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Abstract

We analyze the evolution of male labor force participation rates and retirement trends in Brazil since 1980 and use a stochastic model (Lee-Carter) to forecast death and labor force participation rates. We use estimated rates to calculate and forecast the expected length of retirement from 1980 to 2025. We find a steady decline in the labor force participation rates of young adults and elderly over time, mostly due to access to education and public pension programs. Our findings also indicate that the expected length of retirement might increase from 10% to 20% of Brazilian males’ working lives, as people leave the labor force at early ages and live longer lives. These trends, combined with population aging and longer life expectancy reduce the ratio between workers and retirees, affecting the premise of the PAYGO system. Our approach also has public policy implications, since it provides an alternative way to forecast the Brazilian pension budget.

1Data and scripts are available at: https://github.com/mattlobo
1 Introduction

Population aging has increased the concern in relation to the sustainability of the public support programs for the elderly (Cutler, Poterba, Sheiner, Summers, and Akerlof 1990; Bloom, Canning, and Sevilla 2003; Bloom and Canning 2004; Lee and Edwards 2002; Lee 2003; Lee 1994). If in the past the elderly were supported by family members, today this support comes from programs created by the public sector and, in some countries, also by the private sector (Costa 1998). In general, these programs are very important in order to narrow the difference in income between the elderly and people at an active age and to reduce the poverty rates of the old-age population (Gruber and Wise 2001). However, recently, the vast majority of programs have come up against serious fiscal and financial problems (Bongaarts 2004; Bloom and McNikkon 2010). Most of them function on the Pay-As-You-Go basis, namely, the benefits of today’s retirees is financed by current workers’ contributions. The financial balance of the programs is increasingly difficult with the rise of the dependency ratio, population aging and a faster process of reducing the average retirement age (Bongaarts 2004; Bloom and McNikkon 2010; Turra, Queiroz, and Rios-Neto 2011).

Brazil is one of the countries facing such problems. Despite unabated interest among researchers in issues pertaining to the impacts of population aging and economic development to the social security sustainability in developed countries (Gruber and Wise 2005; Gruber and Wise 2008; Wise 2004) little is known about these issues in emerging economies. Brazil is one example of an important context for elaborating linkages between population aging and public pension systems. The rapidly aging population presents one of the greatest public policy challenges in Brazil (Turra and Queiroz 2005; Turra, Queiroz, and Rios-Neto 2011). Compared to other emerging economies, Brazil is distinct for combining a relatively large public sector with rapidly aging population and declining labor force participation at older ages (Turra, Queiroz, and Rios-Neto 2011). The old-age dependency ratio, ratio of the population aged 65 and above to the working-age population, is estimated to be 36% in 2050, compared to 10% in 2010 (DeSA 2015). These changes in population age structure may impose severe pressures on the public sector (Bongaarts 2004; Miller, Mason, and Holz 2011). At the same time, the length of working life has fallen over time, which results from both increases in educational attainment (younger workers) and changes in retirement behavior (Soares 2010). The fall in economic participation for
older workers (65 and older) is striking: 22.3% of them were in the labor force in 2010 compared to 60% in 1970. In 2005, social security benefits and other forms of elder support represented about 14% of the GDP and are expected to be the fastest growing component of public spending (Brasil 2003; Giambiagi and Além 1997; Queiroz and Figoli 2014). The World Bank estimated the implicit debt of the public pension system in Brazil as 3.5 times the GDP, the highest of 35 low and middle income countries examined (Holzmann, Palacios, Zviniene, et al. 2004).

In this paper, we analyze the evolution of labor force participation in Brazil in the last three decades and estimate the expected length of retirement in Brazil. We also use a stochastic model (Lee and Carter 1992) to forecast death rates and labor force participation rates, for the next few years, and estimate the expected length of retirement over the same time frame. Lee-Carter is a stochastic method widely used for mortality projection it is a very versatile model and uses historical information to design future scenarios (Booth and Tickle 2008). We argue that this approach combined to estimates of population aging are important tools to analyze the sustainability of the Brazilian public pension system. Most of previous researches, focus on the expenditures in relation to GDP (Miller, Mason, and Holz 2011), in the relation between workers contributing to the system and individuals receiving benefits (Queiroz and Figoli 2014) or simply analyzing trends in the old-age dependency ratios (Rocha and Caetano 2008). However, none of these incorporates important changes in the labor force participation of Brazilian workers that have happened in the recent decades.

