrix C with the internal structure of V, the horizontal margins of P and the vertical margins of V.

Through this decomposition, we are hence able to decompose the change between two periods into

$$\Delta I = C_{\Delta is} + C_{\Delta h} + C_{\Delta t} \quad (13)$$

the variation due to the sub-population shares within occupations (the net segregation or changes in internal structure), $C_{\Delta is}$, the variation due to the occupational structure of the labour markets (i.e. the weights of each occupation), $C_{\Delta h}$, and finally the sub-population shares of the total labour force (i.e. gender or racial composition of the labour force), $C_{\Delta t}$.

6.1 Empirical Findings across Formal and Non-Formal labour markets

We perform the decomposition of changes in gender and racial segregation using the Duncan index between two periods: the initial period, comprising the years 1987, 1988, 1989, 1990 and 1992, and the final period, comprising the years 2002 to 2006. We aggregate the first and last five years in order to have a sufficient number of observations to implement the decomposition separately across the formal, informal and self-employed labour markets, as well as disaggregated by key characteristics of the labour force.[24] This aggregation does not appear to be problematic, as changes in occupational distribution within the aggregated years are relatively modest. Finally, we also compute bootstrapped standard errors for the overall changes in occupational segregation, as well as for the components of these changes, based on 500 random samples, in order to test the statistical significance of each component. The findings are reported in Table 2, and in Figure 7.

[Table 2 about here]

[24] For the sake of brevity, we do not report the Shapley decomposition results for the Karmel and Maclachlan index and the Gini segregation index, as the results are largely unchanged, when statistically significant, relative to the results presented here (they are available from the author).

In general, we observe that the decline in both gender and racial segregation, which is also called the 'gross variation', is driven overwhelmingly by 'variations in the internal structure', also called 'net variation' in segregation – that is, declining concentration by gender and race within individual occupations. The contribution of the internal structure component is almost always statistically significant as visible in Table 2. The fact that declining segregation is driven by improvements in the gender and racial composition within occupations is consistent with the arguments made in at least a few similar studies in the developed world (see for example Blau and Hendricks (1979) and more recently Queneau (2009)). By contrast, we find that the impact of 'variations in the margins' (that is, changes in occupational structure - occupations' weights - and in the share of different population sub-groups in the overall labour force) is generally to increase levels of occupational segregation. However, the 'variations in the margins' component warrants more careful analysis, as its two components behave differently across the formal and non-formal labour markets. We look first at the formal, informal and self-employed sectors separately, and then consider the labour market as a whole.

In the formal sector, when looking at both gender and racial segregation, changes in occupational structure (occupations' weights), have contributed to declining segregation, although the effect is only statistically significant in the case of gender. On the other hand, the non-formal sectors show the opposite trend, as changes in occupations' weights are the main cause of upward pressure on levels of both racial and gender segregation, with a particularly dramatic effect in the case of racial segregation. This trend is particularly pronounced for the self-employed sector, where the increase in segregation caused by changes in occupations' weights completely offsets the decline in occupational segregation resulting from variations in the internal structure of occupations, leading to an increase in racial segregation for self-employed workers. All of these findings in the non-formal sector are statistically significant.

The last component, changes in the sub-population shares, generally contributes to increased segregation, with the exception of gender segregation in the informal sector, where the increase in female participation positively contributes to reducing gender segregation (the same happens in the self-employed sector, but the component is not statistically significant in that case). That said, this component is consistently comparatively small in magnitude.

When we combine the formal, informal and self-employed sector and look at the labour market as a whole, we see that the aggregate affect of the changes in occupational structure

component differs between gender and racial segregation. Focusing first on gender segregation, we see that the aggregate effect of changes in occupational structure is to reduce segregation, as the trend in the formal sector (reducing segregation) outweighs the trend that we observe in the informal sector (increasing segregation). This is consistent with the fact that for women experience a larger increase in participation in the formal sector (from 34% to almost 43%) than in the informal sector (from 42.2% to 47.5%), while the formal sector is less segregated than the informal sector, and, as such, the growth of the formal sector is likely to result in a less segregated occupational structure overall. Turning to racial segregation, the results are more straightforward with: variation in the internal structure reduces segregation, as is the case in each sector on its own, while the 'variation in the margins' component increases segregation, consistent with the fact that this component increases segregation in the non-formal labour markets and is statistically insignificant in the formal sector.

[Figure 7 about here]

Having laid out these broad findings about the determinants of gender and racial segregation, it remains to support the findings of the decomposition exercise with reference to the descriptive data on occupational structure and segregation presented earlier.

The most important finding is that the primary driver of falling occupational segregation is variations in internal structure, and this is consistent with the descriptive data explored earlier. Looking first at gender segregation, almost all of the most female dominated occupations in the labour market have experienced a decreasing female share over time, as men have increasingly entered these professions. For example, 93.45% of teaching associate professionals were women in 1987, while this share had fallen to 82.8% in 2006; customer services clerks moved from a female share equal of 83.13% in 1987 to 75.19% in 2006. By contrast, while a small number of male dominated occupations have remained almost closed to women (e.g. drivers and mobile plant operators, extraction and building trades workers, metal and machinery related trades workers), other male dominated occupations have seen a significant entry of female workers (e.g. physics, engineers and sales persons).

Turning to racial segregation, variations in internal structure are equally important, though the sources of this variation are slightly different. Among occupations historically

dominated by non-whites, the share of non-white labourers has declined in some areas (for example, in mining, construction, manufacturing and transports the non-white share fell from 80.36% in 1987, to only 59.93% in 2006), but other non-white dominated professions have seen little change in their composition over time, in part because the extent of segregation in these occupations is comparatively low, as non-white workers heavily dominate very few occupations in Brazil. As such, it appears that another important source of declining within occupation segregation has been the growing share of non-whites in white dominated professions, as this is common across almost all of the occupations that have historically been dominated by white workers (e.g. life science and health professionals and teachers).

While variations in internal structure have driven declining segregation, we find that changes in the margins have, on average, increased occupational segregation. Most importantly, across both gender and racial segregation, changes in occupations' weights have contributed to increasing levels of segregation, though this effect is concentrated entirely in the non-formal labour markets. The implication is that within informal labour markets relatively segregated occupations have grown larger over time, thus increasing occupational segregation, though this has not been the case in the formal sector. Looking at gender segregation we find that the largest and most female dominated occupations (namely cod. 512, 514, 522) have grown rapidly, particularly as non-formal activities, led by housekeepers and restaurant workers (cod. 512) (see Figure 4). We find similar patterns in terms of racial segregation, where the overall impact of variations in occupations' weights in increasing segregation is relatively greater. As with gender segregation, we see that the most rapidly growing occupations, housekeepers and restaurant workers (cod.512) and non-self-employed agricultural occupations (cod. 612), have high and increasing shares of non-white workers and have had their growth concentrated in the informal labour market. Thus, in aggregate we see that the growth of relatively segregated occupations in the tertiary sector has contributed to increasing segregation, but this has been more than offset by greater equity in the internal composition of these occupations over time (for a similar finding see Tomaskovic-Devey et al (2006) who look at the role of the service economy in reducing gender segregation in the US).

Finally, the data suggests, somewhat counter-intuitively, that, after accounting for the other trends discussed so far, the increasing share of women and non-whites in the labour force has contributed to increasing segregation, implying that new entrants to the labour force have

disproportionately entered occupations in which women and non-whites, respectively, were already dominant. This is revealed, for example, in the continued entry of women, and particularly non-white women, into the already dominated housekeeping profession. That said, the magnitude of these effects is comparatively very small.

6.2 Empirical Findings Disaggregated by Characteristics of the Labour Force

Finally, as with the earlier analysis of occupational segregation, we decompose changes in gender and racial segregation disaggregated by several key characteristics of the labour force. Table 3 reports the estimated components of the decomposition together with their boostrapped standard errors. As many of these results are not statistically significant, we comment briefly only on the most relevant results.

When we divide the labour force by age groups we find that changes in internal structure consistently reduce segregation across all groups. Turning to the margins, it is only among the elderly that changes in occupational structure have had a statistically significant impact on occupation segregation, pushing it upwards. By contrast, in the case of racial segregation, changes in the occupational structure increase racial segregation for all age groups, while the negative impact is relatively stronger among young people that is offsets the positive effect of improvements in the internal structure of occupations, leading to an overall increase in labour segregation among young people.

Looking at educational attainment, and considering only the statistically significant components, we find that among more educated workers, gender segregation decreases because of the positive contribution of changes in internal structure, while the negative contribution from changes in occupational structure is negligible. Conversely, racial segregation increases among the well educated because the contribution of changes in internal structure is small and completely offset by the huge negative contribution of changes in occupational structure. This again captured the dominance of white workers in more educated and skilled occupations, while also pointing towards the growth of such white dominated professions over time (for example, financial services).

