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PONTO DE INFLEXÃO: PATTERNS OF OCCUPATIONAL TIPPING IN BRAZIL

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Abstract.

This thesis explores the dynamics behind occupational segregation in Brazil. Applying the theoretical framework of Schelling (1971) to a labour market context, it is investigated whether occupations in Brazil exhibit tipping. Making use of a method by Pan (2015), occupations are shown to exhibit discontinuous declines in growth of net male employment at tipping points between 22% and 72% from 1960 to 1991, providing evidence for patterns of occupational tipping. In creating an index of male gender prejudice, the link between tipping points and male preferences towards working with women is explored. The results show no evidence for the prediction, based on Schelling (1971)'s theories, that regions in which men are more gender-prejudiced tip at lower female shares compared to more tolerant regions.

Keywords: tipping, occupational segregation, preferences, Brazil, Schelling

JEL: J00, J16, J21

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1. Introduction

The notion of innate male and female jobs has existed throughout most of human history. Dating back to prehistoric hunter-gatherer civilisations, different types of tasks have often been associated with one or the other sex. Looking at the labour markets of modern economies, there exist male-dominated and female-dominated occupations – a sort of occupational segregation. Historically, a notable process is the global influx of women into a labour force previously dominated by men. While one could assume that this development would have minimised occupational segregation, the phenomenon persists, with many occupations having become female-dominated. This suggests that once women enter an occupation in large quantities, men leave.

There exists a plethora of theories and explanations behind occupational segregation, and it is actively discussed amongst policymakers and researchers alike. Sociologists point out cultural notions regarding women's appropriate role in society as a reason for why women and men end up performing different labour tasks. Economists on the other hand highlight the role of differences in educational choices of men and women. In these attempts to understand the underlying factors behind occupational segregation, an important dimension is often overlooked, namely that of segregation dynamics. Despite historical changes in attitudes regarding women's appropriate societal role and in women's educational attainment, occupational segregation persists (see e.g. Bergmann, 2005; Blau et al., 1998; Killingsworth and Heckman, 1986).

A subset of economic research focuses on the dynamics of occupational segregation. In *Gender Segregation in Occupations: The Role of Tipping and Social Interaction*, the American economist Jessica Pan (2015) studies the developments of the US labour market, and identifies similarities between the process of occupations becoming feminised and the dynamics behind segregation as described by Schelling (1971). Focusing on social interaction, he illustrates how neighbourhoods become segregated. Once the minority share within a neighbourhood becomes sufficiently large, members of the majority group leave. This occurrence is known as *tipping*. Notably, tipping occurs even in cases when both groups have integrative preferences, i.e. high tolerance towards living in proximity with members of the other group. Further, the degree to which individuals within a neighbourhood have integrative preferences determines the critical point of minority share, just beyond which tipping occurs.

Building upon this framework, Pan (2015) studies the dynamics of occupational segregation between males and females. She finds evidence of tipping patterns, and shows that the critical point at which tipping occurs is related to the degree to which males have integrative preferences, i.e. attitudes towards working alongside women. Thus, she identifies evidence related to the predictions by Schelling (1971).

However, it is not evident if these results are exclusive to the US labour market. We identify an interesting research opportunity, in replicating Pan (2015)'s study in a different labour market context as a way to test the empirical validity of Schelling (1971) and thereby contribute to the current understanding of the dynamics of segregation. A country of interest is Brazil, which like the US has seen a substantial increase in female labour participation. Similar to other developing countries, it has rarely been studied within the realm of occupational segregation. In this thesis, we aim to answer the question: *Are observed patterns of occupational change in Brazil consistent with the Schelling-type tipping phenomenon?*

2. Literature Review

We begin by providing a historical context for the gender division of labour, presenting the concept of occupational feminisation. Secondly, we introduce the concept of *occupational segregation* and how it has been used in academia to explain the driving factors behind gender divisions in the labour market. We then highlight a vein of research focusing on the dynamics of segregation, and in particular the theories of Schelling (1971). This leads us to present research by Pan (2015), who investigates whether there exists a Schelling-like tipping phenomenon within the US labour market. Finally, we cover recent labour market developments in Brazil. In closing, we discuss how we aim to contribute to the current state of knowledge on occupational segregation.

2.1 The Entrance of Women into the Labour Market and Occupational Feminisation

A key characteristic of modern society is the dramatic increase in female labour participation from 1960 and onwards. Most notably, in the US, female civilian labour force participation grew from one third of the female population in 1960 to one half in 1980 (Killingsworth and Heckman, 1986). By 2000, participation was at 60% (The World Bank, 2017). The increase was in large part driven by higher rates of married women entering the workforce (Killingsworth and Heckman, 1986). Many attribute the labour shortages of World War II as an impetus for this persistent shift. As women began replacing men in factories and offices, social perceptions regarding women at work changed and greater numbers of women gained valuable work experience (Doepke, Hazan, and Maoz, 2015).

In the post-war period, the allocation of men and women in the workforce followed notable patterns. Gender division of labour remained, despite increases in female labour participation and social strides towards gender equality (Bradley, 1989). A historical explanation behind this persistency is the process of *feminisation* - a process in which traditionally male-dominated occupations become female-dominated. The process is visible when studying the US, post-war. While many occupations have become increasingly gender mixed, a relatively large number of occupations have gone from majority-male to majority-female; meanwhile, significantly fewer occupations have masculinised (Roos and Stevens, 2018).

Studies have suggested a link between higher female employment and the degree of division amongst labour markets: once female labour market participation increases, so does the number of female-dominated occupations (Bertaux, 1991; European Commission's Expert Group on Gender and Employment, 2009; Levanon, England, and Allison, 2009). It seems that as the share of women in a previously male-dominated occupation becomes sufficiently large, the occupation empties of males and ends up virtually all-female (Pan, 2015). There are several examples of occupations that have undergone feminisation: both high-skilled (within healthcare, human resources and law) and low-skilled (postal-clerks, bakers) (Murphy and Oesch, 2015).

2.2 Occupational Segregation

While there are many possible explanations as to why occupations feminise, it is in research often understood in terms of segregation; as two groups have to share a common area (the labour market), they tend to divide according to group characteristics (male and female).

As segregation can take many forms, there is research on a wide array of topics ranging from spatial segregation between different ethnic groups to the dynamics behind classroom seating (Card et al., 2008; Ruoff and Schneider, 2006). When speaking of segregated labour markets however, the term *occupational segregation* is most frequently used. A Dictionary of Sociology (2014, p. 526) defines occupational segregation as "the division of labour, in the context of paid employment, as a result of which men and women (or members of different ethnic or religious groupings) are channelled into different types of occupational roles and tasks, such that there are two (or more) separate labour forces".

Views on the main factors behind occupational segregation of men and women differ among researchers and fields, most commonly in sociology and economics. In sociology, prejudices and stereotypes regarding gender are often seen as possible explanations behind why women and men end up performing different types of labour. Charles (2003) describes occupational segregation as a cultural phenomenon, deeply rooted in the ideologies of gender essentialism (ideas that certain types of jobs are more suitable for men or for women, based on their respective biology) and male primacy (the idea that men are inherently better suited for positions of dominance and authority). A similar way of thinking is prevalent in research emphasizing labour market choices of both employers and employees. In employer choice theories, employers are suggested to infer qualities about workers on the basis of their gender when other information is unavailable (Phelps, 1972; Reskin and Padavic, 1994). In employee-sided theories, it is studied how gender segregation is affected by the respective actions of male and female workers, and how preconceived notions of the two sexes come into play. Socialisation theory is often used to describe how the reinforcement of gender stereotypes shape gender roles and the occupational preferences of men and women, resulting in them choosing different career paths (see e.g. Busch, 2011; Eccles, Jacobs, and Harold, 1990; Okamoto and England, 1999). Other research identifies a link between men's aversion towards working with women and occupational prestige (see e.g. Astrachan, 1986). Goldin (2013) builds upon this notion by developing a model of "occupational pollution", stating that men desire a distance to women in order to protect the prestige of their occupation. Prestige in this context is based on productivity-related characteristics (strength, ability, education, skill). Once women enter a previously male-dominated occupation, it becomes "polluted" by gender-stereotypical characteristics that convey signs of negative productivity shocks. It is thus implied that men's aversion to working in female-dominated occupations might not be solely taste-based.

In the realm of economic literature, labour market choices of women and men are emphasised as driving factors behind occupational segregation, commonly through the lens of the human capital theory. Human capital theory states that individuals choose occupations based on their planned lifetime earnings. Individuals planning longer work lives choose career paths that generate greater returns to experience. As it is assumed that women to a higher degree plan an intermittent work life (due to domestic household responsibilities), it makes sense for them to invest less in human capital, e.g. education and job training. Using this framework, Polachek (1979) highlights the role of human capital depreciation as a consequence of job intermittency (due to lack of on-the-job training and experience). Assuming that depreciation rates and costs for intermittency vary across occupations, it is more economically sound for those who plan an intermittent work life to choose occupations with

low penalties for intermittency. As a result, men and women self-segregate thereafter (Polachek, 1981).

A limitation of the sociological perspective is that occupational segregation remains, despite developments towards a more egalitarian, unprejudiced perspective on men and women. This issue becomes evident when observing Northern Europe, a seemingly progressive region in terms of egalitarian gender views where countries score high on indices measuring occupational segregation (European Commission's Expert Group on Gender and Employment, 2009). As for the human capital theory, the fact that women's formal educational attainment has surpassed that of men's in many parts of the world (European Commission's Expert Group on Gender and Employment, 2009) calls into question the theory assumption that women invest less in human capital.

A growing body of literature focuses on the dynamics of segregation (Card et al., 2008; Cutler, Glaeser, and Vigdor, 1999; Pan, 2015). Here, it is studied *how* for example occupations segregate, as a way to understand *why* they segregate. This research is grounded in the theories of social interaction and tipping presented by Schelling (1971).

2.3 The Tipping Phenomenon

Schelling (1971) emphasizes the role of individual preferences towards integrating with other societal groups as the key driver behind segregation, and notes that segregation can be understood as a consequence of a *tipping* phenomenon. Grodzins (1957) introduced the concept of the tipping point as part of an analysis of neighbourhood segregation. A large enough number of a recognizable new minority moving into a neighbourhood will cause existing residents of the majority to start moving out; this behaviour was observed in US neighbourhoods that changed from a white majority to a black majority and did not revert back. The point at which the change was instigated was what he called the tipping point. Similarly, Duncan and Duncan (1957) looked at mixed neighbourhoods (25% to 75% white) in Chicago between 1940 and 1950 that had experienced this white-to-black change. They found that for all of these neighbourhoods, the change never halted or reversed.

