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# Recent Trends in Employees' Earnings Inequality in Portugal: A Quantitative Analysis between 1986 and 2017

Summary: This paper examines employees' earnings inequality in Portugal for 1986-2017 using data from the Personnel Records database. Our objective is twofold: (a) characterize earnings inequality by comparing representative distributions, before and after the great crisis; and (b) investigate the role played by the business cycle on the behaviour of earnings inequality by estimating Autoregressive Distributed Lag (ADL) models. To identify trends and variations along the trend in earnings inequality we use cardinal measures and the coefficient of variation. We inspect the characteristics of earnings distributions in terms of moments (mean and median) and polarization (using relative distributions analysis). The main findings are: (1) earnings inequality shows a positive trend (except during the great crisis); (2) polarization is present in every year, with lower polarisation prevailing over upper polarization, both evolving at different paces (very fast 1989-2002; slower pace 2002-2008; negative growth 2008-2017); (3) the business cycle relationship with earnings inequality is negative.

Key words: Earnings inequality, Measures of inequality, Polarisation, ADL models.

JEL: D33, I39, J20, O12.

The behaviour of income inequality in Portugal since the late 1980s has been well documented by several authors. For instance, Carlos Farinha Rodrigues, Rita Figueiras, and Vítor Junqueira (2012) provide evidence of a decrease in income inequality during the 1970s, 1980s and 1990s. Over the 1999-2004 period, the decline is reversed but from 2004 until 2009 is again resumed. For a more recent period, 2004-2011, Jens M. Arnold and Rodrigues (2015) document the decrease in income inequality in the Portuguese economy patent in the decline of the Gini coefficient and the S90/S10 income decile share. However, the authors highlight the fact that the

economic events that followed the 2007-08 crisis have brought this downward trend to a halt in 2011. Farinha Rodrigues, Figueiras, and Junqueira (2016) update their previous study from 2012. The main conclusion from this more recent study, with data ending in 2014, is that the cycle of inequality reduction ceased in 2010 and was even reversed, with Portugal recording an increase in earnings inequality. However, according to Organisation for Economic Co-operation and Development (2016, p. 2) in 2014: "despite an increase in market income inequality between 2007 and 2014, inequality of disposable income (that households 'take home') declined due to the effect of cash public transfers and direct taxes which mitigates market income inequality".

This paper examines employees' earnings inequality in Portugal using data between 1986 and 2017 from the Personnel Records (*Quadros de Pessoal*) database. *Quadros de Pessoal* is a compulsory survey of all firms, conducted annually by the Portuguese Ministry of Labour. The dataset contains information such as gender, age, education, monthly wages, and hours worked, on every wage earner in Portugal (excluding civil servants and independent workers), as well as information on their employers (e.g., size, location, economic activity, and employment). The analysis of the distribution of earnings constitutes an important step for the understating of income inequality in Portugal, since income from work is the main component of personal income and, simultaneously, one of the components which traditionally shows greater asymmetry (Farinha Rodrigues, Figueiras, and Junqueira 2012). Its observation is thus fundamental to consolidate the analysis of income inequality. Although the study of income and earnings is important in itself, it gains greater relevance if it is interpreted as a fundamental element in the analysis of long-run macroeconomic performance, as an essential component of the determination of the ability of a country to achieve a sustained output growth rate, which is influenced by the distribution of personal income. The relationship between inequality and economic growth has been comprehensively analysed in the theoretical and empirical literature resulting in a debate revolving around two competing views, one that argues that inequality is necessary to promote higher growth rates and another one that defends that it constitutes a threat to growth. The positive influence is explained based on the higher propensity to save of the richer (higher inequality leads to more physical and human capital accumulation and thus growth) and an incentives argument. According to the latter, inequality promotes the appearance of entrepreneurs/inventors expecting to belong to the wealthier part of the society, thus enhancing growth when innovation is the driving force of long-run macroeconomic performance, as well as promoting higher effort by workers and thus efficiency. The alternative view claims that inequality is detrimental to growth. For developed countries, the negative effect of inequality on growth is justified on the basis of credit market imperfections that lead to lower levels of human capital investments and thus slower growth, since only initially rich individuals have the collateral to gain access to the credit necessary to invest in human capital. Additionally, or alternatively, in more unequal economies the level of redistribution demanded from the government will be higher, which in turn leads to higher levels of taxation, resulting in less investment and growth. Finally, more inequality can lead to social and political unrest with negative consequences in the proximate causes of growth, input accumulation and productivity improvements. For surveys of the literature on the inequality-

economic growth nexus see e.g. Philippe Aghion, Eve Caroli, and Cecilia García-Peñalosa (1999), Laura de Dominicis, Raymond J. G. M. Florax, and Henri L. F. De Groot (2008), Federico Cingano (2014), Pedro Neves and Sandra Silva (2014).

The objective of the present study is twofold: (a) provide a picture of earnings inequality in Portugal by identifying and comparing representative employees' earnings distributions, before and after the great crisis period (2009-2014 for the Portuguese economy); (b) investigate the role played by the business cycle on the behaviour of earnings inequality. To identify trends and variations along the trend of earnings inequality we use cardinal measures of inequality such as the Gini coefficient, the Zenga index, the Atkinson index and the coefficient of variation. Our aim is to build inequality time-series variables based on those indicators. In order to make suitable comparisons between distributions we further inspect the characteristics of employees' earnings distributions in terms of moments: mean, median and polarization (to the left and to the right of the median) the latter based on relative distributions analysis. To accomplish (b) we estimate autoregressive distributed lag (ADL) models.

This study contributes to the current understanding of inequality levels in the Portuguese economy by focusing on earnings, the main determinant of income inequality since "(…) wages and salaries account for the bulk of household incomes among working-age adults, so changes in the distribution of earnings at household level are key" (Brian Nolan and Luis Valenzuela 2019, p. 403). As argued by (Ken Mayhew and Samuel Wills 2019 and Thomas McGregor, Brock Smith, and Wills 2019), the precise measure of inequality used can influence our perception of the extent of inequality and so we add to the existing research by computing a comprehensive set of inequality measures that contemplate different parts of the distribution and make comparisons between distributions at different points in time. Also, conclusions about what has happened to inequality can be very sensitive to the particular measurement used. As for the causes and determinants of income inequality, Nolan, Matteo G. Richiardi, and Valenzuela (2019, p. 1300), pose that "macroeconomic cycles, and especially major macroeconomic shocks such as the Great Recession from 2007/2008 onwards, may also be important influences on income inequality (…)" with previous results on the distributional impacts of the 2007/08 crisis in rich countries pointing to quite varied effects and claiming for country specific studies. In this vein, we investigate the relationship between the business cycle and inequality for the Portuguese economy, something that has not been done before, to the best of our knowledge.

The paper is organized as follows. Section 1 gives a concise presentation of theoretical and empirical considerations on income inequality. Section 2 contains the descriptive analysis of earnings inequality through the computation of different measures, while Section 3 describes the changes in earnings inequality over the period under analysis. Section 4 describes the empirical model used to identify the role of the business cycle on the behaviour of earnings inequality, presents and discusses the results. Concluding remarks are provided at the end of the paper in Section 5.

## 1. Theoretical and Empirical Considerations on Income Inequality

The increase in earnings or wage inequality in developed countries (but also in developing countries) over the last more or less forty years has been thoroughly analysed

and documented in both the theoretical and empirical literature. Lawrence E. F. Katz and David H. Autor (1999) provide a comprehensive review of the literature on earnings inequality followed by an assessment of the possible explanations for the increase in earnings inequality recorded in Organisation for Economic Co-operation and Development (OECD) countries and especially in the United States of America (USA), where the wages of workers in the 90$^{th}$ percentile increased by approximately 40% relative to those in the 10$^{th}$ percentile over the period 1963-1995. Additionally, there is hardly any wage gain for working men up to the 25$^{th}$ percentile. Daniele Checchi and Wiemer Salverda (2014) provide evidence on increasing wage dispersion for the USA between 1973 and 2012, with the behaviour since the early 1990s different from that of the earlier period: inequality in the lower-half hardly changes in contrast to the preceding period, while inequality in the upper-half keeps on growing, far exceeding bottom-half inequality at the end of the period under analysis. In any case, the authors call our attention to the fact that: "(…) the strength of the increase in the dispersion depends on the measure chosen and also their periodic ups and downs do not fully coincide" (p. 33). The picture for other OECD countries such as Canada, the United Kingdom (UK) and Germany is not as uniform as that for the USA, although in general there is a slightly positive trend. In particular for Portugal, a country with some of the highest earnings inequality levels in the OECD, there was an increase in the upper half of the distribution, while overall there was a decrease. Checchi and Salverda (2014) however, emphasize the need for caution when comparing earnings inequality across countries due to international differences in the concept of earnings. Focusing on the European Union (EU) 28 member states (EU-28), Christian Dreger et al. (2015) describe the evolution of wage dispersion across EU member states using data between 2006 and 2011 from the European Union Statistics on Income and Living Conditions (EU-SILC) and different definitions of labour earnings and inequality measures. They conclude that inequality increased between 2006 and 2011 in around two thirds of the EU member states considered, while in the remaining one third it decreased, including Portugal and Greece.