When looking at sectoral patterns, we find that changes in occupational structure have contributed to increasing gender segregation only in the secondary sector. Consistent with this view, fast growing occupations in the secondary sectors have included, for example, food

processing, wood treaters, textile processing related jobs as well as machine and plant operators and assemblers, all of which are highly gender segregated. In terms of racial segregation, the only statistically significant decomposition finding is within the tertiary sector, where changes in internal structure have strikingly reduced segregation.

When we turn to spatial patterns, and separate rural and urban areas, we notice that gender segregation has decreased in both rural and urban areas, driven by the positive contribution of changes in internal structure, while, particularly in urban areas, the negative contribution of changes in occupational structure is negligible. With respect to racial segregation, we record a consistent decrease in urban areas, driven by a clear improvement of the internal structure within occupations.

[Table 3 about here]

7. Final Discussions and Conclusions

This study has yielded a wide range of new insights about occupational segregation in Brazil. This reflects both the use of a more complete, and more accurate, dataset, and the presentation of a more nuanced and disaggregated view of occupational segregation over time. This section briefly summarizes certain key trends, while pulling together these disparate findings in order to highlight a number of important conclusions.

The results highlight several major trends in the labour market that provide the background to our conclusions about occupational segregation. First, we find a large increase in female participation, which is common for Latin American countries where the gap between male and female participation has narrowed more than in any other region in the developed world (Wajman and Rios Neto 2000, Soares and Izaki 2002). Second, we find a similarly rapid increase in the share of non-white workers, who have comprised the majority of the work force since 2003.[25] Third, we find that the non-formal labour markets have remained relatively

[25] Whether the number of non-white individuals entering the labour force has really increased over time or whether the number of individuals among work force that report themselves as non-white population is increasing cannot be traced, as in the PNAD dataset the race/skin colour is self-reported. This finding hence should be interpreted with caution.

constant as a share of the total labour force between 1987 and 2006. This contrasts with some studies that report rising informality, but, like Ramos and Ferreira (2005), we find that this is a largely a question of sample selection, as Brazilian informality is concentrated in metropolitan areas. Fourth, we observe a very rapid growth of the tertiary sector, which absorbs almost all of the new female and non-white entrants into the labour force, thus leaving the occupational distribution surprisingly stable despite major changes in the composition of the labour force (Baer 2008: chap.18, World Bank 2002a, 2002b).

Finally, we find that the share of women, and particularly non-white women, in the informal sector has increased significantly over time. It may be that key features of informal sector employment, such as flexibility, lower commitment to long-term job positions and higher turnover, are well suited to female labour supply in terms of preferences and tastes. On the other hand, it may be that there are high barriers to entry into the formal sector for women, and that the informal market might correspondingly exploit the lack of choice available to less skilled female workers, mainly non-white, employed in personal services, such as housekeepers.[26] This in consistent with Telles' (1992) earlier finding that *"[...] education and race are more frequently used in screening women's than men's entrance into the formal sector"*.

It is against this background, that the paper highlights a range of novel findings about the extent, evolution and characteristics of occupational segregation. In broad terms, we find that gender segregation is much larger, in absolute terms, than racial segregation, while both have declined over time. This initially seems to point towards particularly unequal opportunities for women, but it must also be borne in mind that an important part of this segregation may be explained by differences in tastes and preferences between men and women (see also the discussion in Bertrand, 2010). By contrast, while segregation by race is significantly lower in absolute terms, it may actually be a more serious problem, as it cannot be as easily explained by differences in tastes and preferences, and has been comparatively persistent over time despite the rapid entry of non-whites into the labour force.

[26] The growing role of non-white women in the personal services sector, as housekeepers and often in the informal sector, has been widely noted in this paper. While not central to the evidence presented here, it is worth noting two additional trends in this area that have gained recent attention. First, as noted earlier, despite the high level of informality attached to this type of occupation, the ILO reports that we are witnessing a significant trend of 'formalization' in recent years (Berg, 2010; ILO, 2010). Second, it has been noted that the income of domestic employees rose 34 percent from 2003 to 2009, which is more than twice the average increase for all of Brazil's active workers, while their working hours fell by 5 percent to 36.2 hours a week. (see *New York Times* article: http://www.nytimes.com/2011/05/20/world/americas/20brazil.html?_r=1)

We gain deeper insight into the particular characteristics of this occupational segregation when we disaggregate the findings into the formal, informal and self-employed sectors, and by key characteristics of the population. Looking first at gender segregation, the patterns are relatively consistent with expectations: segregation has declined in both the formal and informal sectors, and has declined more among young workers and among the better educated. That is, new opportunities are most available to younger, educated, female workers, but there has also, encouragingly, been an important decline in segregation among other workers as well. We observe that gender segregation has widely declined in both the primary and tertiary sectors, but it has been stubbornly high, and modestly increasing, in the secondary sector.

When we turn to racial segregation the trends are much more mixed, reinforcing the notion that, while smaller in magnitude, racial segregation may pose a particular challenge. First, while racial segregation has declined in the formal sector, it has experienced only a negligible decline overall, while it has been *increasing* in the informal sector in recent years. Second, whereas women are well represented in, and even dominate, many highly skilled occupations, non-whites are heavily concentrated in lower skill occupations and racial segregation is, surprisingly, higher among the better educated. That said, while racial segregation increased rapidly among the highly educated from 1987-1993, it has been declining rapidly since then. Third, and even more surprisingly, we find that racial segregation is higher among younger workers, which appears to be an even starker indicator of the relative persistence of racial segregation, and the apparent barriers faced by less experienced non-white workers. Finally, we find that racial segregation is higher in urban areas and in the South and South-East regions, suggesting that it may be non-white migrants who are particularly concentrated in particular professions.

Having described these trends in segregation, the most novel results emerge from our application of the Shapley decomposition, as proposed by Deutsch et al (2009), to identify the forces driving declining segregation. Our results indicate very clearly that the decline in both gender and racial segregation is overwhelmingly the consequences of more homogenous gender and racial composition within occupations. On the other hand, we also find that, particularly in the non-formal labour markets, these improvements are partially offset by changes in occupational structure and the entry of new groups into the labour force, both of which have contributed to *increasing* segregation, with many new entrants to the labour force joining

traditionally more segregated occupations, which have significantly increased in size over time. Our aggregate results are driven by the fact that the increase in segregation provoked by these two latter trends is offset by the general improvement in composition within each occupation. This in many ways represents a more 'real' decline in segregation, and is thus a very encouraging finding from a social perspective.

Finally, it is useful to conclude with a forward looking note about what these results suggest about the possible impact of anti-discrimination legislation (ADL). As was noted at the outset, this is a very difficult question to study directly, and has, consequently, been the subject of limited empirical research in developing countries.[27] The results presented here nonetheless provide important initial insights, resulting primarily from disaggregating the formal and non-formal sectors, as it is only in the former that we expect ADL to play a role. And, indeed, our broad findings are consistent with the view that ADL has, indeed, played a role.

Most obviously, occupational segregation, by both gender and race, is declining more rapidly in the formal sector than in the non-formal sectors. In this view, and following the results of the Shapley decomposition, ADL has not only contributed to significant improvements in the internal structure of individual occupations, but has also restricted the emergence and growth of highly segregated occupations within informal activities. Thus, for example, we see that among housekeepers and restaurant workers, which are female and non-white dominated occupations, there is always significantly less segregation in the formal sector than in the informal sector. Finally, less concretely, but certainly provocatively, we also observe a dramatic decline in gender segregation in the Central West province, and particularly in the *Distrito Federal*, where we might expect the impact of government policy, and thus ADL, to be strongest. In addition, this decline might have something to do with the fact that the government is the major employer in the *Distrito Federal*, and to get a job in the civil service one has to go through examinations which are race and gender blind (Osorio, 2006).

This said, the results presented here are also open to an alternative interpretation, which is also consistent with the Shapley results, and this is that ADL, and government regulation more generally might not have played an important role in reducing segregation, but may primarily have led more segregated occupations to function in the informal sector, where they have grown

[27] Interesting studies applied to developed countries are, among others, Heckman and Payner (1989) and Neumark and Stock (2006).

rapidly. In this view, which is consistent with research noted earlier on the impact of regulation of levels of informality, while ADL may reduce segregation when it is enforced, in practice the real impact may be small, as segregated occupations may simply choose to function in the informal sector, thus explaining the rapid growth of highly segregated occupations in that sector. While this paper has thus presented the most significant and detailed evidence to date on the connections between formality, informality and occupational segregation, it remains an area rich with opportunities for further research.