In most cases, labor force participation rates in Brazil are projected using deterministic models without much scientific basis or without regard to the past variation trends in activity rates and informality of Brazilian workers, or even population dynamics which directly affects the number of people who could be in the labor force. The brazilian public pension system (MPS) uses a similar model and is subject to a number of criticisms. The main one is the adoption of a fixed labor supply function at a given point of time. That is, there are no studies or temporal hypothesis, and it is only considered that the total number of workers in the formal sector only varies due to variations of the population by age. There are some papers working with age, period and cohort models but they are also subject to important limitations.

The paper has some important findings. First, we observe a steady decline in the labor force participation of young adults and elderly over time, mostly due to access to education and public pension programs. We also find
that the expected length of retirement might increase over time in Brazil as people leave the labor force at early ages and live longer lives. This finding, in conjunction with international comparison, imply an impressive transformation in the Brazilian labor market. These trend together with population aging and longer life expectancy reduce the ratio between workers and retirees affecting the basic premise of the PAYGO system. Our approach also has public policy implications, since it provides an alternative way to forecast the Brazilian public pension system budget. The Brazilian public pension system forecast its costs holding labor force participation rates constant, what might underestimate future trends. We also consider our estimates to be conservative, since about 20% of the elderly in Brazil stay in the labor force while receiving pension benefits.

2 The Social Security System in Brazil

The characteristics of the Brazilian public pension program might impact on individual behavior and on the fiscal budget of the federal government (Queiroz and Figoli 2014; Rocha and Caetano 2008). The social security system in Brazil consists of three main segments: the general system (workers in the private sector), the system of public servants, and various systems of private capitalization (Rocha and Caetano 2008). Also, there is a pension program for rural workers and a large non-contributory program (Rocha and Caetano 2008).

The non-contributory program is called Beneficio de Prestação Continuada (BPC). BPC is a temporary social benefit for the disabled and the elderly above 65 with family income per capita of less than 25% of minimum wage. The coverage of the program increased rapidly in the last few years. In 2014 there were three (3) million beneficiaries of those 1.6 million are elderly. The cost of the program was estimated in about 0.3% of GDP in 2014, for comparison the costs of Bolsa-Família were about 0.4% of GDP, reaching about 12 million families (and 40 million individuals).

The social security system for private workers (general system) is an unfunded defined-benefit program. The last major change in regulation happened with the 1988 Constitution, which extended mandatory social security coverage to most of the excluded groups, including rural workers, without requiring equivalent increases in revenues from contributions. Other measures made the system more generous than before: establishing the minimum wage
as the lowest benefit paid by the system, indexing all pensions to the minimum wage, and reducing the minimum age of retirement (Queiroz and Figoli 2014).

The 1988 reform, which was implemented in 1991, had major impacts to the Rural Pension System. In 1972 the Rural Worker Assistance Program (PRORURAL), aimed to support the Rural Worker Assistance Fund was established. The PRORURAL was designed in order to incorporate rural workers to the official social security system. The program provided male rural workers, who were head of household, with a maximum benefit equal to half of the minimum wage. Regarding the pension system, it established the guidelines for a reform in the social security system, regulated by Law 8212/8213 (Queiroz 2008; Ansilio and Paiva 2008; Rocha and Caetano 2008). The Law was passed in July 24,1991, bringing about a reduction in the minimum age required for rural workers from 65 to 60 for males and from 65 to 55 for females. Also, the social security benefits has been extended to rural workers who were not heads of households, and the size of benefits has changed from half to one minimum wage.

Until 1998, full pension benefits were granted to all workers who have contributed for 10 years to the system, have reached normal retirement age through the Old-Age Pension Benefit (65 for men and 60 for women), or could prove that they have been working for a certain number of years with the Length of Service Pension Benefit (35 for men and 30 for women, but without requirement of contribution for the same period of time). In addition, special retirement schemes existed that granted proportional retirement benefits for individuals who had worked for 30 and 25 years, for men and women respectively. The benefits were computed based on the last 36 months of activity(Queiroz 2008; Ansilio and Paiva 2008; Rocha and Caetano 2008). The level of benefits is relatively high: old-age benefits recipients receive, on average, 3 times the minimum wage, and length of service benefits is 2.5 times higher than old-age benefits (Queiroz 2008; Ansilio and Paiva 2008; Rocha and Caetano 2008).