In Schelling (1971)'s application of the tipping phenomenon, he finds that total segregation can occur even in cases where the two racial groups generally express integrative preferences, i.e. a tolerance towards living among members of the other group. In a neighbourhood that tips, a small influx of black neighbours into an all-white neighbourhood initially only causes the most overtly intolerant white residents to move. However, this departure starts a chain reaction. The small decrease in the white-to-black ratio will cause the second least tolerant white residents to depart. Again, the ratio decreases, causing the third least tolerant white residents to move and so on. The white-to-black ratio at which this chain reaction starts is the *tipping point*. Gradually, the departures grow in quantity, and even the more tolerant white residents leave; an irreversible process that leaves the neighbourhood fully segregated. The preference regarding the minority share within the neighbourhood is thus argued to be a key factor behind segregation. This process is according to Schelling (1971) an example of how well-intentioned *micromotives* (integrative preferences) can lead to an unintended *macrobehaviour* (segregation). This is intuitively covered in Schelling (1971)'s spatial proximity model, which we discuss further in the following section.

2.4 The Spatial Proximity Model

The spatial proximity model considers a context in which two types of agents are placed within a certain restricted area. The area represents spaces in which human interaction occurs – e.g. a residential neighbourhood, classroom, concert hall or occupation. To illustrate the model, we consider a chessboard, consisting of 25 cells, 10 black agents and 10 white agents. Each agent is randomly placed within one of the 25 cells. These cells, of which five are empty, can at most be occupied by one agent at a time. In this model, each group is assumed to hold homogeneous preferences. That is, all black agents share the same level of tolerance regarding the percentage of white neighbours around their individual cell and vice versa. While Schelling (1971) specifically allows for variation in each group's tolerance levels and the composition of agents within the whole population, we will in this example stick to a situation in which both groups are equal in size and share integrative preferences, i.e. being satisfied staying in cells where at least a half of their neighbours are of the same group. Sticking to an equally divided population where each group has integrative preferences highlights how individual action can lead to collective results, as mentioned previously.

W		W*	B	W*
B*	W	B	B	B
W		W*	B	W*
B*	W*	B*	W	
B			W*	B*

Figure 2.1 – A chessboard consisting of 25 cells. There are 10 black agents and 10 white agents. 5 cells are empty. The white alike-to-unlike-ratio is 10:33 (approx. 1:3), while the black like-to-unlike-ratio is 20:25 (approx. 1:1). Dissatisfied agents are marked with stars. Figure created by the authors, inspired by figures in Schelling (1971).

Figure 2.1 and 2.2 illustrate how segregation occurs. In Figure 2.1, the agents are randomly distributed across the chessboard. The model is divided into rounds – in each round, agents either remain within their cell or relocate depending on whether or not they are satisfied with their location, based on their tolerance levels. Here we have marked dissatisfied agents with stars. In the following rounds, the population will rearrange until all agents are satisfied with their locations. Movement can occur randomly or on the basis of each agent moving to the closest acceptable cell. In this example, we have chosen randomized movements; however, both cases will lead to segregated outcomes even under integrative preferences, as shown in Figure 2.2.

W	W	B	B	B
W	W	B	B	B
W	W	B	B	
W	W	B	B	
W	W			

Figure 2.2 – The same chessboard, now segregated. The white alike-to-unlike-ratio is 42:11 (approx. 4:1), while the black alike-to-unlike-ratio is 43:11 (approx. 4:1). Figure created by the authors, inspired by figures in Schelling (1971).

The model allows for alterations in the various parameters in order to test the dynamics of segregation and individual preferences. One important parameter to consider for the purpose of studying the implications of the shift in female labour market participation is the composition of the two agent groups. For any given set of equal tolerance levels, Schelling (1971) proves that variations in size differences between the two groups affect the degree and speed of segregation. More notably, he constructs a scenario in which the chessboard starts off with a population where agents belong to the same group, and where members from a minority group enter one by one. In the initial rounds, the minority group begins to cluster. Once the cluster is sufficiently large in size, members of the majority group start to evade the locality of the cluster, creating a stable segregated division of the chessboard.

In conclusion, the spatial proximity model shows how individuals in a restricted area can come to self-segregate over time, even if they have no real desire to do so. It points to the seemingly inevitable nature of segregation, as well as to its persistency.

2.5 A Model of Occupational Tipping

While Schelling (1971)'s models of segregation explain the dynamics behind segregation in general terms, they are meant to be applicable to its more specific forms, including that of occupational segregation. In the labour market context, then, the mechanism discussed above can be understood as one in which individuals, even though they do not mind working with the other sex, still end up segregating into female-dominant and male-dominant occupations. Pan (2015) identifies this in her article *Gender Segregation in Occupation: The Role of Tipping and Social Interactions*. Studying the effect of increased female labour participation in the US[1], Pan (2015) discovers historical patterns of tipping within the gender composition of certain occupations. To investigate whether the phenomenon relates to the predictions by Schelling (1971), she tests whether differences in the location of tipping points across regions vary with regional differences in male attitudes towards working alongside women[2]. It is found that regions with more sexist attitudes generally hold lower tipping points, suggesting a link between preferences and segregation.

Pan (2015) illustrates how tipping can occur within an occupation by constructing a *Model of Occupational Tipping*, inspired by Card et al. (2008). The model focuses on the female and male labour supply of an occupation. Drawing upon literature linking gender identity with occupational choice (Akerlof and Kranton, 2000; England, 2006; Goldin, 2013), it is assumed that males experience disutility working in occupations where the female share exceeds a certain individual critical point, and thus require a wage premium to stay in the occupation. Letting male and female labour supply depend on wage (w) and the female share of an occupation (f), inverted supply curves for female and male workers are drawn (see Figure 2.3).

[1] Using data from the 1910–2000 US population censuses, available from Integrated Public Use Microdata Series (IPUMS).
[2] Pan (2015) creates an index of male attitudes towards working alongside women, based on responses to questions on women's appropriate role in society asked in the 1977–1998 waves of the General Social Survey (GSS).

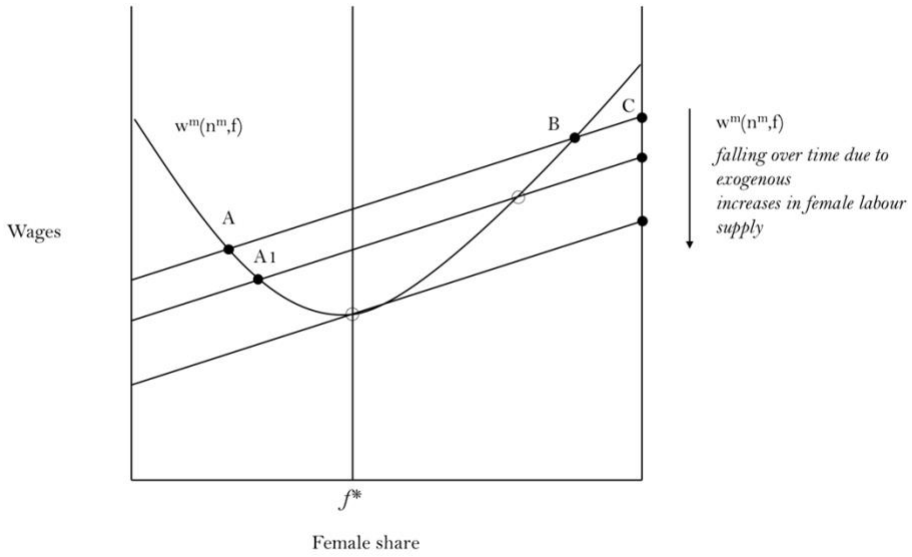

Figure 2.3 – Different equilibria as the female labour supply increases with time. This is a reproduction of a figure from Pan (2015).

Pan (2015) assumes heterogeneous preferences, allowing male workers to tolerate different levels of f before requiring wage premiums. The model shows how shocks in the relative female labour supply can lead to tipping. The tipping point is located at the female share (f^*) at which the two inverse supply curves become tangent (w^m and w^f). Beyond this point, the marginal male worker will start to demand a higher wage compared to the marginal female worker, in order to compensate for their disutility. For occupations with female shares below f^*, female labour supply shocks will only cause small differences in the gender composition. For occupations above f^*, tipping has begun, implying greater than average growth in female labour supply.

The strength of the male workers' distaste for working in the same occupation as women determines the location of the tipping point. The larger the required premiums, the lower the point at which tipping arises.

2.6 The Twentieth Century Developments of the Brazilian Labour Market

Looking at other parts of the world, a country of interest when examining the dynamics of occupational segregation is Brazil. The country is South America's biggest and most populated, and also among its most culturally and ethnically diverse (Torres et al., 2015). Brazil underwent dramatic political and economic developments during the twentieth century. This change was mirrored in the various developments of the labour market. Historically rooted in agriculture, from 1940 and onwards the economy became diversified and industrialised, with many workers shifting towards the industry and service sectors (Momsen, Poppino et al., 2018; Schneider, 1996). Simultaneously, the role of women in society changed. Traditionally, women played a small role in the public life of Brazil. Female-organized protests following the military coup of 1964, the rise of

the feminist movement and the economic development are all seen as factors increasing the economic and political rights of women, reflected in the dramatic rise of employed women within the labour force (Skidmore, 1999). In 1950, roughly 14 percent of the female population participated in the labour force. This number had doubled by 1980. The following decade witnessed the largest growth in female employment, and in 1992, nearly half of the female population participated in some sort of economic activity (Madalozzo, 2010). During this process, the Brazilian labour market has remained divided on the basis of gender, similar to the case of the Western economies (Madalozzo, 2010).

2.7 Our Contribution

Based on the previous discussions regarding the seemingly widespread phenomenon of occupational segregation and the developments of the Brazilian labour market, we identify an interesting research opportunity.

While the schools of sociology and economics shed insight into important factors behind occupational segregation, we find a need for further insights into its dynamics. Looking at the historical processes of how a labour market segregates is important in order to understand the underlying factors of occupational segregation. Viewing occupational segregation through the lens of Schelling (1971) can according to Pan (2015) help narrow this knowledge gap, as the irreversibility of tipping could explain why occupational segregation persists. Further, the idea of micro-motives leading to macro-outcomes could explain why the labour markets of even seemingly gender-egalitarian societies are characterised by segregated occupations.

However, although the findings of Pan (2015) provide valuable contributions to existing literature on the empirical strength of Schelling (1971)'s theories, we still call into question whether one will find similar results in other settings, or if they are exclusive to the US labour market. It is thus valuable to gather empirical evidence from other parts of the world.