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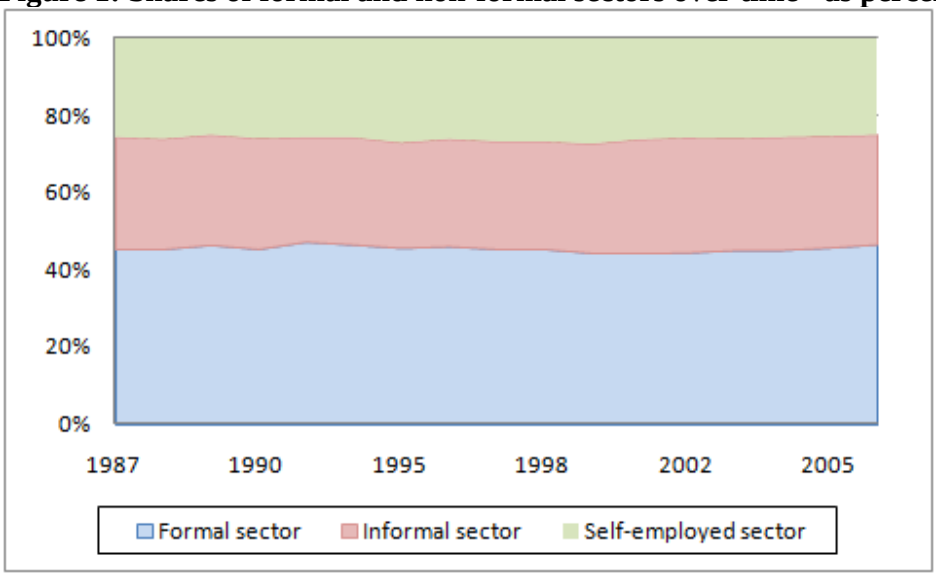
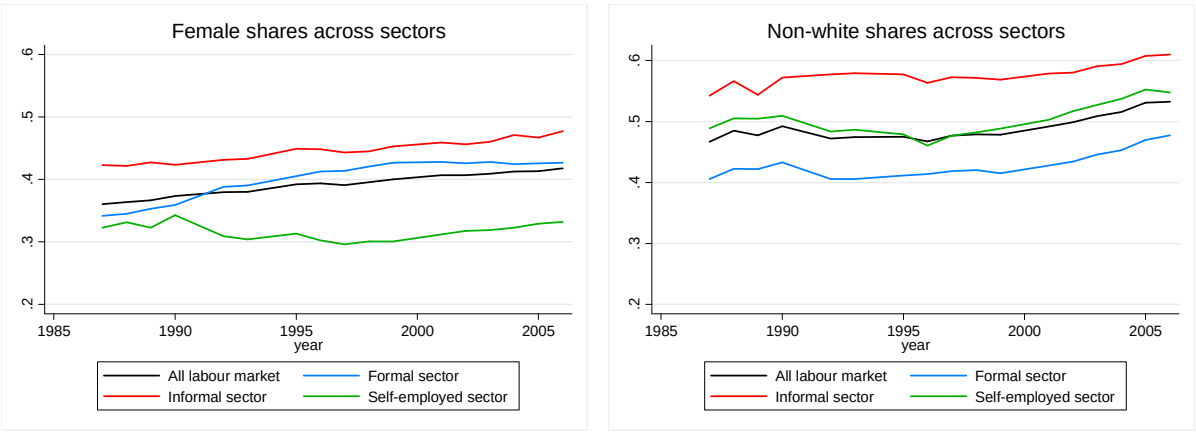
Table and Figures to be inserted in the text

Figure 1: Shares of formal and non-formal sectors over time - as percentage of total labour force



Source: Author's own computations using PNAD 1987 - 2006.
Note: 1991, 1994 and 2001 missing years.

Figure 2: Female and non-white shares across all labour markets over time



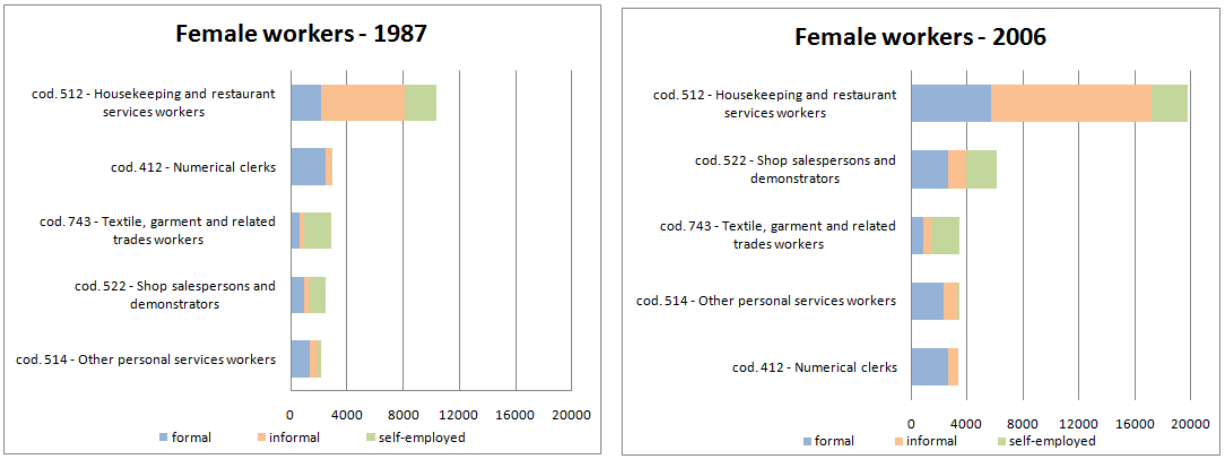
Source: Author's own computations using PNAD 1987 - 2006.
Note: 1991, 1994 and 2001 missing years.

Figure 3: The gender/racial composition across sectors

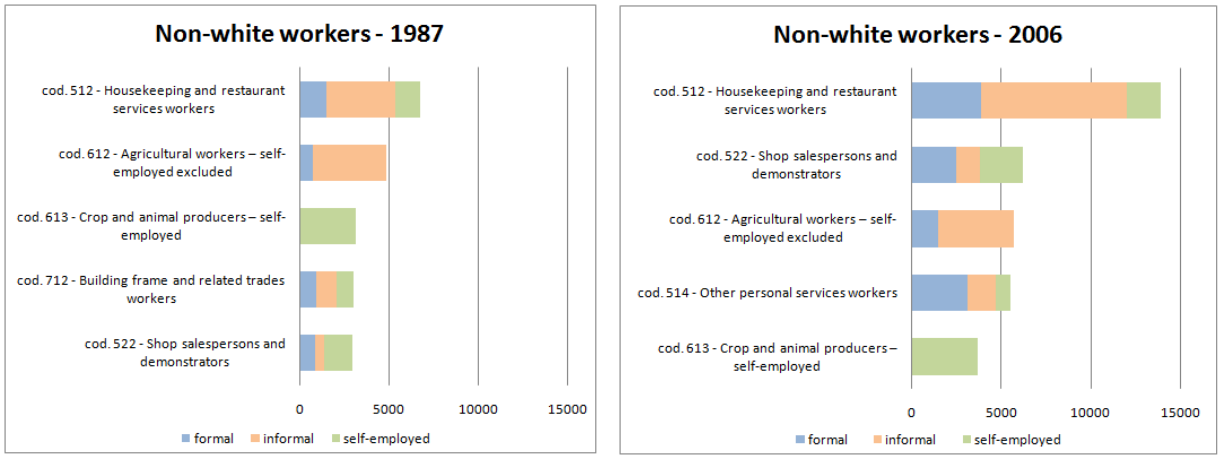
Source: Author's own computations using PNAD 1987 and 2006.