According to Katz and Autor (1999), increases in earnings inequality can be explained by changes in the market forces of supply and demand and by labour market institutions, which they identify as the supply-demand-institutions (SDI) framework for the explanation of the wage structure. Within the market forces explanation, the most often used arguments in favour of increasing earnings inequality are skill-biased technological change (SBTC) and globalisation/trade. The SBCT explanation poses that technology has evolved in a sense that favours the use of skilled workers so that, despite the increase in the supply of skilled workers over the last century, the increase in demand was even higher resulting in a rise of the price of skilled labour. The higher volume of trade between developed countries, more abundant in skilled workers and specializing in skilled labour intensive goods, and developing countries, more abundant in unskilled workers and specializing in unskilled labour intensive goods, also helps to explain the increase in earnings inequality in developed countries. The increase in trade between developed and developing countries leads to a decrease in the relative price of unskilled labour-intensive goods and thus to an increase in the skill premium. Finally, the institutional argument poses that the decline in the minimum

wage and the erosion of the influence of unions in the wage setting process have been important determinants of the increase in wage inequality, at least for the United States. In a survey of the literature, Nathalie Chusseau, Michel Dumont, and Joël Hellier (2008) review the theoretical predictions and empirical evidence on the importance of SBTC and trade as explanations for the observed rise in earnings inequality. At the theoretical level they highlight the fact that both explanations are not in principle independent, with the possibility of trade inducing further skill-biased technological change: "(…) when firms are faced with competition from developing countries, they tend to adopt a defensive innovation strategy which consists in lowering labour intensity in production. (…) Recent estimates (see Section 6) show that openness (trade and outsourcing) stimulates computerization, and thus SBTC" (p. 415). At the empirical level, the authors conclude that early diagnosis showed a prevailing influence of SBTC over trade in explaining the increase in earnings inequality, while more recent studies show that both mechanisms interact to create shifts in factor demands and changes in the skill premium.

More recently, Nolan, Richiardi, and Valenzuela (2019) review the state of the art on the drivers of income inequality specifically for rich countries, from around 1980 onwards, since these countries present distinctive features in terms of inequality levels and trends, as well as institutions and economic structures (see also Nolan and Valenzuela 2019). The authors review studies on a wide variety of factors thought to be implicated in increasing inequality in the rich countries: besides globalization and technological change, they also consider finance and macroeconomic shocks, labour market institutions and labour market power, product market power, re-distribution *via* social protection transfers and direct taxes and demography/household composition. They conclude that, although all the former drivers have played a role in explaining how inequality has evolved in advanced economies, the literature lacks an overall assessment of their relative importance with the few studies that try to evaluate the contributions of the main factors at work arriving at quite different conclusions about which dominate. According to the authors, this calls for "(…) complementing aggregate cross-country econometric analyses with in-depth investigation of individual country experiences, especially when examined through a common analytic lens, where the often episodic nature of inequality increases can be more adequately contextualized and understood" (Nolan, Richiardi, and Valenzuela 2019, pp. 1313-1314). At the empirical level, Davide Furceri and Jonathan D. Ostry (2019) identify a set of robust determinants of inequality across countries and time using model-averaging techniques to deal with the problem of model uncertainty. The 30 variables considered in the empirical model cover three dimensions of influences: (i) development, demographics, and institutions; (ii) technology and globalization; (iii) economic policies and macroeconomics conditions. In advanced countries, the level of development and demographics, unemployment, technological change and globalization play key roles, with opposite effects on inequality from trade (negative) and financial globalization (positive). The authors then go on to conclude, based on the differences identified between high- and non-high-income economies, that "(…) results suggest that specific country settings may lead to different determinants of inequality across countries" and "(…) the results should be interpreted as 'average' effects: results in specific country

settings may deviate from those that hold on average in the sample" (Furceri and Ostry 2019, p. 508 and 512, respectively).

As far as the specific case of Portugal is concerned, the topic of income and earnings inequality has attracted attention from several researchers. Farinha Rodrigues has devoted a significant amount of research to the characterization of inequality and poverty in Portugal (Farinha Rodrigues 1995, 2007; Farinha Rodrigues, Figueiras, and Junqueira 2012, 2016; Farinha Rodrigues and Isabel Andrade 2014; Arnold and Farinha Rodrigues 2015). Farinha Rodrigues, Figueiras, and Junqueira (2012, Chapter 3), provide a systematic review of the studies on economic inequality in Portugal over the last thirty years as well as their own analysis from the mid-90s onwards. The results show a reduction in income inequality during the 1970s, 1980s and 1990s due to an improvement in the relative position of the lowest incomes. In the 1999-2004 period the decline is reversed but from 2004 until 2009 the negative trend is again resumed, with the asymmetries lessened at lower incomes but remaining the same for the top ones. Facundo Alvaredo (2009) analysis of income and earnings concentration in Portugal in terms of top incomes for a long period covering 1936-2005 highlights the decrease in income concentration that started very moderately at the end of the 1960s and afterwards accelerated after the 1974 political revolution. However, this negative trend began to be reversed during the first half of the 1980s, with top income shares increasing steadily over the final 15 years of the period under analysis. Additionally, the results indicate that the rise in wage concentration contributed to this process in a significant way. For a more recent period, 2004-2011, Arnold and Rodrigues (2015) document the decrease in income inequality in the Portuguese economy patent in the decline of the Gini coefficient and the S90/S10 income decile share, the first decreasing from about 0.38 in 2004 to about 0.34 in 2011, and the second from 12 to 10 per cent during the same period. However, the authors highlight the fact that the economic events that followed the 2007-08 crisis have brought this downward trend to a halt and in 2011: the Gini coefficient of income distribution for Portugal was still about 2.6 percentage points above the OECD average of 0.315. Furthermore, the post-crisis behaviour of income inequality cannot be dissociated from the decline in earnings recorded after 2009 and the rise in unemployment. Farinha Rodrigues, Figueiras, and Junqueira (2012, 2016) update their previous study from 2012 that only used data up to 2009. The years that followed were especially harsh for the Portuguese population due to the economic and fiscal sustainability crisis involving an austerity program negotiated with the European Commission, the European Central Bank (ECB) and the International Monetary Fund (IMF) that lasted from May 2011 until June 2014 and implied cuts in public spending, tax increases and higher unemployment. The main conclusion from this more recent study, with data ending in 2014, is that the cycle of inequality reduction ceased in 2010 and was even reversed with the country recording an increase in earnings inequality.

The specific issue of earnings inequality in Portugal was studied by, for instance, Ana R. Cardoso (1998), using Personnel Records data. She analyses the period 1983-1992 and finds that the evolution of earnings over the whole period was characterized by rising inequality, with the top end of the distribution playing a major role in explaining this trend. Using the same data source, Joop Hartog, Pedro T. Pereira, and

José A. C. Vieira (2001) and José A. F. Machado and José Mata (2005) and suggest that a substantial part of this increase must be attributed to the returns to education, in the framework of the literature that explains the general shape of the earnings distribution and its dynamics as a function of workers' human capital, and more specifically education (G. Reza Arabsheibani, Francisco Galrão Carneiro, and Andrew Henley 2006 and Abdul Abdullah, Hristos Doucouliagos, and Elizabeth Manning 2015). Farinha Rodrigues, Figueiras, and Junqueira (2012) devote Chapter 5 to the analysis of wage inequality according to different categories of workers and firms using data from Personnel Records. Their main conclusion is that differences in schooling account for about 50% of earnings inequality, while variables such as firm location and other firm characteristics bear no explanatory power. Overall, up to 2009 there was an increase in wage inequality due to widening disparities at the top of the wage distribution. Focusing on the period after the financial crisis, 2009-2014, Farinha Rodrigues, Figueiras, and Junqueira (2016) conclude that there was a reduction of 2.4% in the real wages of private sector employees, that was even higher among public servants. Across deciles, the workers in the first decile experienced a reduction in earnings of 14.7% between 2009 and 2014, followed by the workers in the 10$^{th}$ decile that saw their earnings decrease 10.8%. Additionally, the proportion of workers in the first decile increased from 20% in 2009 to 29% in 2014, with the distribution of earnings moving to the left. The analysis of the evolution of earnings inequality according to different measures shows a stagnation, also patent in the behaviour of the S80/S20, S90/S10 and S95/S05 income ratios. The authors conclude that: "The current crisis does not appear to have a significant impact on the indicators of wage inequality. The strong reduction in employment and the general, albeit unequal, decline in wages seem somehow to have acted along the distribution of labour income, contributing to the relative maintenance of wage inequality values. The exit from the labour market of a significant part of the workers in a situation of greater precariousness and with lower wages may explain some equalizing effect. The compression of wage gains in the present crisis will also have made an important contribution to maintaining the levels of inequality" (pp. 93-94). Relative to the other EU member states, Portugal is a country with low wage levels, with a strong asymmetry in the distribution of earnings in the upper part of the distribution and with high levels of earnings inequality, according to the authors.