We find in Brazil a suitable country for that empirical aim. Firstly, similar to the US, Brazil is a federation with great geographical differences in culture and demography. Secondly, both nations have persisting occupational segregation, despite increases in female labour participation. Thirdly, like many other developing economies, Brazil has rarely been studied when it comes to occupational segregation (Salardi, 2016).

Therefore, in this thesis we aim to test Schelling (1971)'s theories empirically within the Brazilian labour market context, and thus contribute to the existing research on occupational segregation.

3. Research Focus

In this thesis, we apply the theoretical framework of Pan (2015) and replicate her methods in a study of the Brazilian labour market. We examine Brazilian census data from 1960 to 2010 for potential patterns of tipping and investigate whether they are affected by male attitudes towards working alongside women. In doing so, we test the empirical strength of Schelling (1971)'s theories on segregation. We thus hope to shed light on the dynamics of occupational segregation and its underlying factors. This leads us to our research question:

Are observed patterns of occupational change in Brazil consistent with the Schelling-type tipping phenomenon?

If this is the case, we hypothesise that:

1) There exist patterns of tipping in the Brazilian labour market.

If we find evidence for the aforesaid hypothesis, we will seek to test Schelling (1971)'s theory of individual preferences as a key factor behind segregation, i.e. whether tipping patterns are affected by preferences regarding the female share of an occupation. This leads us to our second hypothesis:

2) Regions in which men exhibit less tolerant preferences towards working with women tip at lower female shares compared to more tolerant regions.

4. Method

4.1 Data Sources

4.1.1 Brazilian Census Data

The main source of data is the 1960–2010 Brazilian censuses[3] accessible through Integrated Public Use Microdata Series, International (Minnesota Population Data Center, 2018).[4] The censuses include variables for sex, age, educational attainment and occupation, among many others. Observations are grouped geographically according to regional residence. This includes both the states of Brazil and its five census regions (North, Northeast, Southwest, South, Midwest). This data allows us to examine changes in the gender shares of Brazilian occupations over time. We follow Pan (2015) in creating a set of occupation-states. Each occupation in each geographical state is an occupation-state. We do this for two reasons. Firstly, we want to ensure comparability with her method. Secondly, analysis at a more refined level would require a more extensive data set. We restrict the analysis to occupation-states with a minimum of 30 observations in all years of the census.[5]

[3] While the 1991 survey was completed 11 years after the previous one, the questions regarding occupational status were based on the year 1990. This means that there was an interval equal to a decade in between 1980 and 1991 censuses.
[4] Data originally produced by Instituto Brasileiro de Geografia e Estatística.
[5] The full procedure of creating occupation-states is further outlined in the Appendix.

4.1.2 Survey Data from the International Social Survey Programme

A secondary source of data is gathered from a dataset of the International Social Survey Programme (ISSP) 2002 survey, *Family and Changing Gender Roles III* (ISSP Research Group, 2013). The survey includes questions on the role of women in society, family and employment. The dataset includes both the collected answers to these and other questions, as well as variables for sex, age, educational attainment, occupation, region and state.

4.2 Empirical Strategy

Our empirical strategy mimics that which is used by Pan (2015). First, it is tested whether occupations in Brazil exhibit tipping patterns, in a method inspired by Card et al. (2008). This corresponds to our first hypothesis. Later, it is examined whether there exists a link between the variation in male preferences for working with women and the tipping phenomenon. This corresponds to our second hypothesis.

4.2.1 Finding Patterns of Tipping

In order to test for tipping in the Brazilian labour market, a two-step procedure is executed in which:

a) Structural breaks in the data are searched for in order to locate *candidate tipping points* for each occupational group (white-collar or blue-collar) in each decade, i.e. the female share at which tipping points are most likely to occur.

b) The magnitude of tipping is tested by regressing the change in net male employment for occupations just above and below the candidate tipping point on their initial female share.

Like Pan (2015), we assume that if a tipping point exists, it is specific to a geographical region, occupational group (white-collar or blue-collar) and decade. Regional differences in male preferences regarding working alongside women might cause the tipping point to vary; thus, it makes sense to look at regionally specific tipping points. Gender attitudes of a population might also change over time, meaning that tipping points could vary with time. Thus, it is logical to also look at decade-specific tipping points.

The dependent variable which we aim to test is the decadal change in net male employment:

$$Dm_{isrj,t}=\left[(M_{isrj,t}-M_{isrj,t-10})/P_{isrj,t-10}\right]-\left[(F_{isrj,t}-F_{isrj,t-10})/P_{isrj,t-10}\right]$$

where $M_{isrj,t}$, $F_{isrj,t}$ and $P_{isrj,t}$ stand for male, female and total employment in occupation *i*, state *s*, region *r*, white- or blue-collar occupational group *j* in year *t*. Change in net male employment is defined as the difference between male and female employment growth over a ten-year period. By using the difference between male and female employment growth as the dependent variable, variation caused by occupational demand for both sexes will be netted, mitigating the issue of

potential correlation between occupational demand and the initial gender composition of an occupation. The main independent variable is the occupational female share in the initial time period:

$$f_{isrj,t-10} = F_{isrj,t-10}/P_{isrj,t-10}$$

In the first step of the procedure, we conduct a search process originally developed by Hansen (2000), in which structural breaks in the data are identified in order to find where tipping points are most likely to occur. Therefore, in this step we are assuming that tipping points exist in order to estimate their location. This assumed tipping point is referred to as a candidate tipping point (f^*). Net male employment growth is regressed on a constant as well as an indicator variable indicating whether an occupation has an initial female share above the candidate tipping point:

$$Dm_{isrj,t} = \alpha + d1[\delta_{isrj,t-10} > 0] + e_{isrj,t} \qquad (1)$$

where $\delta_{isrj,t-10}$ is an occupation-state's deviation from a candidate tipping point, defined as:

$$\delta_{isrj,t-10} = f_{isrj,t-10} - f^*_{rj,t-10}$$

To compute the ordinary least squares (OLS) estimates of (1), we set $f_{isrj,t-10}$ equal to f^* for each observation. The estimate of f^* is the value for which the regression shows the highest value of R-squared. This regression is estimated separately for white- and blue-collar occupations in each time period. We restrict the data using occupation-states with initial female shares between 5% and 95% in order to mitigate the risk of our results being skewed by occupations that are close to being fully dominated by one or the other sex.

In the second step, we use the estimations of f^* from the previous regression in order to determine the magnitude of the structural breaks, in essence testing whether there exist discontinuities in the data consistent with tipping.[6] We estimate the following regression with OLS:

$$Dm_{isrj,t} = p(\delta_{isrj,t-10}) + d1[\delta_{isrj,t-10} > 0] + \tau_{jr} + \gamma_s + X_{isrj,t-10}\beta + e_{isrj,t} \qquad (2)$$

where $p(\delta_{isrj,t-10})$ is a smooth control function in the form of a fourth-order polynomial, τ_{jr} is a set of occupational group fixed effects at the regional level, $\gamma_s$is a vector of state fixed effects and $X_{isrj,t-10}$ is a vector of occupational-level controls (average age, education and log male wages in the initial period). This regression tests whether occupations just above the candidate tipping point exhibit greater net male employment growth than occupations just below it. The smooth control function approximates the data to a fourth-order polynomial, allowing for a more flexible fit.[7]
If tipping exists, then there is a negative discontinuity in the change in net male employment growth at the tipping point: occupations with initial female share just above the tipping point will have lower net male employment growth than occupations with initial female share just below the tipping point.

One possible concern with our empirical strategy is that the way two-step structural break

[6] While similar to a Regression Discontinuity (RD) approach, the estimation of equation (2) should not be seen strictly as such. Since the tipping points are discontinuities that are unknown a priori to the estimation (and possibly non-existent), the RD assumptions might be violated. Instead, the presented empirical strategy makes use of the fact that tipping here is defined as a steep decline in average male employment growth, and looks for the point at which this decline occurs.
[7] Controlling for the occupational-level covariates is necessary, since it is possible that tipping could arise because of occupational characteristics changing close to the tipping point.

procedure is designed creates a search specification bias (Card et al., 2008; Hansen, 2000): identifying candidate tipping points using the full data and estimating tipping magnitude with that same data might cause overestimation of tipping's importance. To remedy this, we will bootstrap the standard errors of the estimates of equation (2).

4.2.2 Index of Male Attitudes

Using Pan (2015)'s theoretical framework of occupational tipping (discussed in Section 2.5), it is assumed that males experience disutility working in occupations where the female share exceeds a certain individual critical point. Beyond this tipping point, men are theorised to demand a wage premium to compensate for their disutility. This means that the location of a tipping point should be related to the size of males' disutility from working alongside females. Like Pan (2015), we identify an absence of data on male preferences for working in occupations that are female-intensive. However, there exists data of male attitudes toward women's appropriate role in society. ISSP conducts cross-national surveys annually on wide-ranging topics, one of which is gender roles. The surveys are nationally representative. In the 2002 ISSP survey *Family and Changing Gender Roles III* (ISSP Research Group, 2013), respondents in Brazil were asked to respond to statements on the role of women in society, family and work.[8]

Similar to Pan (2015), who follows a procedure used in Charles and Guryan (2008) and Charles et al. (2009), we construct an Index of Male Attitudes through combining answers to six questions in the ISSP survey that relate to women's role in society. Two examples are: "To what extent do you agree or disagree…? A man's job is to earn money; a woman's job is to look after the home and family" (ISSP Research Group, 2013, p.22) and "To what extent do you agree or disagree…? A pre-school child is likely to suffer if his or her mother works" (ISSP Research Group, 2013, p.10)[9]. The responses to these questions are given numerical values (so that the more gender-prejudiced answers correspond to higher values) and are combined to make a single score on the level of an individual observation. The individual scores are then aggregated on regional level, separately for males and females as well as for white-collar and blue-collar workers, resulting in an Index of Male Attitudes.

Like Pan (2015), we use the index as a proxy for the size of males' disutility from working in the same occupations as females. Following her reasoning, the attitudes summarised in the survey reflect male views on the degree to which females entering an occupation are seen as "polluting" (Goldin, 2013) an occupation's prestige – in the sense that they are views on women's role and identity in society.

In order to test the link between male attitudes towards working with women and tipping, we estimate the following regression via OLS:

$$f^*_{jrt} = \alpha + \beta MaleAttitudes_{jr} + \tau_j + \theta_t + \gamma X_{jrt} + e_{jrt} \qquad (3)$$

where j denotes the occupational group, r the region and t the time period. τ_j is a dummy for white-collar occupations, θ_t a vector for decadal fixed effects, and X_{jrt} a vector of covariates. The dependent variable is f^*_{jrt}, the location of the tipping point specific to an occupational group, region

[8] The survey was conducted in 34 countries in total.
[9] To view a full list of questions included in the index, read the Appendix.

and time period. The main dependent variable is $MaleAttitudes_{jr}$, the average male prejudice specific for each occupational group and region.