Figure 4: Distribution of female and non-white workers in occupations

Panel A – Female workers



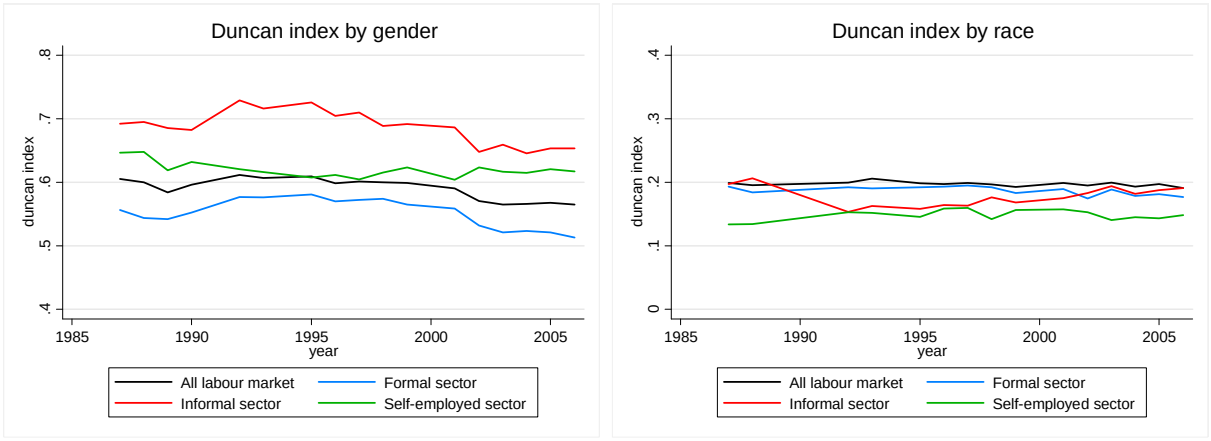
Panel B – Non-white workers



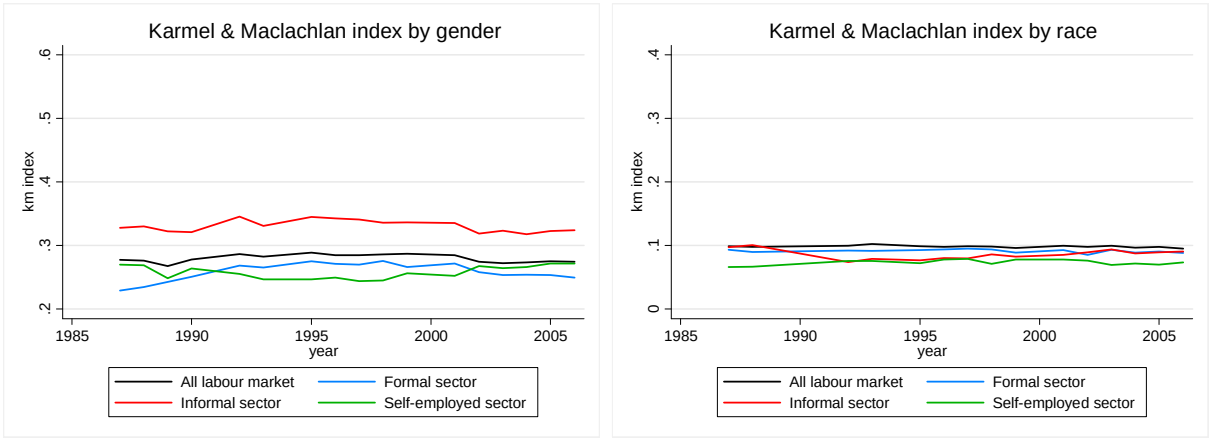
Source: Author's own computations using PNAD 1987 and 2006.
Note: Panels A and B capture the number of women and men, respectively employed in each of the top five most numerous occupations, disaggregated across the formal, informal and self-employed sectors.

Figure 5: Indices of segregation by gender and race over time

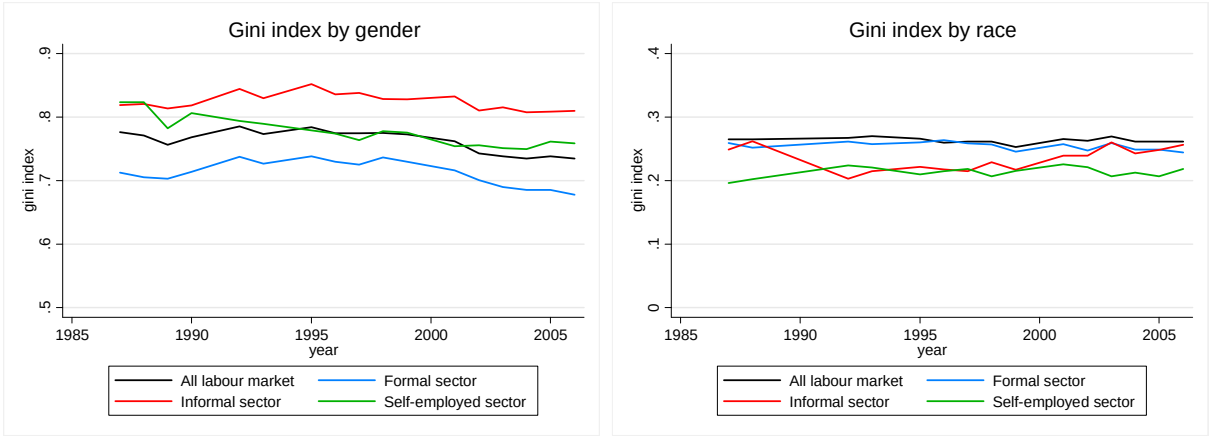
Panel A – Duncan and Duncan index



Panel B – Karmel and Maclachlan index



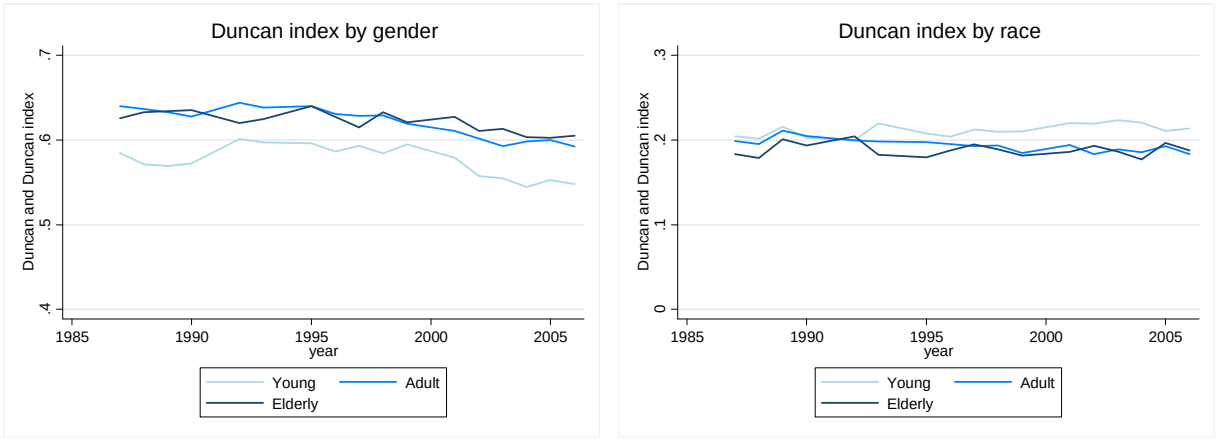
Panel C – Gini segregation index



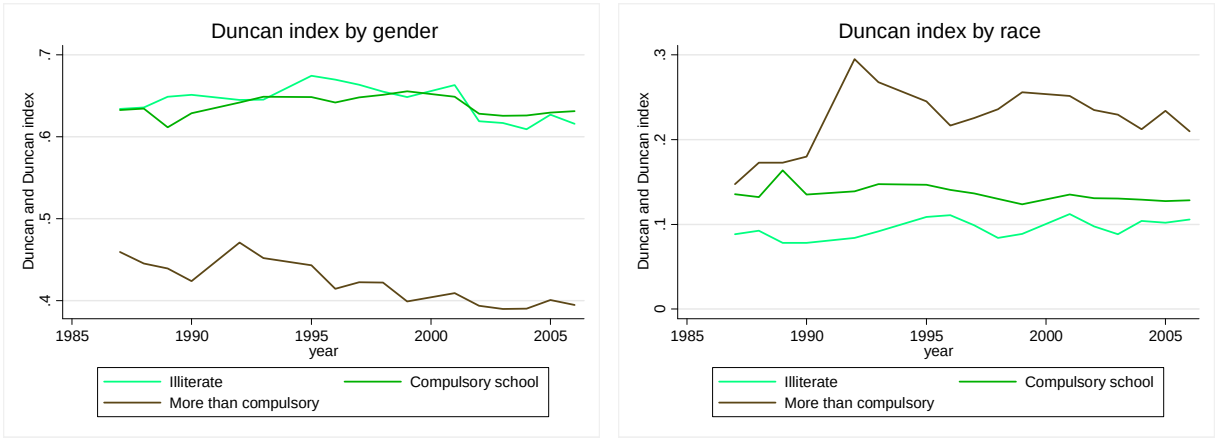
Source: Author's own computations using PNAD 1987 - 2006.
Note: 1991, 1994 and 2001 missing years.

Figure 6: Occupational segregation disaggregated by characteristics of the labour force