## 2. A Portrait of Earnings Inequality in Portugal, 1986-2017

### 2.1 Inequality Measures: An Overview

In what follows we briefly review the inequality measures we use to describe earnings inequality in Portugal over the period 1986-2017. Among these measures some do not rely on parameter values like the Gini and the Zenga indexes, others only account for inequality in some parts of the distribution of earnings, such as the inter-quantile ratios and the quantile share ratios. Furthermore, we rely on parametric indexes like the generalized entropy index (the Theil index, the mean log deviation and the coefficient of variation). All these measures, with the exception of the Zenga index that is quite recent, are commonly used to measure income, earnings and wage inequality because of

their complementarity. According to Roger Wilkins (2015, p. 99): "any single inequality measure provides only a partial picture of inequality and therefore satisfactory comparison of data sources requires considerably more detail than is provided here".

Inequality measures have to meet certain principles: the population principle, symmetry (or anonymity) and the Pigou-Dalton transfer sensitivity; and axioms (mean independence, decomposability) otherwise they are not adequate to measure inequality or welfare, Frank Cowell (2000) and World Bank (2015). The Gini coefficient is the most widely used synthetic inequality measure. It is based on the underlying Lorenz curve, but does not respect, in general, the property of decomposability. Additionally, by assuming a lognormal distribution of incomes, the Gini coefficient has a small elasticity in relation to the variance of the distribution while at the other extreme the coefficient of variation presents great elasticity, Cowell (2011, p. 82).

The Zenga index, Michele Zenga (2007), is an alternative inequality measure based on the Zenga curve of inequality. More recent literature has computed this index, (Matti Langel 2012; Zenga and Leo Pasquazzi 2012; Francesca Greselin, Pasquazzi, and Ricardas Zitikis 2016). The Zenga curve $Z(\alpha)$ is the ratio of the mean income of the $\alpha$% lower incomes to that of the (1 - $\alpha$)% higher incomes. Some arguments favour the use of this index relative to the use of the Gini coefficient, Langel and Yves Tillé (2012): the Gini underestimates results when comparing the very low parts of the population with the whole population and, simultaneously, it overestimates comparisons between identical population subgroups. On the contrary, with the Zenga index all deviations from equality in any part of the distribution are dealt with the same sensitivity Greselin, Pasquazzi, and Zitikis (2010). In addition at "any point measure $Z(\alpha)$ on the curve indicates that the mean income of the $\alpha$% poorest is equal to 1 - $Z(\alpha)$ times the mean income of the richest (1 - $\alpha$)%" (Langel and Tillé 2012, p. 3). When adding a positive income to all values the effect on the curve is more intuitive than that on the Lorenz curve Walter Maffenini and Marcella Polisicchio (2010).

The formulas for the different inequality measures, Tarun Das and Ashok Parikh (1982) and Cowell (2011) can be found in the Appendix.

## 2.2 Portuguese Earnings Inequality Evolution - An Overview based on Inequality Measures

We use data from the Personnel Records (*Quadros de Pessoal)*, the annual macroeconomic database of the European Commission's Directorate General for Economic and Financial Affairs (European Commission 2019)[1] and the Portuguese National Statistics Agency (INE 2019)[2] databases to perform our empirical analysis for the period between 1986 and 2017. We exploit the time coverage available from the database, but we dropped the initial year, 1985, to avoid possible measurement errors. All the earnings components were considered to compute probability distribution functions (PDFs), inequality measures and the relative distribution indicators (see Section 3).

[1] **European Commission.** 2019. AMECO Database. https://ec.europa.eu/info/business-economy-euro/indicators-statistics/economic-databases/macro-economic-database-ameco/ameco-database_en#database (accessed September 12, 2019)

[2] **Portuguese National Statistics Agency.** 2019. Statistics. https://www.ine.pt/xportal/xmain?xpgid=ine_main&xpid=INE (accessed September 12, 2019).

We have excluded workers with earnings below the minimum wage and earnings higher than the 99.5% percentile value to avoid results influenced by the presence of outliers. All the computations were performed using the software Bernhard Pfaff (2008) - haven; Hadley Wickham (2009) - Gdata; Didier Plat (2012) - IC2; Achim Zeileis (2014) - Relative Distribution Methods (reldist); Gregory R. Warnes et al. (2015) - forecast; Mark S. Handcock (2016); Rob J. Hyndman (2016) - urca; R Core Team (2016) and the packages ggplot2; Wickham and Evan Miller (2016) - ineq.

We computed earning PDFs for the years 1986, 2002, 2008 and 2017 based on the macroeconomic performance of the Portuguese economy over the last thirty-one years. Portugal initiated in 1986 a convergence process in real per capita income (earnings) towards EU income levels that however came to a halt in 2001 (João A. S. Andrade and Adelaide Duarte 2011). A divergence period followed and it persisted until 2015, deepening during the Great Recession (2007-2009) and the Portuguese sovereign debt crisis (2010-2014) (see also Banco de Portugal 2009; Luís Aguiar-Conraria, Fernando Alexandre, and Manuel C. de Pinho 2012; Ricardo Reis 2013; Andrade, Duarte, and Marta C. N. Simões 2014). Portugal joined the European Economic Community (currently, the EU) in 1986, after the political revolution of 1974 and the first steps as a democracy, becoming officially committed to the process of European integration, regarded as fundamental for the transition to a developed democracy and to achieve higher standards of living. European integration led to the adoption of new models of governance, requiring more transparency and accountability, and there was also an increase in the number of policies and regulations moving from the national to the European level. Just before EU accession, in 1974-1985, as a result of political turmoil and concomitant economic difficulties, the Portuguese economy became almost stagnant and balance of payments crises resulted in two IMF interventions (1978-1979, 1983-1985). The first years of European integration were very favourable for Portugal in terms of output growth and thus created the conditions for political support for accession to Economic and Monetary Union (EMU). Portugal experienced rapid economic growth in the years before the launch of the euro (between 1995 and 1999-2000). However, since the beginning of the 21st century, economic growth has been dismal. The adoption of the euro, China's accession to the World Trade Organization, the enlargement of the EU to Eastern European countries, the reinforcement of the non-tradables sector as the anchor of the economy and associated productivity growth slowdown, the Great Recession and the austerity measures associated with the financial aid programme following the sovereign debt crisis that led to the third IMF bailout (together with the ECB and the European Commission) which lasted from May 2011 to June 2014, all contributed to Portugal's weak growth. By mid-2013, the Portuguese economy began a gradual recovery, recording higher output growth rates, lower unemployment and declining government deficits.

We have obtained over the 1986-2017 period the following values for the sample size of Portuguese employees: minimum 1,344,649; maximum 2,517,136; median 2,043,125; first quartile 1,615,920; mean 1,950,201; third quartile 2,250,738 (see Table 1 in the Appendix).

The mean Portuguese real earnings increased over the period 1986-2017, going from 664.4€ (2010 prices) in 1986 to 995.9.1€ in 2017, although at different paces

depending on the sub-periods considered, 2.31% in 1986-2002, 0.03% in 2002-2008 and 0.37% in 2008-2017, corresponding to an average annual growth rate of 1.3% for the whole period. Median values follow the same pattern and the corresponding levels are 548.4€ in 1986, 722.5€ in 2002, 720.5€ in 2008 and 754.6€ in 2017. The associated growth rates are: 1.74% in 1986-2002, -0.05% in 2002-2008, 0.52% in 2008-2017, and 1.03% for the whole period.

The PDFs of the Portuguese earnings distribution for the years 1986, 2002, 2008 and 2017 (Figure 1 in the Appendix) provide a picture of the evolution of the Portuguese earnings distribution for period under analysis at a glance. We observe that over the years there seems to have been scale changes in the mean and the median (see Figure 1 in the Appendix). Moreover, changes underlying re-distributional effects in some parts of the distribution in detriment of others seem to have taken place too. In particular, if we compare the 2002 and 2008 distributions to the 1986 distribution, both tails of the distribution became fatter pointing to the possibility of a polarization phenomenon (this issue will be addressed in Section 3). But if we compare the 2002 and 2008 distributions their shapes are quite similar, although it seems that the 2008 distribution is less concentrated around the median (see Figure 1 in the Appendix). Additionally, when we compare the 2017 earnings distribution to the other three, it seems that the shape is similar to the 1986 distribution, which may be explained in part by the effect of the Great Recession that lead to a decrease in earnings inequality.