4.3 Potential Limitations to the Data

Before proceeding further, we address some limitations to the data.

In the Brazilian censuses, the way occupations are defined varies across time. This makes it necessary to remove certain occupations from the data as we construct a consistent set of occupation-states across all years. It is also necessary to remove the 2000 and 2010 census data, as the occupation codes of those years differ too greatly from previous years. Further, there is no data for the occupation-variable for the North region in 1960.

The ISSP survey is limited to one year, 2002. While three other ISSP surveys on gender have been conducted between 1988 and 2012, they were not carried out in Brazil. The year 2002 also lies outside the range given by the chosen census data (1960–1991). However, the ISSP data is used to capture regional differences in attitudes, and we argue that over time such regional differences are believed to be fairly stable.[10]

5. Descriptive Statistics

Some descriptive statistics are shown in Table 5.1. To begin with, our treated sample has an equal amount of occupations (170) in each time period. The number of occupation-states, on the other hand, increases over time. This is due to population growth and increases in the sample fraction of the population (which is 5% in 1960, 1970 and 1980 censuses and approximately 5.8% in 1991).

Panel A overviews the treated sample using occupations as the unit of observation. We see a rise in average female share in occupations over time, going from 21% in 1960 to 26% in 1980. This mirrors the fact that the share of females among economically active in Brazil almost doubled, from 17% to 31%, during this time span. However, growth in total employment is driven in larger part by male employment growth, indicating that relative female supply of labour has not increased. We address this fact later in our discussion of the results.

Looking at panel B, it considers how initial female share affects male employment growth, using occupation-states with at least 30 observations as unit of observation. A general finding is that the higher the initial female share, the less the male fraction of total employment growth in each ten-year period. For occupations with only 0–5% female share in 1960, 1970 and 1980, employment growth over the next ten years was virtually all-male. Further, male employment growth made up a large part of total employment growth for occupations with 5–20% female share in 1960 and 1980. However, looking at occupations with female share of 20% or more, male employment growth played a much smaller role: from 1980 to 1991, male growth accounted for around 30% of total employment growth of occupations with 20–50% as well as 50–80% female share in 1980. From

[10] According to Ribeiro (1997), the cultural diversity of Brazil is rooted in the country's regional differences in climate and soil. We argue that these differences are highly constant over time, which could point to stable differences in men's attitudes amongst the Brazilian regions.

1970 to 1980 in occupations with 50–80% female share in 1970, male growth was only 15% of total growth. Finally, from 1960 to 1970, male growth was in fact negative for 50–80% female share occupations in 1960.

Table 5.1
Descriptive Statistics, 1960–1991

	Base year ($t-10$)		
	1960	**1970**	**1980**
A. Overall:			
Number of occupations	170	170	170
% of employed population	.30	.34	.36
Mean % female	.21	.24	.26
Total employment growth, $t-10$ to t (%)	75.7	44.8	35.5
Male employment growth, $t-10$ to t as % of $t-10$ total employment	55.3	30.6	22.2
Female employment growth, $t-10$ to t as % of $t-10$ total employment	20.4	14.2	13.3
B. Restricted to specific occupation-states with min. 30 observations:			
Number of occupation-states	697	1166	1476
% of employed population	.27	.33	.34
Mean % female	.21	.24	.26
Total employment growth (%)	36.6	40.2	32.7
Male employment growth (%)	25.1	27.1	19.7
0%–5% female in base year:			
Number of occupation-states	411	629	699
Fraction of total occupation-states	.590	.540	.474
Total employment growth (%)	36.4	55.2	27.4
Male employment growth (%)	34.9	54.2	24.4
5%–20% female in base year:			
Number of occupation-states	126	197	278
Fraction of total occupation-states	.181	.169	.188
Total employment growth (%)	26.5	-18.4	56.7
Male employment growth (%)	17.2	-21.3	39.0
20%–50% female in base year:			
Number of occupation-states	52	149	221
Fraction of total occupation-states	.075	.125	.150
Total employment growth (%)	60.7	47.9	24.5
Male employment growth (%)	29.7	21.4	7.5
50%–80% female in base year:			
Number of occupation-states	53	90	111
Fraction of total occupation-states	.076	.077	.076
Total employment growth (%)	23.7	58.8	57.3
Male employment growth (%)	-1.2	8.7	15.8
80%–100% female in base year:			
Number of occupation-states	55	101	167
Fraction of total occupation-states:	.079	.087	.114
Total employment growth (%)	32.4	37.7	37.2
Male employment growth (%)	-1.9	-0.5	6.4

Note that, in panel A, the unit of observation is an occupation and, in panel B, it is an occupation-state with > 30 observations. For an in-depth description on how occupations in every year were classified, read the Appendix. The summary statistics stand in relation to the base-year employment of each occupation in panel A, and to that of each occupation-state in panel B, respectively.

Since the female share in an occupation might vary greatly across occupations, the average female share perhaps does not tell the full picture. Looking at the distribution of female shares provides additional insight. Figure 5.1 graphs, for each year in the data, the distribution of female shares in each occupation as it stands in relation to the female fraction of the total labour force. During the 1960s and 1970s, there was a dominance of majority-male occupations. However, the 1980s and 1990s, while still erring towards majority-male occupations, showcased an increase in majority-female occupations (a possible indication of a tipping mechanism) as well as in integrated occupations. As the fraction female in the labour force grew, the distribution in these years narrowed.

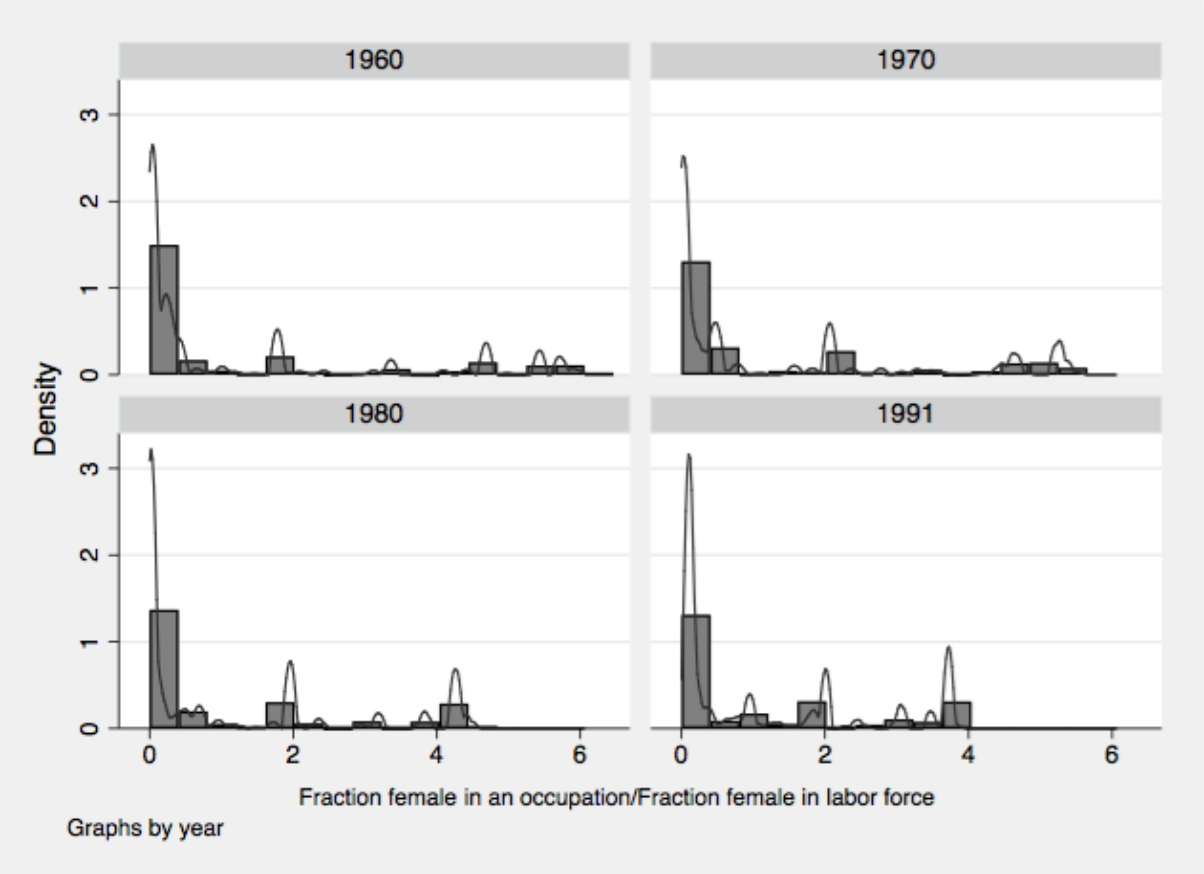

Figure 5.1 – The distribution of female shares across occupations, 1960–1991. The figure displays the fraction females in an occupations relative to the fraction female in the labour force for all four years. Unit of analysis is an occupation, and the total number of occupations is 170 (as in the treated sample). All occupations are weighted by employment size. Figure created by the authors, but inspired by a figure in Pan (2015).

Finally, we examine occupations that have experienced a large decline in the male share over time. Figure 5.2 shows four occupations, Architects, Government attorneys, Hairdressers/Barbers and University teachers, that have experienced a decline in male share of more than 30% in the period 1960–1991. Overall, there are 11 occupations that have experienced a 30% decline or higher over time, and 29 occupations have seen a fall of 20% or more. These numbers suggest the possibility of a tipping phenomenon in the Brazilian labour market.