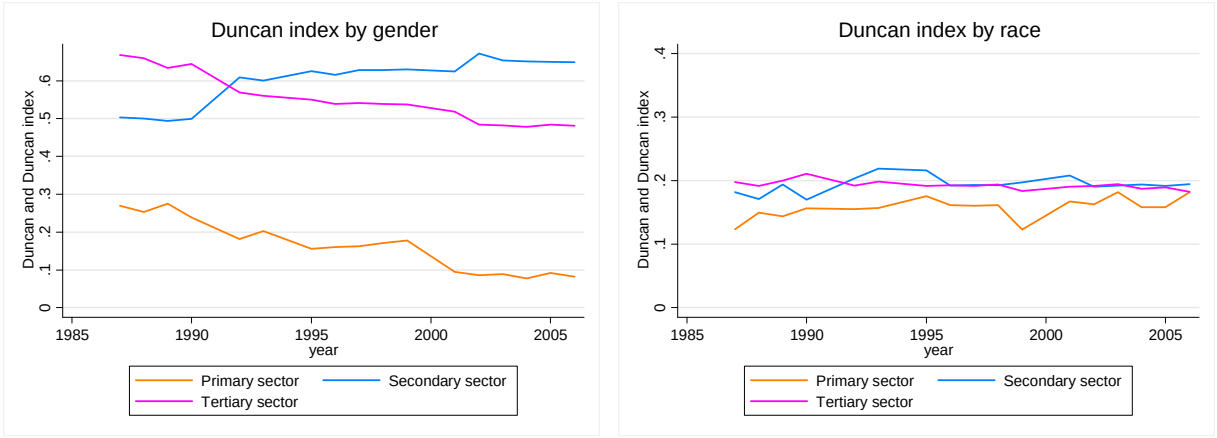
Panel A – Demographic patterns



Panel B- Educational patterns

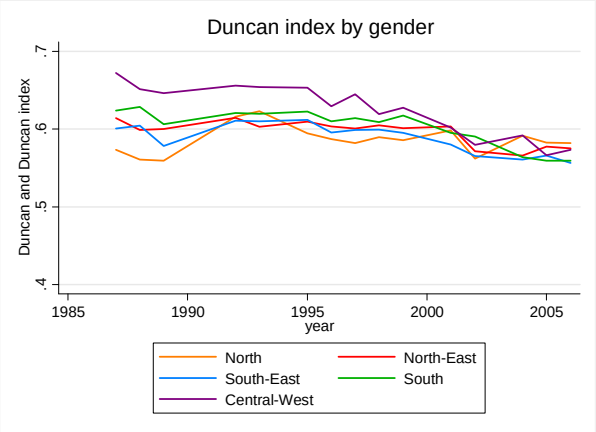


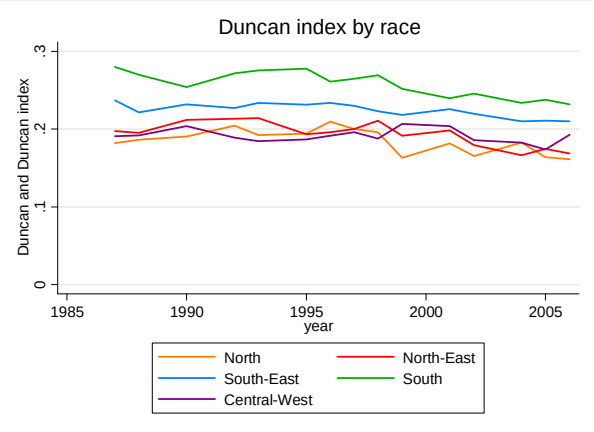
Panel C – Sectoral patterns (three main economic sectors)



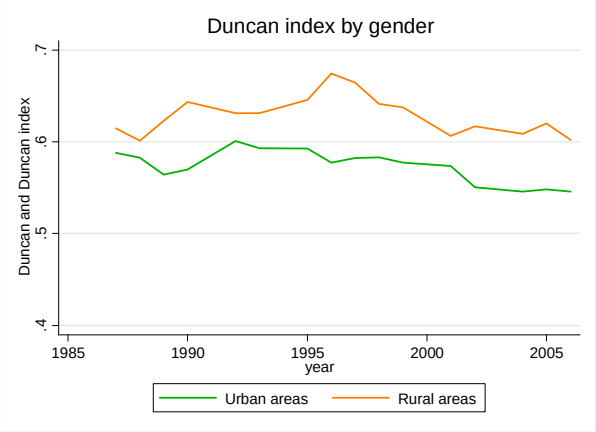
Source: Author's own computations using PNAD 1987 - 2006.
Note: 1991, 1994 and 2001 missing years.

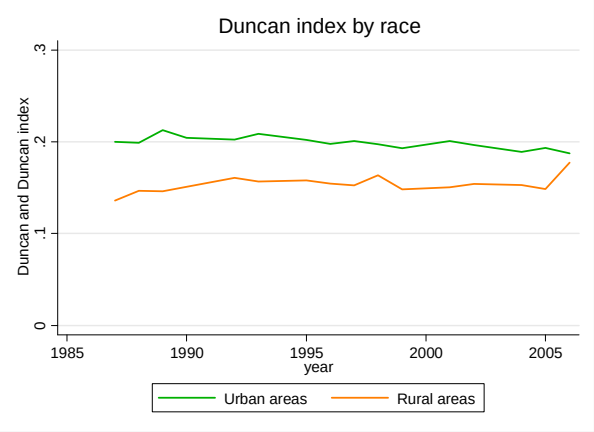
Panel D – Spatial patterns (five main regions)





Panel E – Spatial patterns (urban/rural areas)

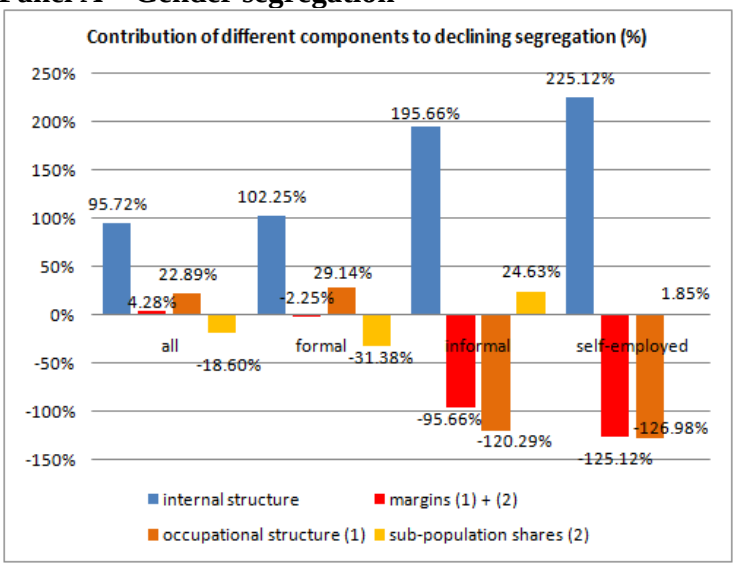




Source: Author's own computations using PNAD 1987 - 2006.
Note: 1991, 1994 and 2001 missing years.

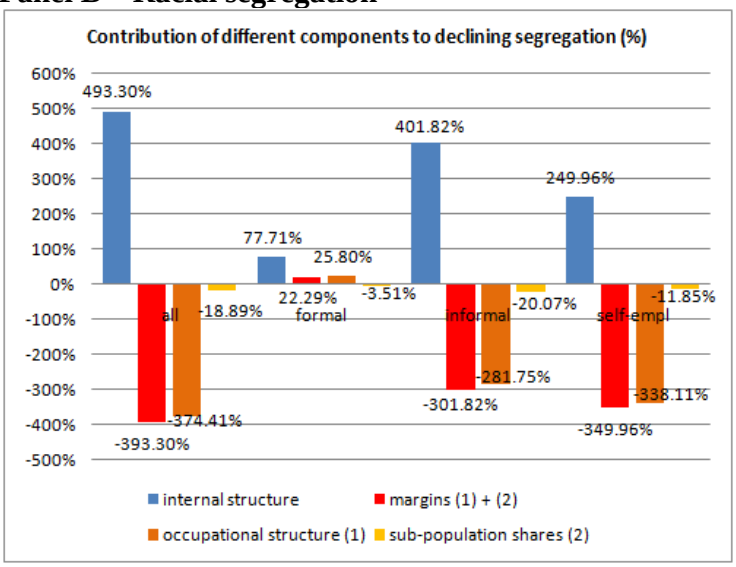
Figure 7: Contribution of different components to declining segregation (%)

Panel A – Gender segregation



Source: Author's own computations using PNAD 1987,1988, 1989, 1990, 1992 and 2002, 2003, 2004, 2005, 2006.

Panel B – Racial segregation



Source: Author's own computations using PNAD 1987,1988, 1989, 1990, 1992 and 2002, 2003, 2004, 2005, 2006.

Table 1: Indices of segregation

	All labour market					Formal sector					Informal sector					Self-employed sector				
	1987	**1992**	**1997**	**2002**	**2006**	**1987**	**1992**	**1997**	**2002**	**2006**	**1987**	**1992**	**1997**	**2002**	**2006**	**1987**	**1992**	**1997**	**2002**	**2006**
Duncan index																				
gender	0.605	0.612	0.601	0.571	0.565	0.556	0.577	0.572	0.532	0.513	0.692	0.729	0.710	0.648	0.653	0.647	0.620	0.605	0.624	0.617
s.e.	0.002	0.002	0.002	0.002	0.002	0.004	0.004	0.003	0.003	0.003	0.004	0.004	0.004	0.003	0.004	0.004	0.004	0.004	0.004	0.004
race	0.199	0.200	0.199	0.195	0.191	0.193	0.192	0.195	0.175	0.177	0.197	0.153	0.163	0.183	0.191	0.134	0.153	0.160	0.153	0.149
s.e.	0.003	0.003	0.003	0.003	0.002	0.004	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.005	0.005
Karmel & Maclachlan index																				
gender	0.277	0.286	0.285	0.275	0.275	0.229	0.268	0.270	0.258	0.249	0.328	0.345	0.341	0.319	0.324	0.270	0.255	0.244	0.267	0.272
s.e.	0.002	0.002	0.002	0.001	0.001	0.002	0.005	0.002	0.002	0.002	0.004	0.004	0.004	0.003	0.002	0.005	0.007	0.004	0.003	0.003
race	0.099	0.099	0.099	0.098	0.095	0.093	0.092	0.095	0.086	0.088	0.097	0.074	0.080	0.089	0.091	0.066	0.076	0.079	0.076	0.073
s.e.	0.002	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.002
Gini segregation index																				
gender	0.776	0.785	0.775	0.743	0.735	0.713	0.738	0.725	0.701	0.678	0.819	0.845	0.838	0.810	0.810	0.823	0.794	0.764	0.756	0.759
s.e.	0.003	0.002	0.004	0.002	0.002	0.005	0.004	0.003	0.003	0.003	0.006	0.005	0.005	0.003	0.003	0.004	0.007	0.004	0.004	0.003
race	0.265	0.267	0.261	0.263	0.262	0.259	0.262	0.259	0.247	0.244	0.249	0.203	0.215	0.239	0.256	0.196	0.224	0.218	0.221	0.218
s.e.	0.003	0.003	0.003	0.003	0.003	0.005	0.005	0.005	0.004	0.004	0.006	0.007	0.006	0.006	0.006	0.007	0.006	0.006	0.006	0.006

Source: Author's own computations using PNAD 1987 – 1992 – 1997 – 2002 – 2006.
Note: Standard errors boostrapped with 500 replications.