In 1998 main changes were introduced to the program. The most important one was to adopt a new methodology to calculate pension benefits based on an actuarial rule. The new benefit computation is based on the Swedish National Defined Benefit Program and takes into account longer earnings history, the life expectancy at age of retirement, and a coefficient that creates disincentives to early retirement. The new methodology (Fator Previdenciário) reduced the system regressivity. Until 1998, workers were
eligible for retirement benefits after 25 years of work for females and 30 years for males. Beneficiares were, on average, 48 years old implying that only those with stable jobs and that could prove the requirements would obtain the benefit. In addition to that, benefits before 1998 were calculated based on the last 36 months of contribution; since the wage curve was ascendant with age workers were able to retire with relatively high pension benefits (Brasil 2003; Giambiagi and Além 1997).

In 2003, an amendment to the Constitution (EC 41/03) was approved by the Brazilian Congress. The amendment changed some of the regulations to the civil servant retirement system. The main points were: a) minimum retirement age, 60 for males and 55 for females; b) possibility of establishing a fully-funded complementary system for civil servants; c) contribution to the system by retirees; d) future benefits to be adjusted by other index instead of wages in the public sector (Brasil 2003; Giambiagi and Além 1997).

The general system was conceived when rapid population growth and low life expectancy combined to sustain the program. Public expenditure on public pension raised from 4.6% of GDP in 1980 to almost 12% in 2010 (Queiroz and Figoli 2014; Turra, Queiroz, and Rios-Neto 2011). The implicit debt, a long term measure of the system’s financial adequacy, is also large and amounts to about two to three times the GDP (Holzmann, Palacios, Zviniene, et al. 2004). Public servants have their own defined-benefit PAYGO pension system. Although it is small in absolute figures compared to the general system, the expenditure of the civil servant program is high, around 4% of GDP.

3 Data and Methods

The study of retirement behavior and trends uses labor force participation rates as its basic measure. We follow the same approach in this paper. Labor force participation rate is defined by the International Labor Organization (ILO) as the proportion of the population of some specific age, normally population aged 16 to 65 years, who is either working or actively seeking work to the total population in the same age group. We use data from the Brazilian Household Survey (PNAD). PNAD is a nationally representative stratified random sample of the Brazilian population comprised of about 90,000 households. The survey consists of cross-sections collected annually since 1971, except in 1994 and during censuses years (1980, 1991 and 2000).
The PNAD contains a comprehensive and comparable set of demographic and economic variables, including detailed information on economic activities, contribution for social security programs and whether individuals receive benefits.

We obtain mortality and population data using from 1980 to 2010 from the Latin America Human Mortality Database. The project aims at disseminating human mortality data and literature of human mortality in Latin America, in order to provide detailed information for researchers, students, policy makers and the general public interested in knowing trends and developments in the study of mortality in the region. Since death registration in Brazil is of low quality, we first evaluate the quality of data using Death Distribution Methods (Hill, You, and Choi 2009; Queiroz and Sawyer 2012) and then adjust mortality data for under-registration. LAHMD data is available in 5 years age group, so we use splines functions to transform in single year age groups. Using corrected data we are able to evaluate the evolution of mortality in Brazil and forecast life expectancy to be used in our retirement model.

3.1 Adjusting Mortality Data: Death Distribution Methods

To evaluate the coverage of reported deaths we use traditional demographic methods, called Death Distribution Methods – DDM henceforth. The DDM are commonly used to estimate adult mortality in a non-stable population and analyze mortality data quality in intercensal periods. There are three alternative approaches (Hill, You, and Choi 2009; Queiroz and Sawyer 2012).