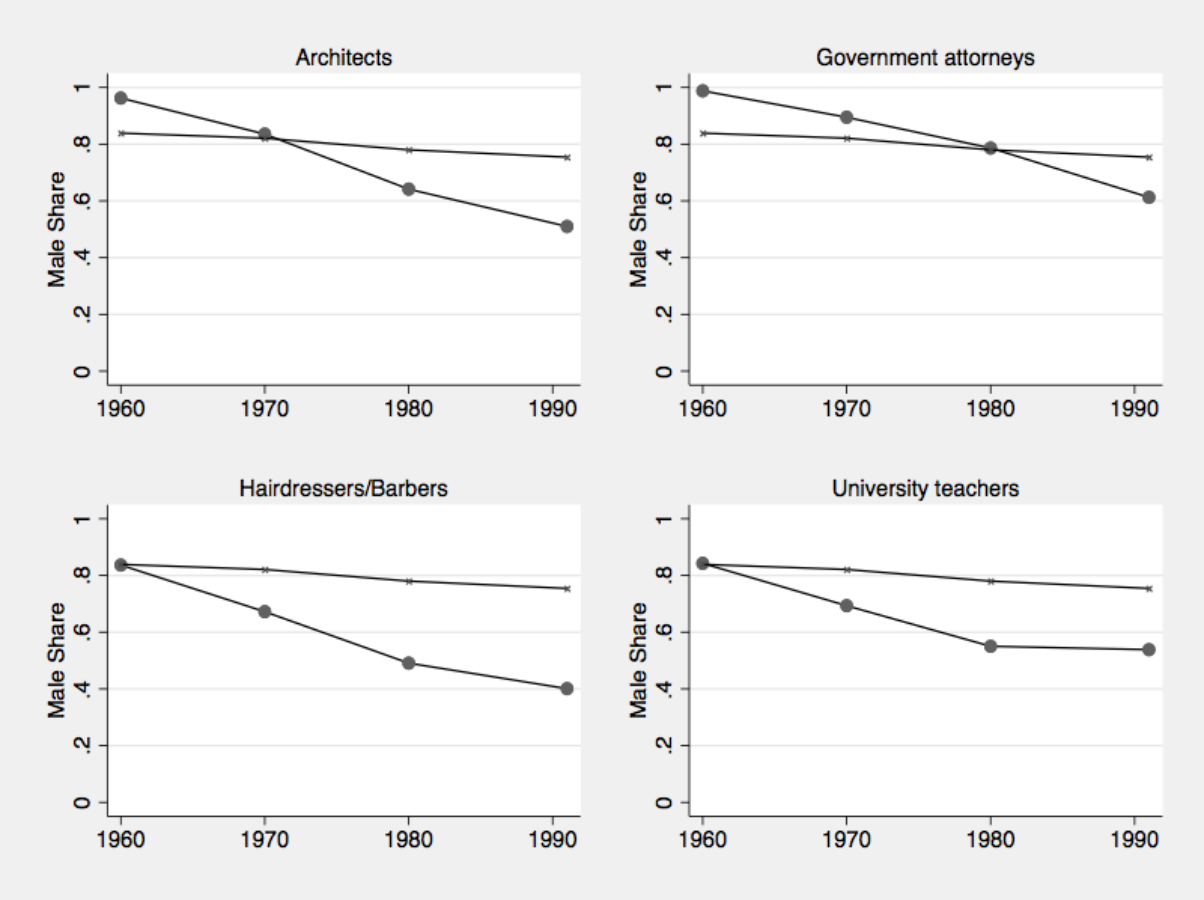

Figure 5.2 - Four occupations in Brazil and their change in gender composition between 1960 and 1991. The crossed lines mark the fraction of males in the labour market over time, same for all occupations in the census sample. The dotted lines mark the fraction of male workers in each occupation over time. Figure created by the authors.

6. Results

6.1 Patterns of Tipping

In this section, we test our first hypothesis. To start off, we highlight the results of the search procedure for structural breaks in the data, with two representations of the candidate tipping points. Later, we provide estimates from equation (2), indicating the magnitude of potential tipping.

In Table 6.1, we display the candidate tipping points as identified by the structural break method. They are presented as averages across all five census regions, for each decade interval and occupational group. Note that since the 1960 census lacks occupational data for North, the two candidate tipping points for the 1960–1970 interval are averaged across the remaining four regions. There is a clear drop in net male growth beyond the candidate tipping point for each decade. Occupations that are below the tipping point have above-average growth in net male employment; inversely, those occupations that are above it display below-average net male employment growth.

For the most part, white-collar occupations exhibit higher average tipping points than blue-collar occupations. Further, the table shows that blue-collar occupations tip at lower female shares over time. Average tipping points for white-collar occupations do not seem to follow a distinct trend over time.

Table 6.1
Average Candidate Tipping Points

	Structural Break Method	
Decade.	White-Collar	Blue-Collar
1960–1970	.56 (.08)	.38 (.19)
1970–1980	.76 (.04)	.28 (.15)
1980–1991	.49 (.17)	.24 (.10)

Note: Estimation of region-specific potential tipping points is done on the full sample. The dependent variable is net male employment growth over the corresponding 10-year interval. Tipping points describe an occupation-states female share, reported in percentage points. Each row corresponds to a specified decade, and reports the average tipping points (and standard deviations parenthesised) across all five census regions for that decade. Estimating the structural break procedure is done for each region for white-collar and blue-collar occupations. It leaves out occupation-states with initial female share below 5% and above 95%.

Another way of illustrating the candidate tipping points is shown in Figure 6.1. The figure plots the decadal change in net male employment growth deviated from the mean for each occupation-state, against initial female share deviated from the specific tipping points of regional occupational groups. The relationship is plotted for each decadal interval. The dots in the panels stand for mean changes for two-percentage-point bins of $\delta_{isrj,t-10} = f_{isrj,t-10} - f^*_{isrj,t-10}$. The solid lines represent local linear regressions that are fit to the data on both sides of the candidate tipping point. The range of $\delta_{isrj,t-10}$ is restricted in the figures to $\delta_{isrj,t-10} \in [-0.5, 0.5]$. The estimated tipping points are represented by the vertical lines at 0 in each panel. The figure shows that when the initial female share of an occupation increases just beyond the tipping point (represented by the vertical line at 0 on the x-axis), mean net employment growth declines approximately 55, 70 and 50 percentage-points in 1960–70, 1970–80 and 1980–91 respectively.

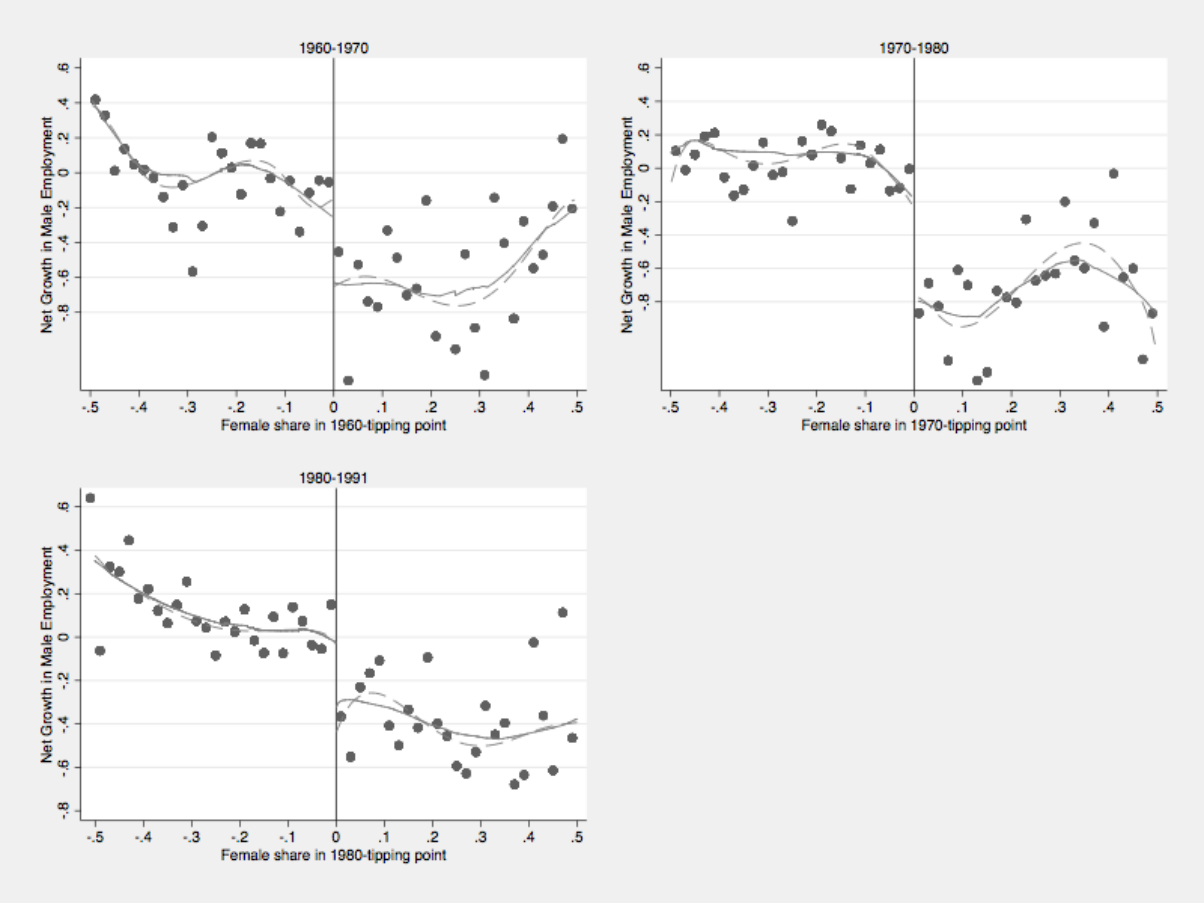

Figure 6.1 – Employment growth in occupations around the tipping threshold, 1960–1991. Each figure plots the decadal change in net male employment growth deviated from the mean for this for every occupation-state, against initial female share deviated from the specific tipping points of the regional occupational group ($\delta_{isrj,t-10} = f_{isrj,t-10} - f^*_{isrj,t-10}$). Each dot stands for the average change in net male growth for two-percentage-point bins of $\delta_{isrj,t-10}$. The solid lines represent local linear regressions that are fit to the data on both sides of the candidate tipping point, while those that are dashed represent fitted values for a polynomial of the fourth order in $\delta_{isrj,t-10}$. This allows for an intercept shift at the point where $\delta_{isrj,t-10}$= 0. The range of $\delta_{isrj,t-10}$ is restricted in the figures to $\delta_{isrj,t-10} \in [-0.5, 0.5]$. Figure created by the authors, but inspired by a figure in Pan (2015).

In Table 6.2, we present estimates of $\hat{d}$ from equation (2) for the ten-year periods 1960–1970, 1970–1980 and 1980–1991. It shows the estimated magnitude of tipping for occupations that have an initial female share slightly higher than the candidate tipping point, compared to occupations with initial female shares slightly lower than the candidate tipping point. The dependent variable is net male employment growth in a 10-year interval. The regressions control for a fourth-order polynomial in initial female share as well as fixed effects for regional occupational groups. Each ten-year period is presented in a separate panel. Each panel has three rows, reporting coefficient estimates of $\hat{d}$, robust standard errors (in parentheses) and bootstrapped standard errors (in square brackets). Bootstrapped standard errors are generally higher than their robust counterparts, but virtually all estimates remain statistically significant at 1%.