Table 2: Shapley decomposition of changes in Duncan index over time across sectors

	Value of the index in the initial period	Value of the index in the final period	Changed observed between the two periods	Component of the change due to variations in the "internal structure"	Component of the change due to variations in the "margins" (1) + (2)	Component due to variations in the occupational structure (1)	Component due to variations in the shares of the sub-population (2)
All labour market							
gender	0.5983	0.5624	-0.0359	-0.0343	-0.0016 [n.s.]	-0.0080	0.0064
s.e.	0.0011	0.0009	0.0014	0.0035	0.0032	0.0032	0.0006
			100.00%	95.72%	4.28%	22.89%	-18.60%
race	0.1981	0.1928	-0.0053	-0.0262	0.0209	0.0199	0.0010
s.e.	0.0014	0.0011	0.0017	0.0043	0.0041	0.0041	0.0001
			100.00%	493.30%	-393.30%	-374.41%	-18.89%
Formal sector							
gender	0.5526	0.5167	-0.0359	-0.0367	0.0008 [n.s.]	-0.0105	0.0113
s.e.	0.0018	0.0014	0.0023	0.0054	0.0053	0.0055	0.0012
			100.00%	102.25%	-2.25%	29.14%	-31.38%
race	0.1891	0.1768	-0.0123	-0.0096 [n.s.]	-0.0027 [n.s.]	-0.0032 [n.s.]	0.0004
s.e.	0.0021	0.0017	0.0026	0.0065	0.0058	0.0058	0.0001
			100.00%	77.71%	22.29%	25.80%	-3.51%
Informal sector							
gender	0.6949	0.6492	-0.0458	-0.0896	0.0438	0.0551	-0.0113
s.e.	0.0020	0.0016	0.0025	0.0103	0.0101	0.0113	0.0021
			100.00%	195.66%	-95.66%	-120.29%	24.63%
race	0.1985	0.1835	-0.0150	-0.0604	0.0454	0.0423	0.0030
s.e.	0.0023	0.0020	0.0030	0.0083	0.0078	0.0077	0.0002
			100.00%	401.82%	-301.82%	-281.75%	-20.07%
Self-employed sector							
gender	0.6300	0.6099	-0.0201	-0.0452	0.0251	0.0255	-0.0004 [n.s.]
s.e.	0.0020	0.0019	0.0027	0.0145	0.0143	0.0143	0.0005
			100.00%	225.12%	-125.12%	-126.98%	1.85%
race	0.1294	0.1400	0.0106	-0.0266	0.0372	0.0359	0.0013
s.e.	0.0027	0.0022	0.0034	0.0089	0.0083	0.0083	0.0002
			100.00%	-249.96%	349.96%	338.11%	11.85%

Source: Author's own computations using PNAD 1987,1988, 1989, 1990, 1992 and 2002, 2003, 2004, 2005, 2006.
Note: the initial period comprises 1987-1988-1989-1990-1992 and the final period comprises 2002-2003-2004-2005-2006. Standard errors boostrapped with 500 replications. [n.s.] indicates those components that are not statistically significant at 5% confidence.

Table 3: Shapley decomposition of changes in Duncan index over time disaggregated by characteristics

	Value of the index in the initial period	Value of the index in the final period	Changed observed between the two periods	Component of the change due to variations in the "internal structure"	Component of the change due to variations in the "margins" (1) + (2)	Component due to variations in the occupational structure (1)	Component due to variations in the shares of the sub-population (2)
By age							
young							
gender	0.5791	0.5500	-0.0291	-0.0324	0.0033 n.s.	-0.0010 n.s.	0.0043
s.e.	0.0017	0.0015	0.0023	0.0064	0.0063	0.0061	0.0007
			100.00%	111.16%	-11.16%	3.52%	-14.68%
race	0.2019	0.2157	0.0138	-0.0205	0.0343	0.0337	0.0006
s.e.	0.0021	0.0019	0.0028	0.0076	0.0072	0.0072	0.0001
			100.00%	-148.09%	248.09%	243.86%	4.24%
adult							
gender	0.6354	0.5926	-0.0427	-0.0411	-0.0016 n.s.	-0.0067 n.s.	0.0051
s.e.	0.0017	0.0013	0.0021	0.0046	0.0043	0.0049	0.0021
			100.00%	96.21%	3.79%	15.71%	-11.92%
race	0.1995	0.1854	-0.0141	-0.0288	0.0148	0.0133	0.0014
s.e.	0.0022	0.0017	0.0027	0.0059	0.0053	0.0053	0.0001
			100.00%	204.88%	-104.88%	-94.75%	-10.14%
elderly							
gender	0.6171	0.6002	-0.0169	-0.0610	0.0441	0.0430	0.0011
s.e.	0.0035	0.0024	0.0045	0.0107	0.0104	0.0105	0.0021
			100.00%	361.70%	-261.70%	-255.04%	-6.65%
race	0.1887	0.1839	-0.0048	-0.0494	0.0446	0.0437	0.0009
s.e.	0.0037	0.0029	0.0048	0.0108	0.0100	0.0100	0.0001
			100.00%	1029.06%	-929.06%	-909.65%	-19.41%
By education							
illiterate							
gender	0.6419	0.6139	-0.0280	-0.1177	0.0897	0.0815	0.0082
s.e.	0.0030	0.0041	0.0048	0.0220	0.0221	0.0224	0.0016
			100.00%	420.45%	-320.45%	-291.08%	-29.37%
race	0.0767	0.0939	0.0172	-0.0001 n.s.	0.0172 n.s.	0.0172 n.s.	0.0001 n.s.
s.e.	0.0034	0.0047	0.0059	0.0141	0.0137	0.0137	0.0001
			100.00%	-0.34%	100.34%	100.01%	0.32%
compulsory school							
gender	0.6295	0.6275	-0.0020 n.s.	-0.0314	0.0294	0.0249	0.0045
s.e.	0.0014	0.0012	0.0018	0.0067	0.0064	0.0065	0.0006
			100.00%	1577.01%	-1477.01%	-1249.55%	-227.45%
race	0.1400	0.1283	-0.0117	-0.0144 n.s.	0.0027 n.s.	0.0018 n.s.	0.0009
s.e.	0.0017	0.0015	0.0023	0.0088	0.0085	0.0085	0.0001
			100.00%	123.03%	-23.03%	-15.31%	-7.72%
more than compulsory school							
gender	0.4438	0.3810	-0.0628	-0.0869	0.0241	0.0274	-0.0033
s.e.	0.0041	0.0028	0.0050	0.0123	0.0113	0.0113	0.0007