The Synthetic Extinct Generations (SEG) method uses age-specific growth rates to convert an observed distribution of deaths by age into the corresponding stationary population age distribution. Since in a stationary population the deaths above each age x are equal to the population aged x, the deaths in the stationary population above age x provide an estimate of the population of age x. The completeness of death registration relative to population is estimated by the ratio of the death-based estimate of population aged x to the observed population aged x. The General Growth Balance (GGB) method is derived from the basic demographic balancing equation, which identifies the growth rate of the population as equal to the difference between its entry

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2The data is available at: http://www.lamortalidad.org.
rate and exit rate. This holds for open-ended age segments $x^+$, and in a closed population the only entries are through birthdays at age $x$. The entry rate $x^+$ minus the growth rate $x^+$ thus provides a residual estimate of the death rate $x^+$. If the residual estimate can be calculated from population data from two population censuses and compared to a direct estimate using the recorded deaths, the completeness of death recording relative to population recording can be estimated. It is argued that the combination of SEG and GGB might be more robust than either one individually. The combined method consists of first applying GGB to estimate any changes in census coverage ($k_1/k_2$), using the estimate to adjust one or the other census to make the two consistent, and then applying SEG using the adjusted instead of the reported population data (Hill, You, and Choi 2009; Queiroz and Sawyer 2012).

They make several strong assumptions: 1) that the population is closed to migration; 2) that the completeness of recording of deaths and population are constant by age; and 3) that ages of the living and the dead are reported without error. There is a large body of literature on the methods, for reasons of space they will not be discussed in detail here (Hill, You, and Choi 2009; Queiroz and Sawyer 2012).

Table 1 shows the estimates for the completeness of death counts coverage in Brazil from 1980 to 2010. The results show that quality of mortality information improved over time, but adjusting mortality levels in the 1980s and 1990s is very important to obtain proper life expectancy estimates and forecast mortality levels using Lee-Carter method.

### 3.2 Lee-Carter method: forecasting mortality and labor force

In the first step, we use the Lee-Carter method (Lee and Carter 1992) to forecast death rates and life expectancy for males from 2014 – 2025. In the second step, we adapted the Lee-Carter method (Lee and Carter 1992) to
forecast labor force participation rates in Brazil. It combines a demographic model with time-series method of forecasting. The method involves modeling two-factors – age and time - and uses matrix decomposition to extract a single time-varying index of the level of admissions, which is then forecast using a time-series model. The Lee-Carter method has been considered a powerful method to forecast mortality due to its precision and simple way to model age distribution of death rates (Lee 2000; Lee and Miller 2001; Booth and Tickle 2008). The more linear trends in age-specific rates, the more robust is the method (Lee 2000; Lee and Miller 2001; Booth and Tickle 2008).

To estimate the model, we need two matrix of $m_x$, one with death rates and another with labor force participation rates and find a solution for Equation 1:

$$
\ln(m_x) = a_x + b_x * k_t + \epsilon_{x,t}
$$

where, $a_x$ and $b_x$ are parameters to be estimated and $\epsilon$ is a set of random disturbances. The solution of this regression is made by applying the Singular Value-Decomposition approach (SVD) on the log of the historical rates matrix. In the model, $a_x$ represents the age pattern of the mortality and labor force participation, $b_x$ represents the amount of mortality/labor force change at a given age for a unit of yearly total mortality and labor force change and $k_t$ measures the general level of mortality or labor force participation rates.

### 3.2.1 Adjusting Mortality Data: P-Splines

Our death rates estimates are only available in five-year age groups within the age interval between 0 and 80 and above, so it is necessary to interpolate this estimates in order to have single-age death rates. We use a two-dimensional P-Spline (age and year) to get smooth estimates for death rates at each age. We use the MortalitySmooth package (Camarda 2012) to fit the two-dimensional P-Spline to our data.

### 3.2.2 Adjusting Labor Force Participation Data: LOESS

The crude estimates for the labor force participation rates present random fluctuations at some ages. In this paper, it is far more important to know the global trend and the level of the labor force participation rates than the specific fluctuations occurring at a few ages, so we used a local regression
method to get smooth curves. We use the LOESS method (Cleveland 1979; Cleveland and Devlin 1988) in order to get smooth estimates. The method consists of fitting a low-degree polynomial to a subset of the data at each point of the dataset, in doing so, we do not change the global trend of the curve and we don’t have to face the problem caused by the fluctuations observed.