Table 6.2: Regression Models of Net Male Employment Growth at Candidate Tipping Points

	Dependent Variable: Net Growth in Male Employment				
	Pooled Sample			White-Collar	Blue-Collar
	(1)	(2)	(3)	(4)	(5)
1960–1970:					
Beyond candidate tipping point	−.704** (.141) [.224]	−.686** (.147) [.251]	−.691** (.112) [.197]	−.410* (.171) [.214]	−.826** (.208) [.318]
Number of observations	689	689	689	221	468
R^2	.215	.251	.372	.602	.247
1970–1980:					
Beyond candidate tipping point	−.720** (.111) [.150]	−.704** (.095) [.157]	−.689** (.212) [.167]	−.977** (.328) [.232]	−.364* (.138) [.223]
Number of observations	1161	1161	1161	454	707
R^2	.316	.345	.395	.432	.365
1980–1991:					
Beyond candidate tipping point	−.236** (.061) [.085]	−.219** (.059) [.084]	−.387** (.071) [.102]	−.457** (.121) [.121]	−.319** (.094) [.160]
Number of observations	1457	1457	1457	609	848
R^2	.272	.304	.348	.467	.204
Controls:					
Regional occupational group fixed effects	Yes	Yes	Yes	Yes	Yes
4th order polynomial in initial female share	Yes	Yes	Yes	Yes	Yes
State fixed effects	No	Yes	Yes	Yes	Yes
Occupation characteristics in (t-10)	No	Yes	Yes	Yes	Yes
Industry fixed effects	No	Yes	Yes	Yes	Yes
4th order polynomial in initial female share x white-collar x region	No	No	Yes	Yes	Yes

Note that the occupation-state with minimum 30 observations in t and $t-10$. The panels show regressions for the time period stated in their heading. Robust standard errors, that are clustered by state, are reported in parentheses, while bootstrap standard errors are in squared brackets.
*Significant at the 5% level
**Significant at the 1% level

Seen in column 1 of Table 6.2, there is a statistically significant, fairly large tipping at candidate tipping points between 1960 and 1991, as shown by the decreases in net male employment growth. The interpretation of the estimate in column 1, panel 1 of Table 6.2, is that from 1960 to 1970, an increase in the initial female share by one standard deviation across the tipping point leads to a 70 percentage-point decline in net male employment growth, holding all other variables constant. Similarly, net male employment growth declines by approximately 72 percentage points from 1970 to 1980 and approximately 24 percentage points from 1980 to 1991.

However, these estimates could potentially be biased, as there might be omitted variables that in fact cause these changes to the net male employment growth and that are discontinuously correlated with initial female share, making it appear as if initial female share drives the results. In column 2, we therefore control for possible omitted variables. These controls are for occupational characteristics from t−10, such as average age, years of education and logged wages for men. Also included are industry-level fixed effects[11] as well as a vector of state-level fixed effects. The estimates change very little once the controls are added, and remain statistically significant. This indicates that there are not discontinuous changes in occupational characteristics at the candidate tipping points that drive the tipping patterns.

Further, in column 3 we show the estimates from letting the fourth-order polynomial $p(\delta_{isrj,t-10})$ differ for each occupational group at the regional level. This is done to ensure that results are not dependent on the polynomial being the same for white- and blue-collar occupations in a decade. The estimates are still statistically significant and, in the case of 1960–1970 and 1970–1980 periods, very similar to those in columns 1 and 2.

Column 4 provides estimates from running this regression only on white-collar occupations, while column 5 does the same for blue-collar occupations. The estimates in these two columns differ slightly from those in the other three, but remain strongly negative and statistically significant.

Overall, the discontinuities in net male employment growth at candidate tipping points range from 46% to 97% female in white-collar occupations and 32% to 83% female in blue-collar occupations, depending on the decade and exact specification of equation (2). Occupations in general experience a 22–72 percentage point decline in net male employment growth at the candidate tipping points.

Based on the results from Table 6.2, we conclude that tipping patterns exist within occupations of the Brazilian labour market. This provides support for our first hypothesis. We discuss this in greater detail in Section 7.1.

6.2 Tipping and Preferences

In this section, we test our second hypothesis. More specifically, we examine the prediction that the census regions where men show less tolerant attitudes toward working alongside women will likely tip at lower initial female shares.

[11] The International Standard Classification of Occupations of 1988 (ISCO-88) divides a labour market into 10 categories: Legislators, senior officials and managers, Professionals, Technicians and associate professionals, Clerks, Service workers and shop and market sales, Skilled agricultural and fishery workers, Crafts and related trades workers, Plant and machine operators and assemblers, Elementary occupations, and Armed forces (International Labor Organization, 2004). Armed forces are excluded from the analysis.

First, we allow the candidate tipping points presented in Table 6.1 to be specific to single census regions. Columns 1-3 of Table 6.3 show the average candidate tipping points across regions between 1960 and 1980, for blue-collar and white-collar occupations separately and together.[12] The Northeast and Midwest regions have the highest average candidate tipping points. Meanwhile, candidate tipping points are lowest in the North and Southwest regions. When it comes to occupational group, white-collar occupations exhibit higher tipping points than those of blue-collar occupations. This holds true for all regions. An interesting result is that the North region has lower tipping points than other census regions, both overall and when separating the two occupational groups.

In Columns 4-6 of Table 6.3, we explore the link between tipping point locations and measures from the Index of Male Attitudes. These columns display scores of male prejudice for each region for blue-collar workers and white-collar workers separately and together, culled from the index. Here, Southeast and Midwest male workers score lowest on the index, indicating the least prejudice. Meanwhile, the North is the most prejudiced region; it has the highest scores in all three columns, mirroring the result that its tipping points are the lowest. Apart from this result, there is no systematic relationship in the data between a low score and a high tipping level for a region. A comparison of occupational groups show that male white-collar workers exhibit lower scores in all regions, meaning they are less prejudiced than blue-collar working men. The lower part of Table 6.3 shows the estimate from regressing the average tipping point locations on our index of male attitudes. The overall estimate is negative, suggesting a negative relation between a low level of tipping and high gender prejudice. But this estimate is not statistically significant. Estimates for white-collar and blue-collar are positive but similarly insignificant.

Table 6.3
Average Tipping Points and Male Attitudes – Regional Variation

	Average Tipping Point			Index of Male Attitudes		
Census Region	Overall (1)	White-Collar (2)	Blue-Collar (3)	Overall (4)	White-Collar (5)	Blue-Collar (6)
North	.289	.427	.152	.108	.001	.163
Northeast	.484	.669	.300	.032	-.006	.072
Southeast	.351	.530	.173	-.011	−.236	.014
South	.416	.579	.354	.037	−.035	.127
Midwest	.495	.515	.475	.024	−.475	.161

	Dependent Variable: Average Tipping Point		
	Overall	White-Collar	Blue-Collar
Bivariate OLS coefficient	-.952 (1.025)	.090 (.244)	.739 (1.085)
Number of observations	5	5	5
R^2	.223	.043	.134

Note: Average tipping points are the means of candidate tipping points across the three time periods in the census for each region. The Index of Male Attitudes is constructed using the ISSP 2002 survey *Family and Changing Gender Roles*. The blue-collar and white-collar indices restrict the overall index to males who reported a blue-collar or white-collar occupation, respectively, in the ISSP survey. The table's lower part displays coefficients from bivariate regressions of the average tipping point overall on the overall index as well as on the average blue-collar (white-collar) tipping points on the blue-collar (white-collar) index.
*Significant at the 5% level

[12] Note that since there is an absence of data from the North region in 1960, the averages in the first row of columns 1–3 are based on candidate tipping points from 1970–1980 and 1980–1991 only.

To more formally investigate the relation of prejudiced attitudes and the location of tipping points on a regional level, we estimate equation (3). The estimates of the regression are shown in Table 6.4. Standard errors are clustered by region and occupation group. The estimates in column 1 are for a baseline version of equation (3) with only a white-collar dummy variable and year fixed effects to go along with dependent and main independent variables.

Table 6.4:
Relationship between Location of Tipping Points and Index of Male Attitudes

		Dependent Variable: Candidate Tipping Point (Mean = .42, SD = .21)					
	Mean [SD]	(1)	(2)	(3)	(4)	(5)	(6)
Male prejudice (ISSP)	−.03 [.19]	.225 (.172)	.063 (.239)	.428 (.343)		.341 (.194)	.185 (.263)
Female prejudice (ISSP)	−.14 [.14]				−.220 (.242)	−.345 (.286)	−1.144* (.388)
Fraction female	.27 [.14]		.506 (.459)	−1.049 (1.921)			1.905 (1.881)
Fraction high school (male)	.08 [.09]		−3.763 (2.443)	−.519 (5.463)			−6.863 (5.699)
Fraction high school (female)	.07 [.09]		2.632 (2.075)	2.627 (3.411)			3.119 (4.329)
1970		−.023 (.076)	−.089 (.085)	−.067 (.071)	−.009 (.069)	−.013 (.073)	−.094 (.086)
1980		−.138 (.099)	−.184 (.175)	.014 (.139)	−.123 (.091)	−.127 (.096)	−.050 (.134)
White-collar		.333** (.076)	.416* (.156)	−2.909 (4.134)	.260** (.073)	.342** (.078)	−2.535 (3.683)
Industry type		No	No	Yes	No	No	Yes
R^2		.518	.573	.678	.515	.558	.779

Note that the unit of observation is a region x year x occupation-group. The prejudice indices are constructed using the ISSP 2002 survey *Family and Changing Gender Roles*, and vary regionally and by occupational group. The female fraction in each observation is computed using the censuses of Brazil. Controls for industry type include the share of workers in every major occupation field defined by ISCO88, in each region and year, excluding armed forces. In parentheses, we present standard errors that are clustered by region x occupation-group.
*Significant at the 5% level
**Significant at the 1% level

The estimate for male prejudice in column 1 is positive, but statistically insignificant. The interpretation of it is that an average male prejudice increase by one standard deviation results in a tipping point that is 22 percentage points higher. For example, the difference in index score of Southeast and North is approximately 0.12. As the coefficient is 0.22, it means that North's tipping

points are approximately 2.6 percentage point lower than in Southeast.

The baseline is expanded upon in columns 2–6. First, we control for the female share as well as for the fraction of men and women that have graduated high-school. Those results are shown in column 2. Column 3 shows the results of adding a control for industry type in each region. In column 4, we show the relation between female prejudice and candidate tipping points. In column 5, both male and female prejudice are included. Column 6 adds all previous controls to the regression that was performed in column 5. Like in column 1, the estimates for male prejudice are positive and statistically insignificant throughout.