We can also provide a picture of the evolution of earnings inequality in the Portuguese economy from 1986 to 2017 by using different inequality measures (see Section 2.1 above and the Appendix), more specifically the Gini coefficient (*g*); the Zenga coefficient (*z*); generalised entropy coefficients, the Theil index (*e.1*), the mean log deviation (*e.0*), the coefficient of variation (*e.2*); quantile share ratios, quantile share 90/10 (*q.9.1*) and the 90$^{th}$ share ratio (*qsr.9*). We computed the correlation matrix between these different inequality measures and we can observe that the absolute values of the correlation coefficients are quite high varying between 0.940 to 0.998 (see Table 2 in the Appendix). We plotted the different earnings inequality curves from 1986 to 2017 and concluded that we can work with just two inequality measures: the Gini coefficient and the coefficient of variation because their evolutions mimic those of two groups of inequality measures (see Figure 2 in the Appendix). The Gini index records the value 0.247 in 1986, it reaches its highest value of 0.318 in 2008 and decreases to 0.288 in 2017. A similar evolution is captured by the coefficient of variation that starts at 0.131 in 1986, reaches its maximum of 0.254 in 2008 and then its value decreases to 0.214 in 2017. The inequality evolution pattern is quite similar: earnings inequality increases from 1986 to 2008 but at a different pace, the Gini average annual growth rate is 1.47% between 1986 and 2002 and 0.32% during 2002-2008; it becomes negative, -1.1%, in 2008-2017 and records the 0.5% value for the whole period under analysis. Similar growth rates can be obtained for the coefficient of variation for the same periods: 3.8%, 1.09%, -1.89% and 1.6%, respectively.

# 3. Changes in the Portuguese Earnings Distribution over the Period 1987-2017: A Relative Distribution Approach

## 3.1 Relative Distribution Indexes: An Overview

The Relative Distribution (RD) analysis is a non-parametric approach particularly appropriate to the investigation of differences between distributions. Relative to the Lorenz Curve (LC) and the Gini summary statistic associated with the LC, the RD analysis allows for direct comparisons of two distributions. In the case of the LC, if we want to analyse two distributions, we must compare the deviations from the distributional standard of exact equality of each of the distributions, but sometimes we face the problem of curves intersecting. The LCs are multiplicatively scale invariant and the RD is invariant to all monotonic transformations of the reference distribution data. This property implies that RD is the maximal invariant, Eric B. Holmgren (1995). This methodology, Handcock and Martina Morris (1999), is applied in order to measure and characterize more accurately changes that occurred in the Portuguese earnings distribution over the 1986-2017 period using relative distribution indicators such as the entropy index and its components and the polarization indexes. This methodology relies on the relative distribution function whose relative values measure the percentage rank that the original comparison values could have in the chosen population distribution. According to Handcock and Morris (1999, p. 24), $G(r)$ is: "the proportion of the comparison group whose attribute lies below the $r^{th}$ quantile of the reference group" and $g(r)$ "the density ratio, the fraction of respondents in the comparison group to the fraction in the reference group at a given level of outcome attribute".

This methodology applies an overall measure of entropy based on the Kullback-Leiber (K-L) divergence ratio to the RD distribution in order to measure the overall distributional differences between two distributions, Handcock and Morris (1998) and Jan Mielniczuk (1992). The K-L for the overall difference is the sum of K-L for location and shape RD (see the Appendix).

We are interested in the polarization phenomena, i.e. the phenomena of accrued (reduced) concentration of earnings in the tails of the relative distribution at the expense of the central part of the distribution: around the median, upper and lower after correcting for location shift (median change), (see the Appendix). Less polarization means that earnings are more concentrated around the median with the concomitant weight reduction at the tails. This effect is measured by the median relative polarization index (MRP) that represents the mean absolute deviation from the median of the location-matched relative distribution and can take values between -1 and 1. A zero value for MRP corresponds to no differences in the shape of the distribution. A positive value corresponds to an increase in the tails of the distribution, which is equivalent to more polarization, while a negative value indicates convergence towards the centre. Increased upper-polarization means a higher concentration of earnings in the richest at the expense of a lower earnings concentration in the middle class earners. An increased lower-polarization means a higher concentration of earnings in the poorest at the expense of a lower earnings concentration in the middle class earners.

It should be noticed that other indicators like the decile dispersion ratio, the ratio of average earnings of the richest x% to the average earnings of the poorest $x$%, the

Palma ratio, Alex Cobham, Luke Schlogl, and Andy Sumner (2015), that compares the top 10% with the bottom 40%, can be used to measure the polarization phenomena. However, concerning the analysis of what happens in the tails, the above RD polarization indexes are more robust.

### 3.2 Entropy and Polarization Indexes from RD Analysis: The Portuguese Earnings Distribution over the Period 1987-2017

In order to compute polarization indicators based on relative distributions, the choice of the reference distribution is crucial to obtain robust results. The initial year of our period of analysis is 1986, the year when Portugal's accession to the European Economic Community (EEC) became effective and the second year for which *Quadros de Pessoal* collected data. We decided to compute an earnings distribution reference comprising the years 1986, 1987 and 1988 with a weight of 1/3 for each individual distribution to build the multiyear base sample. This new economic framework associated with accession to the EEC implied several important changes (shocks), of different natures, namely economic, cultural and informational in the Portuguese economy. This applies mostly to expectations about future earnings. As labour contracts at the time had on average a two years length, by merging the years 1986-1987 and 1988 we tried to mitigate the effects of those changes. We have used the R software for organizing *Quadros de Pessoal* data and for computing the appropriate inequality indices.

In what follows, we analyse the polarization phenomena for the Portuguese economy over the period 1988-2017 using earnings data from *Quadros de Pessoal* based on the median, lower and upper polarization indicators. Median polarization is the joint result of left and upper polarization but in this case left polarization dominates median polarization (both curves have the same configuration), although if upper polarization exists its positive values are always lower, placing its curve below the upper and median polarization curves. Median polarization is present for the whole period and the values are always positive meaning that earnings concentration around the median decreased over the period, although at different rhythms (see Figure 3 in the Appendix).

The positive values of the polarization index confirm the result of a higher concentration of earnings at the two tails of the relative earnings distribution, at the expense of earnings for the central part of the two tails. However, median polarization is increasing between 1989 and 1994 only at the expense of a higher concentration of earnings at the left part tail of the relative earnings distribution. From 1994 onwards the accumulated median polarization index varies between 0.4 and 0.5 showing a decrease in that interval since the Great Recession. Between 1990 and 1994 the concentration at the right tail diminishes and it starts to increase ever since, stabilizes by 2004 and experiences a reduction since the Great Recession (see Figure 3 in the Appendix).

## 4. Business Cycle and Earnings Inequality: An Econometric Analysis

### 4.1 Econometric Strategy

Can the business cycle explain part of the behaviour of earnings inequality in Portugal? We carry out an econometric analysis to answer this research question. We estimate a

short-run relationship between the business cycle and earnings inequality in order to find evidence on the role of the business cycle in the explanation of the behaviour of earnings inequality. For this purpose, we estimate ADL models in order to capture the dynamics of the short-run relationship above mentioned and to prevent the existence of spurious regressions due to the presence of non-stationary variables. We use the methodology for model reduction proposed by Hans-Martin Krolzig and David F. Hendry (2001a, b) to obtain parsimonious and congruent models in order to illustrate data behaviour. Based on this methodology, we selected the ADL coefficients through the elimination of statistically irrelevant variables and their lags, imposing a maximum of two lags for all the explanatory and dependent variables in each model.

We also provide two types of robustness checks: we implement a sensitive analysis by using two inequality proxies to measure earnings inequality and we apply forecast methods to selected models in order to check for the respective predictive accuracy/capability.

A general ADL model, $ADL(p, q_1,\ldots, q_k)$ is represented as follows:

$$A(l)y_t = m + B_1x_{1t} + B_2x_{2t} + \cdots + B_kx_{kt} + \varepsilon_t,$$

with

$$A(L) = 1 - \alpha_1 L - \alpha_2 L^2 - \cdots - \alpha_p L^p \quad (1)$$

and

$$B_n(L) = B_{n0} + B_{n1}L + B_{n2}L^2 + \cdots + B_{nq}L^q,$$

where $A(L)$ and $B_n(L)$ denote polynomial lags of order $p$ and $q_n$ (with $n = 1, \ldots, k$), respectively; $y$ is the dependent variable; $x$ is a vector of $k$ independent variables; $x_1$ to $x_k$; $t$ is the time period and ε is the error term. The inequality proxies used in the model are I(0) at a significance level of less than 10% and the remaining variables have the same characteristic except for the real effective exchange rate[3].