3.3 Forecasting Labor Force Participation Rates

There are two main lines of research about forecasting labor force participation rates in Brazil. The first one uses data from Brazil and other countries and define different patterns of labor force participation rates. From this information and based on the evolution of labor force participation by cohorts in Brazil they try to find a pattern that they might follow based on the observed patterns they observed for other countries (Rios-Neto and Wajnman 1994). A second line uses uses age-period-cohort models (APC) from generalized linear models to generate estimates and projections of labor force participation rates in Brazil. The method, however, involves the application of various designs and the need for choosing the best fit criteria. As the authors point out, the over-dispersion problems and sample size makes the choice of the best model tests not very reliable (Rios-Neto and Hermeto 1999). In addition, APC models estimates are influenced by the identification problem. In general, the identification problem is not solved simply by restrictions on statistical modeling, but an accounting problem. Once we have the expected effect is the result of age + period + cohort and one of the elements is determined by the other two (ie, age = period - cohort). It is noteworthy that these recent proposals as Yang (Yang, Schulhofer-Wohl, Fu, and Land 2008) have the same restrictions to identify the traditional APC models (Bell and Jones 2014).

Frees (2003) and Frees (2006), to our knowledge, are the only few papers that aim to forecast labor force participation rates using stochastic models. His main goal is to provide the US Social Security Administration better labor force estimates to produce a more robust analysis of the future of the US Public Pension Program. Frees (2006) argues that the Lee-Carter method does not work as well as for mortality forecasting when working with labor force data. Specially, because the method is not flexible enough to incorporate some particularities of the data. We argue that changes in male labor force participation in Brazil are very stable over the last few
decades, allowing us to use the Lee-Carter method, based on the Principal Components Methods. We argue for that because we can establish a linear combination of the age cells that are most important in explaining the overall variability in labor force participation rates.

3.4 Expected Length of Retirement

The duration of retirement can be estimated as a weighted average of life expectancy at each retirement age, where the probability of retiring at age $x$ is the weight of the life expectancy at that age.

Lee (2001) express the expected length of retirement in Equation 2:

$$ELRP = \sum_{x=20}^{89} S_x T_x \gamma_x \ast [1 - (0.5 \ast q_x)] \left[ \left( \frac{e_x + e_{x+1}}{2} \right) \right]$$

where $ELRP$ = expected length of retirement at age 20, $S_x$ is the probability of remaining alive to age $x$, $T_x$ is the probability of remaining in the labor force until age $x$ conditional on surviving until age $x$, and $\gamma_x$ is the probability of retiring at age $x$ conditional on remaining in the labor force at age $x$. The other terms account for men who die before they leave the labor force, and for those who retire between ages $x$ and $x+1$.

4 Results

4.1 Demographic Dynamics

The panels of Figure 1 display some of the main features of the demographic changes that have occurred in Brazil over the last decades. Figure 1 also depicts future demographic scenarios. The demographic transition started with mortality improvements in the 1930s, which were followed by fertility declines in the later 1960s. Despite the delayed onset, the demographic transition in Brazil has been characterized by rapid changes. The total fertility rate has reduced by more than half since 1970 (5.3 to 1.9 in 2010) and life expectancy at birth has improved steadily: from 57.5 years in 1970 to 73 years in 2010. From a young quasi-stable age structure in 1970, the age distribution has gradually shifted to an older distribution. Until 2000, the most important changes were the decline in the share of the young and a rise in the share of the working age population. Significant increases in
the elderly population are expected to occur only in the next decades. Official projections indicate that by 2050, the population aged 65 and older will represent about 20% of the total population, compared to 3% in 1970. These shifts in the age structure can be seen in the dependency ratios, which follow a well documented pattern: the total dependency ratio will decline until 2010 following the decline in the young dependency ratio. The trend will then shift upwards as increases in the old-age dependency ratio becomes more important. This rapid change has an important impact to the public pension program in Brazil, making it very important to analyze labor force participation and retirement trends that could impact the sustainability of the pension program.