In general, these results do not provide statistical evidence that confirms or contradicts the prediction that the regions in which men are less prejudiced will likely tip at lower initial female shares. However, one notable finding is that the white-collar control variable is statistically significant in all columns except 3 and 6.[13] The estimates are fairly large and positive.

7. Discussion

Based on our obtained results, we present some general findings. We begin by discussing tipping patterns in the context of the Brazilian labour market. It is concluded that tipping exists among Brazilian occupations. Building from this, we connect back to our research question and discuss whether the results are consistent with the Schelling-type tipping phenomenon. While we observe some signs of correspondence between the location of tipping points and male attitudes, no statistically significant evidence for their relation is found. Later, we consider possible reasons for why tipping could not be linked with Schelling (1971)'s predictions. Here, we also illuminate the limitations of the data and its implications for our results. Finally, areas of interest for future research are highlighted.

7.1 Tipping in Brazil

Through replicating the methods by Pan (2015) within the Brazilian labour market, we obtain evidence for patterns of tipping. For all of the candidate tipping points, discontinuities in net male employment growth were negative and statistically significant, as shown in Table 6.2. The discontinuities in net male employment growth at candidate tipping points range from 46% to 97% female in white-collar occupations and 32% to 83% female in blue-collar occupations, depending on the decade and exact specification of equation (2). Overall, occupations experience a 22–72 percentage point decline in net male employment growth at the candidate tipping points. This shows that for occupations with initial female shares close to the candidate tipping points, net male growth in employment experiences a steep decline if the occupation is just above the tip compared to if it is just below it. Net male employment growth and initial female share are thus discontinuously correlated.

[13] That the white-collar variable is insignificant when controlling for industry type (as in columns 3 and 6) is natural, as the division of occupations used for that control splits occupations into white-collar and blue-collar, and then further into low-skilled and high-skilled subcategories.

However, in the theoretical models of both Schelling (1971) and Pan (2015), once an occupation tips it empties of men and ends up in a fully segregated equilibrium. While we identify discontinuous patterns in the occupational data, there is a lack of occupations that have become completely female-dominated. Looking at the employment patterns of Brazil could help explain this occurrence. To begin with, while the female share of the labour force increased over the three decades, the increase was marginal. This implies that few occupations experienced greater shocks in relative female labour supply, the main catalyst behind tipping as theorised by the Model of Occupational Tipping. If the relative female labour market participation had increased at higher rates, then possibly we would have seen shocks in a greater number of occupations and of larger sizes. This in turn would have led to a greater probability of occupations becoming completely female-dominant.

Further, considering the fact that occupational feminisation in other countries has been slowly evolving, it is reasonable to assume that the move towards full segregation following the tipping point is not captured fully within the time period of 1960 to 1991 (only three decadal intervals). The move might not have been completed until later.

In addition, it is worth contemplating the Schelling (1971) and Pan (2015) definitions of segregation, i.e. a *complete* dominance of one or the other sex. Considering that the gender composition of the Brazilian labour market is in total fairly male-dominated, occupations that end up with seemingly gender-mixed structures could arguably still be viewed as segregated.

To summarise, while occupations might not have become fully female-dominated, we find evidence for that a tipping process has begun within the Brazilian labour market. Thus, there is support for our first hypothesis.

7.2 The Role of Preferences

In the predictions of our theoretical framework, preferences determine the location of tipping points. If this is proven to be true, then regions in which men exhibit less tolerant preferences towards working with women tip at lower female shares compared to more tolerant regions. Based on the results from Table 6.4, this prediction cannot be confirmed nor contradicted. We thus do not find support for our second hypothesis.

A possible explanation is that our results might be affected by limitations in the IPUMS-I census data. When adjusting for the inconsistencies in occupational classifications across different census years, a fraction of the actual growth in female share across all occupations was lost. As mentioned previously, in the original sample the female share doubled from 17% to 31% between 1960 and 1991. In our treated sample, the growth was from 21% to 26%. This treatment could possibly mask the true magnitude of tipping in the labour market, and thus the true relationship between tipping levels and preferences. Thus, even if there exists a link between tipping and attitudes such as it is described by our second hypothesis, we might not have been able to properly identify it.

Moreover, the Index of Male Attitudes could misrepresent the true link between male preferences and the location of tipping points. The Index is based upon survey results from only one point in time, outside of our studied timespan. It is thus possible that it fails to capture eventual changes in regions' male attitudes relative to one another over time.

Finally, we cannot eliminate the possibility that the observed patterns of occupational change are not in fact consistent with the Schelling-type tipping phenomenon, i.e. that male preferences have no explanatory power for patterns of tipping in the Brazilian labour market. While there might be other factors affecting tipping patterns in Brazil, we leave this avenue unexplored.

7.3 Future Contributions

In this thesis, we contribute to the current knowledge on the dynamics of occupational segregation by providing evidence of tipping within the Brazilian labour market. However, as we cannot confirm that these patterns are consistent with the Schelling-type tipping phenomenon, we encourage future researchers to further investigate its existence in Brazil. This could possibly provide answers to whether the results of Pan (2015) are exclusive to the US.

Although we do not find a statistically significant relationship between male attitudes and tipping, for Brazil both attitudes and tipping differ between white-collar and blue-collar occupations. Additional investigation into whether the location of tipping points in the Brazilian labour market can be explained by variation in male preferences across occupational groups rather than across regions is encouraged. This could add an important class dimension into the analysis of occupational segregation.

8. Conclusion

The aim of this thesis has been to analyse patterns of occupational change in Brazil in order to find empirical evidence of a tipping phenomenon as theorised by Schelling (1971). We make use of data from the Brazilian census. Replicating the methods of Pan (2015), we first search for discontinuities in net male employment growth near candidate tipping points, in other words critical values of occupational female share. We identify discontinuous declines ranging from 22% to 72% in net male employment growth at the tipping points.

Thereafter, approximating male preferences towards working with women through an Index of Male Attitudes, we investigate the correspondence between the location of the tipping points and male preferences. We find no statistically significant correlation between tipping point locations and the level of male preferences across regions. We thus conclude that while there are patterns of tipping in the Brazilian labour market, we cannot confirm that these patterns are consistent with the Schelling-type tipping phenomenon.

Our thesis contributes to the existing literature on the dynamics of occupational segregation. Firstly, our findings add empirical evidence of tipping as a process behind occupational segregation. Secondly, by studying patterns of occupational change in Brazil, we generate new knowledge on an often-overlooked part of the world within the field.

9. References

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Appendix

This appendix details how the occupation-state dataset and the male attitude index were constructed.

A1. Constructing an Occupation-State Dataset using the Census

The occupation by state data are built out of censuses of Brazil from the years 1960, 1970, 1980, 1991, 2000 and 2010 provided by IPUMS-I (Minnesota Population Data Center, 2018). The restriction for each decade's sample varies from year to year, but adjustments are made to the samples (see below) so that only individuals aged 16 and in the labour force are included. This corresponds to the restriction imposed by Pan (2015). The occupation-states are tabulated by using a consistent occupation code created from the census data (the process is documented below) and then weighted with person-level weights.

In this tabulation, excluded are those cells that meet one of two criteria:

- The cells contain under 30 observations.
- Male or female employment ten-year growth is more than 200% of total employment in the base-year.

Occupational Classification

The Brazilian Census data uses a unique occupation variable for each year in the data, meaning there is not an existing set of consistent occupation codes upon which to base occupation-states. A consistent occupation code must therefore be created manually before generating occupation-states. The following steps were taken in the process of making raw IPUMS-I data into occupation-states.

Creation of singular occupation code across all years

First, we restrict the sample for each decade to individuals aged 16 and above who are in the labour force.

Second, we remove all data from 2000 and 2010 census years, as the occupation variables for these years are too different from those of previous years. On the other hand, the four remaining census years (1960, 1970, 1980, 1991) have very similar occupation variables, allowing us to create a singular occupation-code. We do this in order to get a consistent occupation code upon which we can base our occupation-state tabulations. Our basic rule in creating these codes were: if an occupation with the same Portuguese name exists in all four years in the data, an occupation code can be created for it. Beyond this, there were cases where we through analysis of the occupation variables could reach the conclusion that an occupation was the same through all years, even if the actual definition of it differed, and create an occupation code.

In a few cases, we aggregate some small categories to achieve consistency across the years:

- Nurses and masseurs combine codes: 243 (Nurses) in 1960; 133 (Nurses with diploma), 134 (Nurses without diploma), 135 (Physiotherapists and masseurs) in 1970; 153 (Nurses with

diploma), 162 (Nurses without diploma) 163 (Masseurs) in 1980; 153 (Nurses with diploma), 162 (Nurses without diploma) 163 (Physical therapy assistants) in 1991.

- Administrative aides is one category in 1960 (191) and 1970 (045) and 1991 (064), but two categories in 1980 (064, 065).
- Draftsmen and cartographers is one category in 1960 (214) and 1970 (104), but two categories in 1980 (104, 111) and 1991 (104, 111).
- Primary teachers is one category in 1960 (252) and 1970 (151), but three categories in 1980 (214, 215, 216) and 1991 (214, 215, 216).
- Lumberjacks and woodcutters is one category in 1960 (341) and 1970 (241), but two categories in 1980 (331, 332) and 1991 (331, 332).
- Laminators is one category in 1960 (513) and 1970 (413) and 1991 (413), but two categories in 1980 (412, 413).
- Hairdressers and barbers one category in 1960 (931) and 1970 (821), but two categories in 1980 (821, 822) and 1991 (821, 822).
- Armed forces is one category in 1960 (971) and 1970 (841), but two categories in 1980 (851, 852) and 1991 (861, 862).
- Hairdressers and barbers is one category in 1960 (931) and 1970 (821), but two categories in 1980 (821, 822) and 1991 (821, 822).

Occupations that were not defined across all years were dropped. These occupations are listed in Appendix List 1. After emitting these occupations, we were able to create a consistent occupation code, Occ_singular (shown in Appendix Table 1), of which we use as a foundation for the occupation-states.