Earnings inequality is the dependent variable in our ADL model and we selected the coefficient of variation and the Gini coefficient as proxies based on their evolution over the period under analysis. Accordingly, we selected those proxies as representative of the behaviour of the other inequality measures that were also considered in this study (see Section 2.2 for further details). As for the explanatory variables, we define our empirical model based on a small open economy that presents the characteristics of the Portuguese economy. Thus, besides a variable that captures the influence of the business cycle, we also included variables that represent production decisions by firms over the business cycle, in particular investment decisions, the degree of openness of the economy as well as its level of external competitiveness, the current fiscal situation of the general government and the financial environment of Portuguese firms.

We expect that the inequality indicators ($CV$ and $g$) will increase with: (a) the descending phase of the business cycle since workers with average qualifications will be to some extent replaced by new technologies; (b) higher investment to the extent that it represents an increase in the capital stock associated with more advanced technologies; (c) a higher degree of openness due to an increase in exports, because the

[3] The results of the unit root tests are available from the authors upon request.

technological pattern of Portuguese exports is moving away from traditional low-tech exports; (d) with external competitiveness losses of the economy resulting in the elimination of less technologically advanced firms; (e) a higher deficit under Ricardian or quasi-Ricardian regimes associated to the progressive structure of income taxes; and finally (f) a higher short-run interest rate as an indication of liquidity/credit constraint and with a reduction in the long-run interest rate that corresponds to a reduction in the cost of capital complementing the effect of higher investment. All of these relationships are confirmed by the results obtained with our estimations, the only exception refers to exports in two of the eight models retained.

The business cycle is proxied by the output gap (the difference between actual and trend gross domestic output at constant market prices divided by trend gross domestic output at constant market prices) and the trend is computed using the HP filter methodology (European Commission 2019). The remaining explanatory variables included in vector *x* are, according to our description of the model specification above, the following: the investment ratio (*Inv*); the exports ratio (*Ex*); the logarithm of the real effective exchange rate (*l_REER*); the general government deficit ratio (*Def*); the short-run real interest rate (deflated according to the GDP implicit price index), (*SRIR_R*); and the long-run real interest rate (deflated according to the GDP implicit price index), (*LRIR_R*). All the ratios correspond to the values of the variables relative to GDP. AMECO (European Commission 2019) macroeconomic database is the source for all macroeconomic variables, except for *l_REER*, retrieved from the World Bank (2019)[4] database. All macroeconomic and *Quadros de Pessoal* variables are in real terms considering 2010 prices.

We have also addressed the possible existence of structural breaks that could undermine the results from our empirical analysis. For this purpose, we performed Chow and CUSUM stability tests. The results of both tests support the idea of no structural breaks in the models presented in Table 3 (Appendix). The Chow tests were performed with Pc-Give and the CUSUM tests with Gretl. Additionally, we examined whether the inclusion of dummy variables would improve the models estimations. According to the results, we could not identify any improvements since the null of the estimated coefficients of the dummy variables was never rejected[5]. The set of three dummies that take into account the financial crisis are the following: *D200915* (1 for the period 2009-2015 and zero otherwise), *D200914* (1 for the period 2009-2014 and zero otherwise) and *D200913* (1 for the period 2009-2013 and zero otherwise). In what concerns Models A5, A6 and A7 besides the above mentioned dummies we have also include dummies to identify the beginning of the Portuguese Crisis (Andrade and Duarte 2011), one for the year 2002 (*D2002*) and the other for the period 2001-2003 (*D200103*) and the null of the estimated coefficients was again never rejected.

We consider the above specification for our empirical model based on the structural characteristics of the Portuguese economy, a small open economy, as well as on its evolution over the past three decades marked by accession to the EU in 1986 and becoming a founding member of the European Monetary Union (EMU) or Euro Zone

[4] **World Bank.** 2019. World Development Indicators.
https://databank.worldbank.org/source/world-development-indicators (accessed September 12, 2019).
[5] The results are available from the authors upon request.

in 1999. We do not consider a human capital proxy because we use annual data and this variable takes longer to record relevant changes that produce an effect on earnings inequality. We have used Pc-Give in all model estimations including parameter selection in the case of the ADL models. We have used Gretl for forecasting based on the information presented in Tables 4 and 5 in the Appendix due to the enhanced graphical possibilities offered by this software.

## 4.2 Results

The results on the relationship between the output gap and earnings inequality that we estimated using ADL models are presented in Table 3 in the Appendix. We present eight ADL models (A1 to A8), where the first four models (A1 to A4) use the coefficient of variation (*CV*) to proxy earnings inequality and the remaining four (A5 to A8) use the Gini coefficient (*g*). We started by estimating two similar models, with the same specification, where all selected control variables were included, differing only in the inequality proxies used. However, we only retain the models that include explanatory variables statistically significant at least at the 5% significance level and where the presence of error autocorrelation can be excluded. In what follows we describe, interpret and compare the main results obtained for each of the eight models.

All the models, except model A6, are static models because lags of the dependent variables are not present in the right-hand-side of the model as explanatory variables. The eight models show a negative sign for the current GAP coefficient and when we account for the overall magnitude of current and lagged GAP coefficients the sign is still negative. This sign indicates that earnings inequality increases when a recession deepens, which may be the consequence of the relative reduction in employment of workers with intermediate earnings, in accordance with the evidence we found on the existence of left polarization from the median (for further details see Section 3).

In the case of the investment ratio, the sign is always positive either for the current coefficient or the one-lag coefficient. This positive relationship with inequality probably reflects the fact that new investment uses more advanced technologies that require higher levels of human capital. The current exports ratio coefficient presents a positive sign (A7 model) but different signs for the exports ratio lagged one period: positive in model A1 and negative in model A2. Nevertheless, if we had to choose one of the three models it would be model A2 on the grounds of the selection criteria described in Section 4.1 and the values for the Schwarz's Bayesian information criteria (BIC). The negative sign seems to indicate that relative export growth is predominantly at the expense of the growth of traditional exporting sectors that have lower earnings inequality, for a given real effective exchange rate. In the case of the latter variable, the positive relationship with earnings inequality seems to indicate that the deterioration of external competitiveness affects technologically advanced exporting sectors to a much lesser extent. As for the government deficit, the estimated coefficient is always positive. Possible explanations for this sign may rely on a public revenue approach according to which rising income taxes usually decrease wage inequality, see David Powell and Hui Hui Shan (2012) and Thomas Piketty, Emmanuel Saez, and Stefanie Stantcheva (2014). On the expenditure side, the link may be an indirect one: political

factors are the ultimate cause, indicating that more inequality is associated to less fiscal discipline (Martin Larch 2010).

Model A4 is the only model that includes as explanatory variables the short-run and long-run real interest rates. The inclusion of these two variables is justified because the nullity of the spread is rejected, revealing that the relationship between the interest rates and earnings inequality is non-linear. We are aware that the interest rate differential as a financial indicator is not a clear leading indicator of the business cycle (Paulo Maio and Dennis Philip 2013) but we also know that when the long-term interest rates are lower than the short-term, the so called inverted yield curve, this is a prediction of a future recession. The joint estimated signs for these variables confirms this thesis.

Finally, we selected the two best models, each from the subsets A1 to A4 and A5 to A8, respectively. We consider the BIC criteria because it offers us the possibility to select between models that use the same dependent variable and corrects for the number of parameters. But before comparing the BIC values we also looked at error consistency and model fit. The LMF test values report that models A5 and A7 exclude at the 1% and 10% significance levels, respectively, the null of no autocorrelation of the errors, whereas the remaining models do not. In terms of model fit, values for the standard error of the regression (SER) show a good fit for all the models but higher for models A3, A6 and A8. Based on the BIC criterion the two best models are A3 and A6 since they show the lowest values, within each group of models, for BIC.

As an additional robustness test, we submitted the former two models, A3 and A6, to an *acid test* using dynamic forecast methods based on model estimation between 1987 and 2009. For both models (see Figures 4 and 5 and Tables 4 and 5 in the Appendix) the predictions are quite accurate (at a $90^{th}$ confidence interval). However, it should be noticed that in the case of model A6 the estimators are efficient but inconsistent due to endogeneity between the dependent variable and its lag taking in account the small number of observations of our base estimation.

## 5. Conclusion

This paper examined employees' earnings inequality in Portugal using data between 1986 and 2017 from the Personnel Records (*Quadros de Pessoal*) database. We characterized earnings distribution applying different measures of inequality and analysed the changes occurred over the years in the earnings distribution. Additionally, we estimated a short-run relationship to assess the role of the business cycle in the behaviour of earnings inequality.