Figure 1: Demographic Transition in Brazil, 1970–2050

Figure 2 displays the mortality surface in Brazil from 1980 to 2010. The mortality surface shows the evolution of death rates by age, from ages 0 to 80 and above, and overtime in the country in a recent period of time. Two main features of the surface are relevant to highlight. First, is the step decline in the death rates for infant and child in this period. The second one, is the increase in mortality levels for young adults, which is mainly due to the impact of external causes of deaths on the male population. We also observe a decline in mortality levels at older ages that are closely related to an improvement in the health status of males in Brazil in recent decades. The combination of all those changes led to a significant increase in life expectancy.
at birth in the country in the last few decades. The variation of young adult mortality rates is explaining by the increase in the external causes of deaths, homicides and accidents, during that period. It is important to highlight that this fluctuation in mortality at specific ages impose some constraints to our mortality forecast model.

Figure 2: Mortality Surface, Males, Brazil, 1980–2010

We use the death rates matrix to forecast death rates in Brazil from 2010 to 2015 using the Lee-Carter model. Figure 3 depicts the observed and forecast \( k_t \), indicating the decline in mortality level over time and a continuing declining in death rates in Brazil. We do not show results for \( a_x \) - the variable has the expected shape of mortality. Figure 4 shows the estimated \( b_x \) for the Brazilian data. The results indicate the fast decline in mortality at very young ages, the increase in death rates for young adults and capture the recent downward trend in adult and older age mortality in Brazil. The variation in the young adults mortality observed in the past decades has some impacts in our estimates. We are working in a different model, using multiple decrement models, to reduce the possible impacts of the increase in the mortality levels to our forecast. Preliminary results indicate that the trends in the expected duration of retirement does not change nor is very affected by the new projections.

Figure 5 shows death rates for selected years from 1980 to 2025. Forecasted death rates are used to estimate life tables that are used to estimate
Figure 3: Lee-Carter Mortality Forecast - $h_t$, 1980-2025

Figure 4: Lee-Carter Mortality Forecast - $b_x$
the expected length of retirement overtime in the country. To our knowledge, the only study that uses the Lee-Carter model to forecast mortality in Brazil is from 1998 and uses life tables from the UN system (Figoli 1998), so it is not straight forward to compare the estimates produced in her paper and ours.

4.2 Labor Force Participation Trends

The trend in labor force participation for Brazilian male workers shows significant changes in the last decades (Figure 6). It is clear that the length of working life shrank over time. Labor force participation rates of young individuals have declined because of the increase in educational attainment. The rates have also declined for older workers. In 1950 almost 90% of the population aged sixty to sixty-four years were in the labor force, and this number has declined to less than 60% in 2010. The same rate of decline is observed for younger old workers. The fall in economic participation is even greater for older workers, those above sixty-five years of age: less than 30% of them were in the labor force in 2010 compared to over 60% in 1950.

3Based on census data we calculated that 95% of the population aged 10-14 years were in school in 2000 compared to 54% in 1960.
We do not show all the Lee-Carter estimates. We focus our attention on the validation of the method. Figure 7 show observed and forecasted labor force participation rates in 2013. We forecast labor force participation rates in 2013 using data from 1980 to 2000. The results are very good based on the limitations to use Lee-Carter method to estimate labor force participation rates. The observed value in 2013 is around the confidence interval estimated for the period. Figure 6 show observed and forecasted participation rates by age. We show that participation rates for the elderly continue to decline in the country as well at younger ages. This is an improvement compared to what is done by the Brazilian public pension system that forecast pension costs holding labor force participation rates constant at the levels observed in a particular year.

The previous sections showed that labor force participation of older men fell substantially in Brazil while life expectancy increase rapidly. At the same time the country witnessed a rapid increase in life expectancy. In 1950, life expectancy at birth was less than 51 years, whereas in 2000 it was 70.3 years. In the middle of last century, over 60% of males aged 65 and above were in the labor force, compared to less than 30% in 2000. The two simultaneous trends imply that the duration of retirement has increased.
4.3 Expected Length of Retirement in Brazil: 1980-2025

Lee (2001) suggests that changes in length of retirement have important implications for economic issues (e.g. savings, and public pension finances). Despite its relevance, very few studies have tried to estimate such a measure (Lee 2001). The author shows that in the United States, retirement years have increased six-fold since 1850 and now represent 30% of a worker’s productive years. In Brazil, the rapid changes in life expectancy and labor force participation rates can have important implications for the economy. These two events combined to increase the percentage of one’s life spent in retirement. According to Lee (2001), length of retirement can be estimated under two scenarios. The first one it assumes that an individual assesses the length of his retirement based on current levels (period data) of labor force participation and mortality. In the second one, individuals adjust their expectations based on their cohort experience. The first, a synthetic cohort approach, gives us a lower bound of the estimates. For lack of cohort data in Brazil, and lack of good labor force participation projections, I can only calculate the period estimates.