			100.00%	138.37%	-38.37%	-43.60%	5.24%
race	0.1747	0.2178	0.0432	-0.0381	0.0812	0.0897	-0.0084
s.e.	0.0051	0.0032	0.0058	0.0110	0.0106	0.0108	0.0011
			100.00%	-88.24%	188.24%	207.74%	-19.50%
By main economic sectors							
primary sector							
gender	0.2419	0.0818	-0.1601	-0.0343 [n.s.]	-0.1258	-0.1297	0.0039
s.e.	0.0050	0.0056	0.0074	0.0336	0.0337	0.0341	0.0015
			100.00%	21.41%	78.59%	81.03%	-2.44%
race	0.1429	0.1666	0.0238	-0.0027 [n.s.]	0.0265 [n.s.]	0.0262 [n.s.]	0.0003
s.e.	0.0036	0.0036	0.0052	0.0344	0.0340	0.0340	0.0001
			100.00%	-11.48%	111.48%	110.27%	1.21%
secondary sector							
gender	0.5156	0.6542	0.1386	-0.0145 [n.s.]	0.1531	0.1526	0.0005
s.e.	0.0023	0.0018	0.0030	0.0086	0.0084	0.0085	0.0002
			100.00%	-10.47%	110.47%	110.08%	0.39%
race	0.1779	0.1911	0.0132	-0.0005 [n.s.]	0.0137 [n.s.]	0.0124 [n.s.]	0.0012
s.e.	0.0024	0.0024	0.0033	0.0113	0.0108	0.0108	0.0002
			100.00%	-3.42%	103.42%	94.27%	9.14%
tertiary sector							
gender	0.6291	0.4792	-0.1499	-0.0954	-0.0545	-0.0513	-0.0032
s.e.	0.0016	0.0012	0.0021	0.0065	0.0065	0.0064	0.0003
			100.00%	63.63%	36.37%	34.22%	2.15%
race	0.1977	0.1868	-0.0109	-0.0377	0.0268	0.0263	0.0006
s.e.	0.0020	0.0013	0.0024	0.0078	0.0077	0.0077	0.0001
			100.00%	346.79%	-246.79%	-241.53%	-5.26%
By rural and urban areas							
rural areas							
gender	0.6222	0.6171	-0.0051	-0.0648	0.0597	0.0842	-0.0244
s.e.	0.0033	0.0027	0.0042	0.0174	0.0172	0.0166	0.0019
			100.00%	1275.74%	-1175.74%	-1656.87%	481.13%
race	0.1429	0.1532	0.0103	-0.0020 [n.s.]	0.0123 [n.s.]	0.0126 [n.s.]	-0.0003 [n.s.]
s.e.	0.0033	0.0030	0.0047	0.0178	0.0172	0.0173	0.0003
			100.00%	-19.40%	119.40%	122.34%	-2.93%
urban areas							
gender	0.5807	0.5475	-0.0332	-0.0378	0.0046 [n.s.]	0.0003 [n.s.]	0.0043
s.e.	0.0014	0.0010	0.0017	0.0034	0.0032	0.0032	0.0007
			100.00%	113.81%	-13.81%	-0.82%	-12.99%
race	0.2021	0.1918	-0.0104	-0.0285	0.0181	0.0172	0.0010
s.e.	0.0016	0.0012	0.0020	0.0044	0.0040	0.0040	0.0001
			100.00%	274.91%	-174.91%	-165.41%	-9.50%

Source: Author's own computations using PNAD 1987,1988, 1989, 1990, 1992 and 2002, 2003, 2004, 2005, 2006.
Note: the initial period comprises 1987-1988-1989-1990-1992 and the final period comprises 2002-2003-2004-2005-2006. Standard errors boostrapped with 500 replications. [n.s.] indicates those components that are not statistically significant at 5% confidence.

Appendix

Table A1: Classification of occupational codes

ISCO88	MAJOR, SUB-MAJOR, MINOR AND UNIT GROUPS
	MAJOR GROUP 1: LEGISLATORS, SENIOR OFFICIALS AND MANAGERS
11	**Legislators and senior officials**
111	Legislators
112	Senior government officials
113	Traditional chiefs and heads of villages
114	Senior officials of special-interest organisations
12	**Corporate managers**
121	Directors and chief executives
122	Production and operations department managers
123	Other department managers
13	**General managers**
131	Managers of small enterprises
	MAJOR GROUP 2: PROFESSIONALS
21	**Physical, mathematical and engineering science professionals**
211	Physicists, chemists and related professionals
212	Mathematicians, statisticians and related professionals
213	Computing professionals
214	Architects, engineers and related professionals
22	**Life science and health professionals**
221	Life science professionals
222	Health professionals (except nursing)
223	Nursing and midwifery professionals
23	**Teaching professionals**
231	College, university and higher education teaching professionals
232	Secondary education teaching professionals
233	Primary and pre-primary education teaching professionals
234	Special education teaching professionals
235	Other teaching professionals
24	**Other professionals**
241	Business professionals
242	Legal professionals (Lawyers and Judges)
243	Archivists, librarians and related information professionals
244	Social science and related professionals
245	Writers and creative or performing artists
246	Religious professionals
247	Public service administrative professionals
	MAJOR GROUP 3: TECHNICIANS AND ASSOCIATE PROFESSIONALS
31	**Physical and engineering science associate professionals**
311	Physical and engineering science technicians
312	Computer associate professionals
313	Optical and electronic equipment operators
314	Ship and aircraft controllers and technicians
315	Safety and quality inspectors
32	**Life science and health associate professionals**
321	Life science technicians and related associate professional
322	Modern health associate professionals
323	Nursing and midwifery associate professionals
324	Traditional medicine praticioners and faith healers

33	**Teaching associate professionals**
331	Primary education teaching associate professionals
332	Pre-primary education teaching associate professionals
333	Special education teaching associate professionals
334	Other teaching associate professionals
34	**Other associate professionals**
341	Finance and sales associate professionals
342	Business services agents and trade brokers
343	Administrative associate professionals
344	Customs, tax and related government associate professionals
345	Police inspectors and detectives
346	Social work associate professionals
347	Artistic, entertainment and sports associate professionals
348	Religious associate professionals
	MAJOR GROUP 4: CLERKS
41	**Office clerks**
411	Secretaries and keyboard-operating clerks
412	Numerical clerks
413	Material-recording and transport clerks
414	Library, mail and related clerks
419	Other office clerks
42	**Customer services clerks**
421	Cashiers, tellers and related clerks
422	Client information clerks
	MAJOR GROUP 5: SERVICE WORKERS AND SHOP AND MARKET SALES WORKERS
51	**Personal and protective services workers**
511	Travel attendants and related workers
512	Housekeeping and restaurant services workers
514	Other personal services workers
515	Astrologers, fortune tellers and related workers
516	Protective services workers
52	**Models, salespersons and demonstrators**
521	Fashion and other models
522	Shop salespersons and demonstrators
523	Stall and market salespersons and demonstrators
	MAJOR GROUP 6: SKILLED AGRICULTURAL AND FISHERY WORKERS
61	**Skilled agricultural and fishery workers**
611	Market gardeners and crop growers
612	Agricultural workers – self-employed excluded
613	Crop and animal producers – self-employed
614	Forestry and related workers
615	Fishery workers, hunters and trappers
	MAJOR GROUP 7: CRAFT AND RELATED TRADES WORKERS
71	**Extraction and building trades workers**
711	Miners, shotfirers, stone cutters and carvers
712	Building frame and related trades workers
713	Building finishers and related trades workers
714	Painters, building structure cleaners and related trades workers
72	**Metal, machinery and related trades workers**
721	Metal molders, welders, sheet-metal workers, structural-metal preparers, and related trades workers
722	Blacksmiths, tool-makers and related trades workers
723	Machinery mechanics and fitters
724	Electrical and electronic equipment mechanics and fitters

73	**Precision, handicraft, craft printing and related trades workers**
731	Precision workers in metal and related materials
732	Potters, glass-makers and related trades workers
733	Handicraft workers in wood, textile, leather and related materials
734	Craft printing and related trades workers
74	**Other craft and related trades workers**
741	Food processing and related trades workers
742	Wood treaters, cabinet-makers and related trades workers
743	Textile, garment and related trades workers
744	Pelt, leather and shoemaking trades workers
	MAJOR GROUP 8: PLANT AND MACHINE OPERATORS AND ASSEMBLERS
81	**Stationary plant and related operators**
811	Mining and mineral-processing-plant operators
812	Metal-processing plant operators
813	Glass, ceramics and related plant operators
814	Wood-processing- and papermaking-plant operators
815	Chemical-processing-plant operators (and machine operators)
816	Power-production and related plant operators (and machine operators)
817	Industrial robot operators
82	**Machine operators and assemblers**
821	Metal- and mineral-products machine operators
822	Chemical-products machine operators
823	Rubber- and plastic-products machine operators
824	Wood-products machine operators
825	Printing-, binding- and paper-products machine operators
826	Textile-, fur- and leather-products machine operators
827	Food and related products machine operators
828	Assemblers
829	Other machine operators not elsewhere classified
83	**Drivers and mobile plant operators**
831	Locomotive engine drivers and related workers
832	Motor vehicle drivers
833	Agricultural and other mobile plant operators
834	Ships' deck crews and related workers
	MAJOR GROUP 9: ELEMENTARY OCCUPATIONS
91	**Sales and services elementary occupations**
911	Street vendors and related workers
916	Garbage collectors and related labourers
92	**Agricultural, fishery and related labourers**
921	Agricultural, fishery and related labourers
93	**Labourers in mining, construction, manufacturing and transport**
931	Mining and construction labourers
932	Manufacturing labourers
933	Transport labourers and freight handlers
	MAJOR GROUP 0: ARMED FORCES
100	Armed forces
998	**Mal definidas**
999	**Nao declarada**

Source: Author's own computations using PNADs.
Note: The categories highlighted in yellow have been omitted because it was not possible to find the related occupations across all Brazilian datasets.