We concluded that mean real earnings increased over the period 1986-2017, going from 664.4€ (2010 prices) in 1986 to 995.9.1€ in 2017, albeit at different paces, 2.31% in 1986-2002, 0.03% in 2002-2008 and 0.37% in 2008-2017, corresponding to an average annual growth rate of 1.3% for the whole period. The Gini index of the earnings distribution recorded the value 0.247 in 1986, reached a maximum of 0.318 in 2008 and decreased to 0.288 in 2017. A similar evolution is captured by the coefficient of variation that starts at 0.131 in 1986, reaches a maximum of 0.254 in 2008 and decreases to 0.214 in 2017. The inequality evolution pattern is quite similar to that of mean earnings: inequality increases from 1986 to 2008 but at different paces. The Gini

index average annual growth rate is 1.47% between 1986 and 2002 and 0.32% during 2002-2008; it becomes negative, -1.1%, in 2008-2017, corresponding to an annual average growth rates of 0.5% for the whole period. Similar growth rates were obtained for the coefficient of variation for the same sub-periods: 3.8%, 1.09%, -1.89% and 1.6%, respectively.

The PDFs of the Portuguese earnings distribution for the years 1986, 2002, 2008 and 2017 allowed us to provide a picture of the evolution of the Portuguese earnings distribution for the time period covered at a glance. We observed that over the years there were scale changes to the right in the mean and in the median and also changes underlying re-distributional effects: both tails of the distribution became fatter pointing out to the possibility of a polarization phenomenon, which we later confirm. Over the whole period (positive) median polarization exists and is dominated by (positive) left polarization, showing a positive trend between 1986 and 2008 and then decreases until 2017.

We next used ADL models suited to describe the behaviour of earnings inequality in a small open economy like the Portuguese economy to estimate the short-run relationship between the output gap (business cycle) and earnings inequality. We found that the business cycle plays a role in the short-run adjustment of earnings inequality and the relationship presents a negative sign. This negative association might in part be explained by demand and supply in the labour market (the relationship between employers and employees) and the prevalence of short-run factors in the behaviour of that market but also by the resilience/persistence of the earnings distribution.

Future research to gain a deeper understanding of earnings inequality in Portugal involves extending our analysis within the SDI framework. In particular, from a labour supply perspective, the decomposition of earnings inequality by gender, schooling and experience will help to identify the contribution of cultural, educational and training factors in the explanation of earnings inequality and its evolution. From a labour demand perspective, technological differences and different degrees of openness across sectors that might have an impact on the earnings structure should be addressed, with the help of sectoral level analysis.

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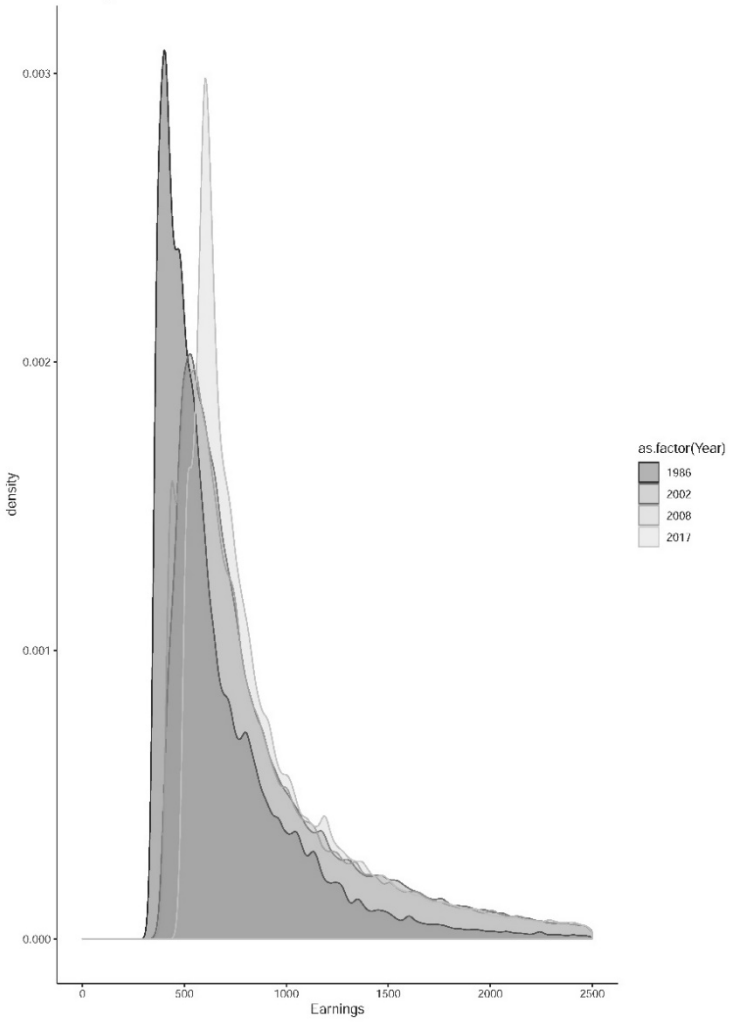
# Appendix

## Formulas

- the interquartile ratio, $IQR = \frac{Q_{1-\alpha}}{Q_\alpha}$, for $\alpha = 0.1$;
- the quantile share ratio, $QSR = \frac{Y - Y_{1-\alpha}}{Y_\alpha}$, for $\alpha = 0.1$;
- the median share ratio, $MSR = QSR$, for $\alpha = 0.5$;
- the coefficient of variation, $c = \frac{\sqrt{V}}{y}$; $CV = \frac{1}{2}\sqrt{c}$; notice that the true $CV$ is $c$ but we use the last formula and named it improperly the coefficient of variation;
- the Gini coefficient, $g = \frac{1}{2n^2 y \sum_{i=1}^{n} \sum_{J=1}^{n}} \left| y_i - y_j \right|$;
- the generalized entropy, $E_\theta = \frac{1}{\theta^2 - \theta}\left[\left[\frac{1}{n}\sum_{i=1}^{n}\left[\left[\frac{y_i}{\bar{\imath}}\right]\right] - 1\right]\right]$; Theil index ($\theta = 1$);
- mean log deviation ($\theta = 0$); coefficient of variation ($\theta = 2$).

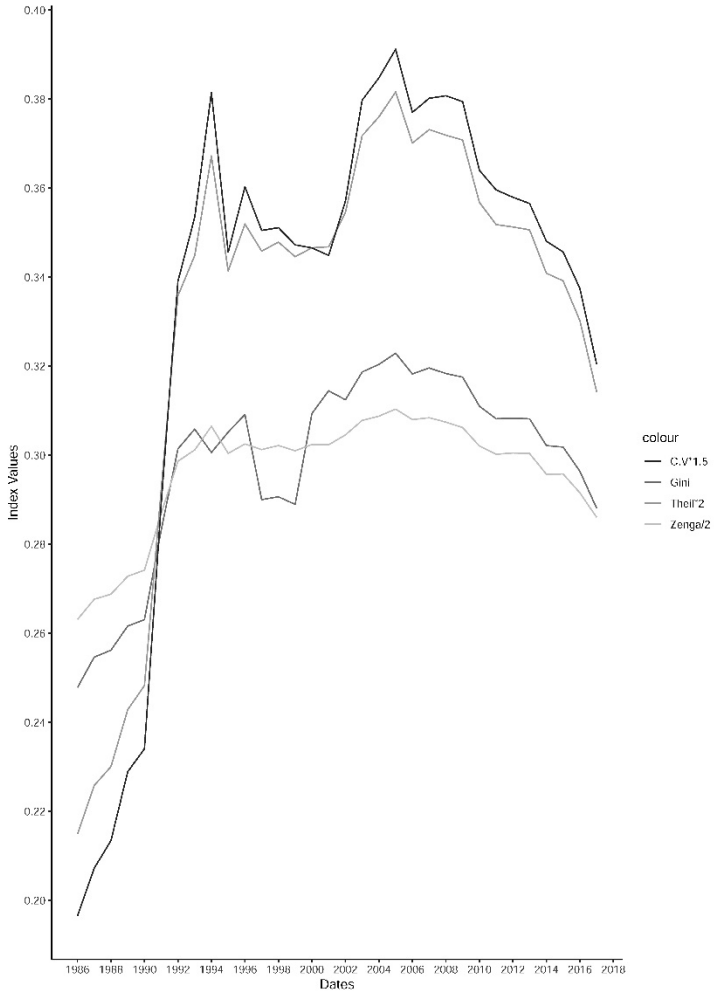
- if $0 \le y_{(1)} \le y_{(2)} \le \ldots \le y_{(n)}$, the Zenga (2007) inequality measure is given by, $I^Z = \frac{1}{n}\sum_{i=1}^{n} I_i$, where $I_i = \frac{\overset{+}{\tilde{M}}_i - \overset{-}{\tilde{M}}_i}{\overset{+}{\tilde{M}}_i}$, $\overset{-}{\tilde{M}}_i = \frac{1}{i}\sum_{t=1}^{i} y_{(t)}$, for $i = 1, 2, \ldots, n$ and $\overset{+}{\tilde{M}}_i = \begin{cases} \frac{1}{n-i}\sum_{t=1+i}^{n} y_{(t)} & for\ i = 1,2,\ldots,n-1 \\ y_{(n)} & for\ i = n \end{cases}$;
- the RD_Kullback-Leiber entropy indicator $D(F; F_0) = \int_0^1 \log\big(g(r)\big)\, g(r) dr$; the median relative polarization index (MRP) of $Y$ in relation to $Y_0$ is defined as: $MRP = 4\int_0^1 \left| r - \frac{1}{2} \right| g_0^A dr1$;
- the lower (LRP) and upper (URP) relative polarization indexes: $LRP = 8\int_0^{1/2} \left| r - \frac{1}{2} \right| dr g_0^A - 1$; $URP = 8\int_{1/2}^{1} \left| r - \frac{1}{2} \right| dr g_0^A - 1$.