Appendix List 1:
Other livestock breeders, Non-specified agricultural and livestock owners, Entrepreneurs in vegetation extraction or fishing, Entrepreneurs in small industries, Entrepreneurs in mineral extraction, Entrepreneurs in transformation industry, Entrepreneurs in civil construction, Transportation employee, Street vendors, Street market merchants, Industrial Businessmen, Other owners, Other administrators, Ministers of State, etc., Administrators and managers in vegetation extraction, and fishing, Administrators and managers in mineral extraction, Administrators and managers in transformation industry, Administrators and managers in civil construction, Administrators and managers in trade and merchandising, Administrators and managers of hotels and similar establishments, Administrators and managers in transportation, Administrative managers, Bill conductors, Biologists, Pharmacologists, X-ray operators, Lab technicians, Other health-related occupations, Interns, Medical equipment operators, Orthopedists and opticians, Technicians in clinical analysis, Mathematicians, Mathematicians and actuarial specialists, Statisticians, Sociologists, anthropologists, archaeologists, Accountants, Economists, Systems analysts, Administrative technicians, Accounting technicians, Statistical technicians, Computer programmer, Psychologists, Geographers, Other social scientists, Census agents, Unspecified teachers, Teaching inspectors, Research professor, Professional teachers, Preschool teachers, Teacher liaison, Vocational teachers, Notary Clerks, Justice officials, Other justice assistants, Social agents, Religious Workers, Advertising technicians, Musicians, Movie, circus, radio, tv performers, Announcers, Other cinema/theater technicians, etc., Artisans, Producer, Sound and camera equipment operators, Other radio/tv operators, Projectionist, Librarian, Curators/archeologists, Other occupations, Religious workers, Priests, Agricultural technicians, Plowmen, Country house workers and market gardeners, Gardeners, Hoe workers, Cattle raising workers, Autonomous agricultural producer, Other agricultural and ranch workers, Self-employed agricultural and

Livestock producers, Agricultural and livestock technicians, Other agricultural and livestock workers, Aquaculture workers, Machinery operators, Saltworks workers, Well sounders, Technicians in mineral extraction, Technicians in transformation industry, Masters in textile industry, Masters in civil construction, Electric energy technicians, Other masters, Metal Castors, Metal pressers and cutters, Molders, Galvanizers, Stone buffers and polishers, Toolmakers, Metal Press Operators, Assembly adjusters, Galvanizers, Metal riveters, Tinsmiths, Ferradores, Fabric Reweavers, Sewing Assistant, Pants makers and shirt makers, Pattern markers and cutters, Shoe factory worker, Joining Machinery Operators, Plywood Prepares, Basket makers and mat weavers, Assembler electric. equip., Assembler electronic equipment, Equipment repair technician, Radio and TV assembler, Radio and TV repair technician, Installation electrician, Tele. Installer and rep. tech, Inst. and rep. electric lines, Operator/inst. electric energy, Electricians, Radio Technicians, Masters in civil construction, Employees in the fishing industry, Occupations in the tea industry, Occupations in the vegetable oil industry, Occupations in the food industry, Other Occupations in printing industry, Masters and foremen transformation industry , Quality Control Inspectors, Rubber workers, Other occupations in the transformation industry, Basket makers, Spray painters, Suitcase makers, Naval construction repair workers, Unspecified craftsmen, Stokers, Packagers, Butchers, Street vendors, Shop attendants and delivery persons, Brokers and agents, Insurance brokers, Insurance agents, Real estate agents, Buyers, Auctioneers, Stock brokers, Appraisers and auctioneers, Other agents and brokers, Cigar and cigarette makers, Spray painters, Forklift operators, Stokers, Merchandise packagers, Empl. in paper industry, Empl. in rubber and plastic industry, Empl. in cement products industry, Safety and security supervisors, Other empls. in transformation industry, Self-employed businessmen, Salespersons, Cashiers, Stock clerks, Demonstrators, Street market stand owners, Water vendors, Candy makers, etc., Grocery store employees, Street candy vendor, Vendors of entrails, fish and milk, Ticket vendor, Other street vendors, Harbor Pilots, Motormen, Streetcar conductors, Highway construction workers, Postal clerk, Postal and telegraph handlers, Telegraph Linemen, Stamp sellers, Kitchen workers, Domestic help, Laundresses, Chambermaids, Hotel and boarding house owners, Chamberlains / Chambermaids, Bartenders, Nannies, Cooks (female), Cleaning personnel (female), Governesses and butlers, Non-specialized domestic help, Other occupations in domestic service, Governesses and butlers (except for domestic help), Hotel maitre d"s, Maitre d"s in food services, Doormen and janitors, Doormen, Elevator operators, Watchmen, Cleaning staff, Office-boys, Make-up, Musicians, Movie actors and actresses, Announcers, actors and actresses, Radio operators, Cinema operators, Car washers, Waxers, Owners in self-owned farming, Owners in self-owned service, Professional athletes, Soccer players, Wrestlers, Referees, Coaches, Fingerprint specialists, Private guard, Ill-defined occupations

Appendix Table 1: Occ_singular, the finished occupation code based on IPUMS-I data

Occupation	Code	Occupation	Code	Occupation	Code	Occupation	Code	Occupation	Code	Occupation	Code
Farmers	101	Judges	261	Blacksmiths	518	Stone masons	572	Brick makers	623	Fare takers	742
Cattle ranchers	102	Government attorneys	262	Vehicle electricians	519	Hod carriers	573	Jewelers	630	Teamsters	743
Poultry farmers	103	Public lawyers and defenders	263	Carders and combers	521	Painters and white washers	574	Gem cutters	631	Inspectors and dispatchers	751
Merchants	104	Notaries public	264	Textile rollers	522	Stucco masons	575	Vulcanizers	632	Railway maintenance	752
Hotel owners	105	Writers and journalists	271	Textile spinners	523	Tile and parquetry workers	576	Firework makers	633	Postal agent	761
Public administrators	111	Sculptors and painters	272	Lace makers	524	Plumbers	577	Broom makers	641	Telegrapher	762
Financial administrators	112	Photographers	273	Loomsetters	525	Glaziers	578	Marble workers	642	Telephone operator	763
Farm and ranch administrators	113	Cinematographers	274	Rope makers	526	Pavement workers	579	Tobacco preparation	643	Postmen	764
Typists	121	Decorators and set designers	275	Weavers	527	Caulkers	580	Newspaper vendors	651	Cooks	911
Stock clerks and warehousemen	122	Fishermen	321	Carpet weavers	528	Civil construction machinery operators	581	Vendors	652	Waiters	912
Administrative aides	123	Hunters	322	Net makers	529	Sausage makers	590	Sales representatives	653	Hairdressers and barbers	921
Cashiers	124	Lumberjacks and woodcutters	331	Textile bleachers	530	Jerky makers	591	Advertising agents	654	Manicurists and pedicurists	922
Tax collectors	125	Charcoal makers	332	Textile printers	531	Slaughterhouse butchers	592	Civil aviators	701	Shoeshiners	923
Engineers	211	Rubber tappers	333	Textile finishers	532	Dairy workers	593	Flight attendants	702	Laundresses and ironers	924
Architects	212	Maté workers	334	Leather good makers	541	Candy makers	594	Merchant and marine officers	711	Armed forces	931
Draftsmen and cartographers	213	Pickers	335	Tanners	542	Pasta makers	595	Boatswains	712	Fire Dept.	932
Chemists	221	Miners	411	Tailors	551	Bakers	596	Ship machinists	713	Police chiefs	933
Pharmacists	222	Stone cutters	412	Embroiderers	552	Grain millers	597	Ship stokers	714	Police investigators	934
Non-certified pharmacists	223	Oil extraction workers	413	Straw hat makers	553	Sugar workers	598	Marine sailors	715	Civil and traffic police	935
Agronomists	231	Prospectors	414	Hat makers	554	Beverage workers	599	Ship stewards	716	Jailers and prison guards	936
Veterinarians	232	Oventenders	501	Shoe makers	555	Fishing workers	600	Small boat operators	717		
Physicians	241	Laminators	502	Purse makers	556	Linotypists	610	Crane operators	721		
Dentists	242	Tool grinders	503	Cabinet makers	561	Typographers	611	Stevedores	722		
Midwives	243	Mechanical stampers	511	Carpenters	562	Printing engravers	612	Railway agents	731		
Prosthetists	244	Milling machinists	512	Coopers	563	Printing press operators	613	Train conductors	732		
Social workers	245	Lathe operators	513	Sawyers	564	Proof readers	614	Train engineers	733		
Nurses and masseurs	246	Engine mechanics	514	Upholsterers	565	Book binders	615	Train stokers	734		
Primary School teachers	251	Mechanics	515	Mattress makers	566	Glass workers	620	Railroad brakemen	735		
Secondary School teachers	252	Welders	516	Wood polishers	567	Ceramists	621	Switchmen	736		
University teachers	253	Boilermakers	517	Reinforced concreters	571	Ceramics painters	622	Drivers	741		

Generation of occupation-states

This consistent occupation code is then used, along with the state data in the IPUMS-I censuses to generate occupation-states. Note that the data uses state divisions for Brazil that for two individual cases has since changed. First, in 1988 Tocantins became its own state (separated from Goiás in the Central West region), and is since then counted as a state in the North region. Second, in 1979 Mato Grosso do Sul was separated from Mato Grosso and became its own state within the same Central West region.

The data does not take into consideration these changes. We argue that despite this, it is still reasonable to use the state divisions presented in the IPUMS-I data. Indeed, it is the only possible option in order to make use of the data.

Classifying occupational groups

For the purposes of the analysis, we also divide occupations into two occupation groups, depending on whether an occupation is white-collar or blue-collar. This division is based upon the International Labour Organization Standard of Occupations, ISCO-88 (International Labour Organization, 2004), where occupations are grouped based on their respective skill-level. In order to further place the occupations into blue- and white-collar categories, we follow the Eurofound Survey's grouping system (Eurofound, 2010) where occupations with ISCO codes 1–5 are classified as white collar and 6–9 are classified as blue collar.

A2. Constructing an Index of Male Attitudes

We use data from the 2002 ISSP survey *Family and Changing Gender Roles III* (ISSP Research Group, 2013) to construct an index of gender-based prejudice. With the aim of making an index that is comparable to the one in Pan (2015)'s paper, we identify six questions regarding women's societal role. The six questions were presented as statements, to which respondents could give one of seven answers: Strongly agree, Agree, Neither agree nor disagree, Disagree, Strongly disagree, Can't choose, No answer. The statements were:

Q1a. A working mother can establish just as warm and secure a relationship with her children as a mother who does not work.

Q1b. A pre-school child is likely to suffer if his or her mother works.

Q1c. All in all, family life suffers when the woman has a full-time job.

Q1d. A job is all right, but what most women really want is a home and children.

Q2a. Both the man and the woman should contribute to the household income.

Q2b. A man's job is to earn money; a woman's job is to look after the home and family.

Responses from respondents aged 18 or older from Brazil are kept and used. The answers are re-coded so that the most gender-prejudiced answer gives the highest value, while the least prejudiced give the lowest value. The values are combined to make single score for each observation. The individual scores are first divided by the standard error score with the purpose of normalisation, and then aggregated to create scores for entire regions as well as for white-collar and blue-collar occupations. This process is done separately for males and for females. The end result is an Index of Male Attitudes that is specific to each region and each occupational group.