Table A2: Test of mean differences across sectors

Duncan index - gender

	1987	1992	1997	2002	2006
Formal vs Informal	-23.688	-27.956	-26.329	-24.061	-29.268
Formal vs Self-Empl.	-15.109	-7.671	-5.994	-17.677	-20.439
Informal vs Self-Empl.	7.559	18.254	18.217	4.631	6.827

Duncan index - race

	1987	1992	1997	2002	2006
Formal vs Informal	-0.580 [n.s.]	5.649	4.981	-1.316 [n.s.]	-2.412
Formal vs Self-Empl.	8.139	5.443	5.203	3.430	4.707
Informal vs Self-Empl.	7.920	0.048 [n.s.]	0.518 [n.s.]	4.267	6.283

Karmel & Maclachlan index - gender

	1987	1992	1997	2002	2006
Formal vs Informal	-19.498	-11.791	-15.621	-18.038	-23.908
Formal vs Self-Empl.	-6.991	1.487 [n.s.]	6.110	-2.519	-5.961
Informal vs Self-Empl.	8.374	10.894	17.366	12.412	13.408

Karmel & Maclachlan index - race

	1987	1992	1997	2002	2006
Formal vs Informal	-1.111 [n.s.]	5.448	4.899	-1.135 [n.s.]	-0.947
Formal vs Self-Empl.	7.675	4.783	4.748	2.979	5.013
Informal vs Self-Empl.	7.917	-0.401 [n.s.]	0.238 [n.s.]	3.654	5.277

Gini segregation index – gender

	1987	1992	1997	2002	2006
Formal vs Informal	-13.031	-16.286	-19.371	-26.223	-32.868
Formal vs Self-Empl.	-16.732	-7.177	-7.590	-11.459	-18.163
Informal vs Self-Empl.	-0.634 [n.s.]	5.870	11.788	11.368	11.652

Gini segregation index – race

	1987	1992	1997	2002	2006
Formal vs Informal	1.262 [n.s.]	6.929	5.715	1.069 [n.s.]	-1.775
Formal vs Self-Empl.	7.135	4.533	5.249	3.531	3.828
Informal vs Self-Empl.	5.535	-2.280	-0.421 [n.s.]	2.153	4.848

Source: Author's own computations using PNAD 1987 – 1992 – 1997 – 2002 – 2006.
Note: z-tests reported in the table; [n.s.] not statistically significant; all other z-tests are statistically significant at 5% confidence.

Table A3: Test of mean differences over time for each sector

All labour market

Duncan index - gender

	1987	1992	1997	2002	2006
1987					
1992	1.838 n.s.				
1997	-1.225 n.s.	-3.142			
2002	-10.780	-12.585	-10.129		
2006	-12.861	-14.666	-12.344	-2.021	

Duncan index - race

	1987	1992	1997	2002	2006
1987					
1992	0.205 n.s.				
1997	-109.677	-0.262 n.s.			
2002	-111.811	-1.164 n.s.	-0.928 n.s.		
2006	-121.453	-2.242	-2.030	-1.053 n.s.	

Karmel & Maclachlan index - gender

	1987	1992	1997	2002	2006
1987					
1992	3.557				
1997	3.058	-0.548 n.s.			
2002	-1.165 n.s.	-5.291	-4.769		
2006	-1.228 n.s.	-5.265	-4.750	-0.125 n.s.	

Karmel & Maclachlan index – race

	1987	1992	1997	2002	2006
1987					
1992	0.209 n.s.				
1997	0.045 n.s.	-0.170 n.s.			
2002	-0.713 n.s.	-0.944 n.s.	-0.783 n.s.		
2006	-1.997	-2.264	-2.119	-1.326 n.s.	

Formal sector

Duncan index - gender

	1987	1992	1997	2002	2006
1987					
1992	3.846				
1997	3.075	-0.926 n.s.			
2002	-4.646	-9.172	-8.499		
2006	-8.342	-13.221	-12.671	-4.006	

Duncan index - race

	1987	1992	1997	2002	2006
1987					
1992	-0.188 n.s.				
1997	0.330 n.s.	0.520 n.s.			
2002	-3.211	-2.966	-3.668		
2006	-2.975	-2.722	-3.448	0.394 n.s.	

Karmel & Maclachlan index - gender

	1987	1992	1997	2002	2006
1987					
1992	7.026				
1997	13.178	0.337 n.s.			
2002	9.203	-1.880	-4.242		
2006	6.377	-3.489	-7.280	-3.028	

Karmel & Maclachlan index – race

	1987	1992	1997	2002	2006
1987					
1992	-0.312 n.s.				
1997	0.601 n.s.	0.894 n.s.			
2002	-2.846	-2.416	-3.491		
2006	-2.023	-1.605 n.s.	-2.690	0.986 n.s.	

Informal sector

Duncan index - gender

	1987	1992	1997	2002	2006
1987					
1992	6.357				
1997	3.078	-3.373			
2002	-8.247	-15.129	-11.727		
2006	-7.202	-14.016	-10.629	1.055 n.s.	

Duncan index - race

	1987	1992	1997	2002	2006
1987					
1992	-5.820				
1997	-4.616	1.384 n.s.			
2002	-1.962	4.100	2.793		
2006	-0.904 n.s.	5.335	4.032	1.165 n.s.	

Karmel & Maclachlan index - gender

	1987	1992	1997	2002	2006
1987					
1992	2.789				
1997	2.079	-0.779 n.s.			
2002	-1.759 n.s.	-5.246	-4.446		
2006	-0.891 n.s.	-4.480	-3.631	1.314 n.s.	

Karmel & Maclachlan index – race

	1987	1992	1997	2002	2006
1987					
1992	-6.263				
1997	-4.879	1.590 n.s.			
2002	-2.246	4.212	2.717		
2006	-1.832 n.s.	4.842	3.322	0.506 n.s.	

Self-employed sector

Duncan index - gender

	1987	1992	1997	2002	2006
1987					
1992	-4.257				
1997	-6.881	-2.575			
2002	-3.880	0.572 n.s.	3.279		
2006	-4.998	-0.547 n.s.	2.145	-1.176 n.s.	

Duncan index - race

	1987	1992	1997	2002	2006
1987					
1992	2.391				
1997	3.210	0.819 n.s.			
2002	2.544	0.007 n.s.	-0.867 n.s.		
2006	1.984	-0.597 n.s.	-1.487 n.s.	-0.650 n.s.	

Karmel & Maclachlan index - gender

	1987	1992	1997	2002	2006
1987					
1992	-1.663 n.s.				
1997	-4.005	-1.416 n.s.			
2002	-0.414 n.s.	1.570 n.s.	4.786		
2006	0.246 n.s.	2.099	5.638	0.921 n.s.	

Karmel & Maclachlan index – race

	1987	1992	1997	2002	2006
1987					
1992	2.419				
1997	3.213	0.822 n.s.			
2002	2.665	0.154 n.s.	-0.704 n.s.		
2006	2.000	-0.607 n.s.	-1.490 n.s.	-0.804 n.s.	

Gini segregation index - gender

	1987	1992	1997	2002	2006
1987					
1992	2.287				
1997	-0.293 [n.s.]	-2.288			
2002	-8.675	-14.855	-6.985		
2006	-10.757	-17.819	-8.717	-2.945	

	1987	1992	1997	2002	2006
1987					
1992	3.746				
1997	1.997	-2.471			
2002	-1.931 [n.s.]	-7.499	-5.597		
2006	-5.731	-12.373	-11.090	-5.579	

	1987	1992	1997	2002	2006
1987					
1992	3.226				
1997	2.526	-0.869			
2002	-1.253 [n.s.]	-5.706	-4.942		
2006	-1.306 [n.s.]	-5.803	-5.041	-0.076 [n.s.]	

	1987	1992	1997	2002	2006
1987					
1992	-3.737				
1997	-10.750	-3.813			
2002	-12.527	-4.881	-1.444 [n.s.]		
2006	-12.671	-4.663	-1.031 [n.s.]	0.498 [n.s.]	

Gini segregation index - race

	1987	1992	1997	2002	2006
1987					
1992	0.497 [n.s.]				
1997	-0.721 [n.s.]	-1.229 [n.s.]			
2002	-0.491 [n.s.]	-1.031 [n.s.]	0.277 [n.s.]		
2006	-0.731 [n.s.]	-1.286 [n.s.]	0.053 [n.s.]	-0.247 [n.s.]	

	1987	1992	1997	2002	2006
1987					
1992	0.347 [n.s.]				
1997	-0.023 [n.s.]	-0.389 [n.s.]			
2002	-1.693	-2.077	-1.777		
2006	-2.232	-2.635	-2.364	-0.513 [n.s.]	

	1987	1992	1997	2002	2006
1987					
1992	-4.974				
1997	-3.859	1.283 [n.s.]			
2002	-1.058 [n.s.]	4.035	2.862		
2006	0.933 [n.s.]	6.151	5.035	2.075	

	1987	1992	1997	2002	2006
1987					
1992	2.923				
1997	2.362	-0.652 [n.s.]			
2002	2.647	-0.365 [n.s.]	0.297 [n.s.]		
2006	2.433	-0.700 [n.s.]	-0.020 [n.s.]	-0.331 [n.s.]	

Source: Author's own computations using PNAD 1987 – 1992 – 1997 – 2002 – 2006.
Note: z-tests reported in the table; [a] not statistically significant; all other z-tests are statistically significant at 5% confidence.