## Figures



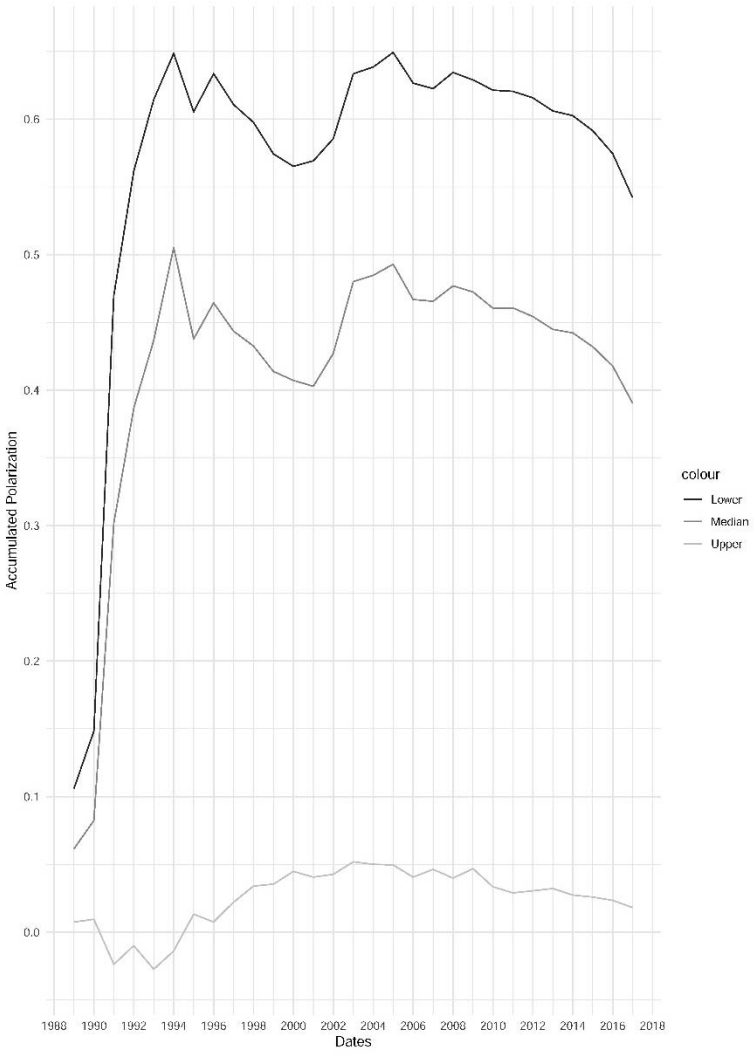

Source: Authors' construction.

**Figure 1** Earnings Distributions 1986, 2002, 2008 and 2017



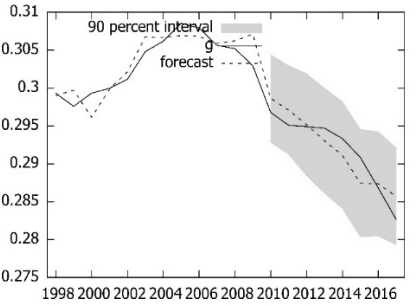

Source: Authors' construction.

**Figure 2** Several Inequality Indexes (CV, Gini, Theil and Zenga), 1986-2017



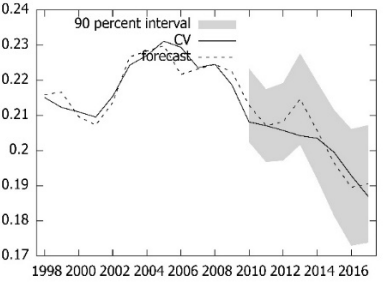

Source: Authors' construction.

**Figure 3** Polarization with Reference to 1986-1988




Source: Authors' construction.

**Figure 4** Forecasts for Model A6




Source: Authors' construction.

**Figure 5** Forecasts for Model A3

## Tables

**Table 1** Number of Employees Retained from Personnel Records (*Quadros de Pessoal*)

| Min. | 1st Qu. | Median | Mean | 3rd Qu. | Max. |
|---|---|---|---|---|---|
| 1344649 | 1615920 | 2043125 | 1950201 | 2250738 | 2517136 |

Source: Authors' computations using R, GRETL, PCGive and data from Personnel Records (*Quadros de Pessoal*), European Commission (2019) and INE (2019) for the period 1986-2017.

**Table 2** Correlation Matrix between Inequality Measures

| | g | z | e.1 | e.0 | e.2 | q.9.1 | qsr.9 |
|---|---|---|---|---|---|---|---|
| g | 1.000 | 0.953 | 0.961 | 0.962 | 0.962 | 0.940 | -0.961 |
| z | 0.953 | 1.000 | 0.991 | 0.996 | 0.984 | 0.977 | -0.981 |
| e.1 | 0.961 | 0.991 | 1.000 | 0.998 | 0.999 | 0.957 | -0.997 |
| e.0 | 0.962 | 0.996 | 0.998 | 1.000 | 0.994 | 0.971 | -0.992 |
| e.2 | 0.955 | 0.984 | 0.999 | 0.994 | 1.000 | 0.943 | -0.997 |
| q.9.1 | 0.940 | 0.977 | 0.957 | 0.971 | 0.943 | 1.000 | -0.938 |
| qsr.9 | -0.961 | -0.981 | -0.997 | -0.992 | -0.997 | -0.938 | 1.000 |

Notes: *g* - gini coefficient; *z* - zenga coefficient; generalised entropy coefficients: *e.1* - Theil index, *e.0* - mean log deviation, *e.2* - coefficient of variation; quantile share ratios: *q.9.1* - quantile share 90/10, *qsr.9* - 90th share ratio.

Source: Authors' computations using R, GRETL, PCGive and data from Personnel Records (*Quadros de Pessoal*), European Commission (2019) and INE (2019) for the period 1986-2017.

**Table 3** The Influence of the Business Cycle on Earnings Inequality (ADL Models)

| CDep. Var, CV | A1 | | | A2 | | | A3 | | | A4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| cconst | | | | --1.3082 | 0(.0773) | **** | --1.2833 | 0(.0543) | **** | --1.1896 | 0(.0475) | **** |
| CCV_1 | | | | | | | | | | | | |
| EEx | | | | | | | | | | | | |
| EEx_1 | 0.1997 | 0(.0512) | **** | --0.1381 | 0(.0194) | **** | | | | | | |
| EEx_2 | | | | | | | --0.1596 | 0(.0147) | **** | | | |
| llnv | 0.7328 | 0(.0719) | **** | | | | | | | | | |
| llnv_1 | | | | | | | | | | | | |
| llnv_2 | | | | | | | | | | 0.2813 | 0(.0369) | **** |
| GGAP_T | --0.4305 | 0(.1045) | **** | --0.2639 | 0(.0530) | **** | --0.1523 | 0(.0412) | **** | --0.2654 | 0(.0468) | **** |
| GGAP_T_1 | | | | | | | | | | | | |
| GGAP_T_2 | 0.2604 | 0(.0970) | *** | | | | | | | | | |
| DDef | | | | 0.0017 | 0(.0007) | *** | 0.0018 | 0(.0005) | **** | | | |
| DDef_1 | | | | | | | | | | | | |
| DDef_2 | | | | 0.0026 | 0(.0007) | **** | 0.0025 | 0(.0005) | **** | | | |
| ll_REER | | | | 0.3433 | 0(.0173) | **** | 0.1451 | 0(.0373) | **** | 0.1720 | 0(.0264) | **** |
| ll_REER_1 | | | | | | | 0.1940 | 0(.0354) | **** | 0.1214 | 0(.0243) | **** |
| SSRIR_R | | | | | | | | | | 0.0032 | 0(.0005) | **** |
| LLRIR_R | | | | | | | | | | -0.0025 | 0(.0004) | **** |
| SSER | 0.0090 | | | 0.0063 | | | 0.0045 | | | 0.0048 | | |
| AAR2 | | | | 0.9542 | | | 0.9768 | | | 0.9739 | | |
| BBIC | -161.58 | | | -212.09 | | | -230.98 | | | -227.38 | | |
| LLMF | | | | 0.3356 | | | 0.0323 | | | 0.0029 | | |