Table 2 presents the period estimates for the Expected Length of Retirement (ELRP) and their ratios to life expectancy at age 20. Not surprisingly,
improvements in life expectancy and decline in labor force participation results in the extension of retirement years. The ELRP at age 20 went from 4.93 years in 1980 to 10.57 years in 2025. The results suggests that since 1980 the expected duration of retirement has doubled and now represents 20% of the life expectancy at age 20.

We also show how changes in mortality and labor force participation rates impact the expected length of retirement. This estimate is made by calculating ELRP assuming that either mortality or labor force participation rates remain constant at the 1980 levels. For example, to examine the relative contribution of mortality decline, we calculate the ELRP using varying retirement rates and the 1980 death rates. This counterfactual estimate shows how large the increase in ELRP would be during the period had there been only change in labor force participation rates. To estimate the contribution of changes in retirement, we perform similar analysis holding retirement rates constant at the 1980 levels.

Table 2: Life Expectancy at 20, Expected Length of Retirement and Percentage of Working Life as Retired, Brazil, 1980–2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Expected Length of Retirement</th>
<th>$e_{20}$ in years</th>
<th>% of Life Retired</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>4.93</td>
<td>46.54</td>
<td>10.58</td>
</tr>
<tr>
<td>1991</td>
<td>5.50</td>
<td>47.95</td>
<td>11.47</td>
</tr>
<tr>
<td>2000</td>
<td>6.50</td>
<td>50.07</td>
<td>12.98</td>
</tr>
<tr>
<td>2010</td>
<td>8.19</td>
<td>52.00</td>
<td>15.74</td>
</tr>
<tr>
<td>2015</td>
<td>9.05</td>
<td>53.02</td>
<td>17.07</td>
</tr>
<tr>
<td>2020</td>
<td>9.79</td>
<td>54.12</td>
<td>18.09</td>
</tr>
<tr>
<td>2025</td>
<td>10.57</td>
<td>55.26</td>
<td>19.13</td>
</tr>
</tbody>
</table>

Figure 8 shows the estimates for the baseline scenario and the two counterfactual analysis from 1980 to 2025. We find that the decline in mortality levels is the more important factor in determining the changes in ELRP, as compared to changes in mortality. First, I hold labor force participation rates constant at 1980 levels. On one hand, I find that the ELRP would be shorter if there were no changes in labor force participation rates. On the other hand, improvements in mortality explains most of the variation in the ELRP. This result reflect the impressive decline in labor force participation discussed before and the rapid mortality transition.
These results are the lower-bound of changes in ELRP. It is clear that age-specific labor force participation rates are declining and life expectancy is rising for younger cohorts, meaning that younger generations will have a longer length of retirement. The increase in ELRP indicates that workers should save more of their income to smooth their consumption over the life-cycle. It also suggests that pressures on the Brazilian pension system will be greater in the near future, as suggested elsewhere (Turra, Queiroz, and Rios-Neto 2011; Queiroz and Figoli 2014).

5 Conclusions

The rapid process of population aging will have huge impacts on the sustainability of the Brazilian pension system. The increase in the old age dependency ratio means a larger number of beneficiaries will depend on a smaller number of workers. The demographic problem is not the sole issue in this matter. There is also a strong downward trend in labor force participation at older ages. Early retirement has increased the dependency ratio more than would be predicted by demographic analysis. Labor force participation rates of older men fell significantly between 1950 and 2010 and we forecast that the decline will continue until 2025.

These results are the lower-bound of changes in ELRP. It is clear that
age-specific labor force participation rates are declining and life expectancy is rising for younger cohorts, meaning that younger generations will have a longer length of retirement. The increase in ELRP indicates that workers should save more of their income to smooth their consumption over the lifecycle. It also suggests that pressures on the Brazilian pension system will be greater in the near future, as suggested elsewhere.
References