Notes: *BIC* is the Schwarz's Bayesian Information Criterion for model specification in terms of the number of parameters - a smaller BIC corresponds to a better model specification; *LMF* is the Lagrange Multiplier *F*-test, an autocorrelation test of order one under the null of no autocorrelation; *AR2* is the adjusted R squared; *SER* is the standard error of the regression; (***), (**), (*) denotes significance levels at 1%, 5% and 10%, respectively, with standard errors in parenthesis; *CV* is the generalized entropy inequality measure, with the alpha parameter equal to two; *GAP_T* is the output gap; *Ex* is the exports ratio (volume); *Inv* is the investment ratio*; l_REER* is the logarithm of the real effective exchange rate; *Def* is the general government deficit ratio; SRIR_R is the short-run real interest rate (deflator GDP price); *LRIR_R* is the long-run real interest rate (deflator GDP price); _1 - for one lag and _2 - for two lags. Number of observations T(model): 30(A1); 31(A2); 31(A3); 31(A4); 32(A5); 31(A6); 32(A7) and 32(A8).

Source: Authors' computations using R, GRETL, PCGive and data from Personnel Records (*Quadros de Pessoal*), European Commission (2019) and INE (2019) for the period 1986-2017.

**Table 3** The Influence of the Business Cycle over Earnings Inequality (ADL Models), Continued

| DDep. var. C g | A5 | | | A6 | | | A7 | | | A8 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| cconst | --0.6733 | 0(.0335) | **** | --0.2878 | 0(.0759) | **** | 0.0981 | 0(.0271) | **** | --0.5963 | 0(.0316) | **** |
| 1 g_1 | | | | 0.4382 | 0(.0863) | **** | | | | | | |
| EEx | | | | | | | 0.2443 | 0(.0301) | **** | | | |
| EEx_1 | | | | | | | | | | | | |
| EEx_2 | | | | | | | | | | | | |
| llnv | 0.1904 | 0(.0267) | **** | 0.1178 | 0(.0238) | **** | 0.6065 | 0(.1005) | **** | | | |
| llnv_1 | | | | | | | | | | 0.1823 | 0(.0259) | **** |
| llnv_2 | | | | | | | | | | | | |
| GGAP_T | --0.0890 | 0(.0349) | *** | --0.1175 | 0(.0320) | **** | --0.5205 | 0(.1257) | **** | --0.0932 | 0(.0333) | **** |
| GGAP_T_1 | | | | 0.0593 | 0(.0288) | *** | 0.4867 | 0(.1040) | **** | | | |
| GGAP_T_2 | | | | | | | | | | | | |
| DDef | | | | | | | | | | 0.0013 | 0(.0004) | **** |
| DDef_1 | | | | | | | | | | | | |
| DDef_2 | | | | | | | | | | | | |
| ll_REER | 0.1335 | 0(.0300) | **** | 0.0937 | 0(.0211) | **** | | | | 0.1021 | 0(.0287) | **** |
| ll_REER_1 | 0.0693 | 0(.0272) | *** | | | | | | | 0.0854 | 0(.0260) | **** |
| SSRIR_R | | | | | | | | | | | | |
| LLRIR_R | | | | | | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| SSER | 0.0037 | | 0.0025 | 0.0107 | | 0.0035 | |
| AAR2 | 0.9694 | | 0.9820 | 0.7381 | | 0.9726 | |
| BBIC | -256.24 | | -270.41 | -187.52 | | -257.44 | |
| LLMF | 3.4563 | * | 0.2779 | 9.7557 | *** | 0.0983 | |

Notes: *BIC* is the Schwarz's Bayesian Information Criterion for model specification in terms of the number of parameters - a smaller BIC corresponds to a better model specification; *LMF* is the Lagrange Multiplier *F*-test, an autocorrelation test of order one under the null of no autocorrelation; *AR2* is the adjusted R squared; *SER* is the standard error of the regression; (***), (**), (*) denotes significance levels at 1%, 5% and 10%, respectively, with standard errors in parenthesis; *CV* is the generalized entropy inequality measure, with the alpha parameter equal to two; *GAP_T* is the output gap; *Ex* is the exports ratio (volume); *Inv* is the investment ratio; *I_REER* is the logarithm of the real effective exchange rate; *Def* is the general government deficit ratio; SRIR_R is the short-run real interest rate (deflator GDP price); *LRIR_R* is the long-run real interest rate (deflator GDP price); _1 - for one lag and _2 - for two lags. Number of observations T(model): 30(A1); 31(A2); 31(A3); 31(A4); 32(A5); 31(A6); 32(A7) and 32(A8).

Source: Authors' computations using R, GRETL, PCGive and data from Personnel Records (*Quadros de Pessoal*), European Commission (2019) and INE (2019) for the period 1986-2017.

**Table 4** Model A6: OLS, Using Observations 1987-2009 (*T* = 22)

| | Coefficient | Std. error | ***t***-ratio | ***p***-value | |
|---|---|---|---|---|---|
| const | −0.2821 | (0.0909) | −3.105 | 0.0064 | *** |
| Inv | 0.1144 | (0.0503) | 2.274 | 0.0362 | ** |
| GAP_T | −0.1033 | (0.0435) | −2.378 | 0.0294 | ** |
| GAP_T_1 | 0.0637 | (0.0362) | 1.757 | 0.0970 | * |
| I_REER | 0.0922 | (0.0250) | 3.702 | 0.0018 | *** |
| g_1 | 0.4453 | (0.1061) | 4.198 | 0.0006 | *** |
| Mean dependent var. | | 0.290255 | S.D. dependent var. | 0.021293 | |
| Sum squared residuals | | 0.000120 | SER | 0.002661 | |
| AR2 | | 0.984387 | | | |
| F(5, 17) | | 278.4246 | ***p***-value(***F***) | 1.11e-15 | |
| Log-likelihood | | 107.2129 | | | |
| B | | −195.6128 | | | |
| rho | | −0.321091 | | | |

Notes: *, **, *** indicate that the coefficients are statistically significant at the 10%, 5% and 1% levels, respectively; *rho* is the coefficient of the auto-regressive residuals. See also the notes to Table 3.

Source: Authors' computations using R, GRETL, PCGive and data from Personnel Records (*Quadros de Pessoal*), European Commission (2019) and INE (2019) for the period 1986-2017.

**Table 5** Model A3: OLS, Using Observations 1987-2009 (*T* = 21)

| | Coefficient | Std. error | ***t***-ratio | ***p***-value | |
|---|---|---|---|---|---|
| const | −1.2851 | (0.0858) | −14.98 | < 0.0001 | *** |
| Ex_2 | −0.1539 | (0.0425) | −3.617 | 0.0023 | *** |
| GAP_T | −0.1736 | (0.0605) | −2.871 | 0.0111 | ** |
| Def | 0.00148 | (0.00067) | 2.223 | 0.0410 | ** |
| Def_2 | 0.00264 | (0.00073) | 3.623 | 0.0023 | *** |
| I_REER | 0.1527 | (0.0427) | 3.573 | 0.0025 | *** |
| I_REER_1 | 0.1864 | (0.0461) | 4.044 | 0.0009 | *** |
| Mean dependent var. | 0.201901 | | S.D. dependent var. | 0.034186 | |
| Sum squared resid. | 0.000342 | | SER | 0.004622 | |
| AR2 | 0.981722 | | | | |
| F(6, 16) | 197.9420 | | ***p***-value(***F***) | 4.28e-14 | |
| Log-likelihood | 95.20856 | | | | |
| BIC | −168.4687 | | | | |
| rho | −0.190039 | | | | |

Notes: *, **, *** indicate that the coefficients are statistically significant at the 10%, 5% and 1% levels, respectively; *rho* is the coefficient of the auto-regressive residuals. See also the notes to Table 3.

Source: Authors' computations using R, GRETL, PCGive and data from Personnel Records (*Quadros de Pessoal*), European Commission (2019) and INE (2019) for the period 1986-2017.