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"Policy Uncertainty induced by Pension Reforms "

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Declaration of Authorship

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FIRMA DEL CANDIDATO

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Introduction

In the last two decades, reforms on social security have been a key issue of the policy debate in Italy and all around the world. For all developed economies, social protection represents the biggest fraction of the public expenditure and, in particular, Italy has the highest percentage of pensions expenditure on GDP in Europe and among all OECD countries (16,3 % according to OECD, 2015). Moreover, only 20 % of the Italian workers have private coverage thanks to occupational and personal pension schemes, hence for most of the individuals public pension represents the unique source of income during the last part of the life-cycle (Bottazzi et al., 2006).

This huge financial burden, together with the inadequacy of pension benefits to population aging and growing elderly needs, were the main reasons that implied a sequence of frequent pension reforms and overhauls across several EU countries. Moreover, also the political pressure and the technical advice of the European institutions have had a role in spreading the implementation of these structural measures.
To this extent, Italy represents a really interesting case study since its social security system has been often discussed and modified from the moment was first introduced until recent periods. At the end of the 80s, the main issues affecting the Italian pension system were the long-term fiscal unsustainability, due to really generous methods of benefits computation, and the unfairness of treatment across different individual categories. As a consequence, starting from the beginning of 90s, seven main reforms aimed at changing the pension legislation plus other smaller measures were carried out: Amato Reform in 1992; Dini Reform in 1995; Prodi Reform in 1997; Maroni Reform in 2004; Damiano Reform in 2007; Fornero Reform in 2011 and the Stability Law in 2016.

Since most of the pension reforms implemented have affected potential work horizon (by changing the minimum retirement age) and future expected retirement income (by adopting different pension scheme), part of the economic literature has focus its attention in estimating the impact of these measures on individual behaviours and welfare. The bulk of this papers has studied the effect of changes in pension rules on employment outcomes, health behaviours and private wealth accumulation assuming pension reforms to be *exogenous* with respect to individual responses. However, recent researches have demonstrated that usually individual reactions to pension reforms are far to be perfectly rational and may be motivated by reasons different from the classical consumption smoothing theory. In particular, individual expectations about future policy changes (*policy uncertainty*) play a key role, therefore the assumption of exogeneity is not actually standing. Since policy uncertainty has remarkable impact on individual welfare, to correctly estimate the effect of pension reforms on individual behaviors becomes crucial to measure the level of pension-related policy uncertainty perceived by economic agents and to understand how the latter is affected by the introduction of pension reforms.

In this dissertation, we focus our analysis on the initial part of the process. We first build an index for pension-related policy uncertainty in Italy using Google Trends data about pension related queries. Afterwards, we measure how this particular level of policy uncertainty is affected by the introduction of the main 2000s pension reforms estimating an ARCH(1) model with dummy variables. Our results suggest that all the reforms considered had a remarkable impact on the level of perceived uncertainty. In particular, considering only the ones already implemented, measures increasing the individual potential work horizon leads to increase in the perceived level of uncertainty and vice versa. Some insights are eventually provided about the possibility that too many reforms implemented in a small time interval may lead to higher confusion among individuals regardless of the type of changes introduced.

In Chapter 1 we provide a narrative analysis of pension reforms in Italy, comparing the Italian situation with the rest of the OECD countries. Chapter 2 examines the major contributions in the literature concerning the impact of pension reforms on individual behaviours and policy uncertainty. Chapter 3 is dedicated to our empirical analysis.

Chapter 1

Pension Reforms in Italy: a Narrative Analysis

Starting from the beginning of 90s, and more intensively from 2000, the European Union has deeply encouraged governments of the member countries to design and develop new social security plans able to counter the demographic pressure and enhance fiscal sustainability, always maintaining an adequate level of retirement income. The main "guidelines" provided were referred to: the increase in statutory and early average retirement age, in order to adapt the length of the post-retirement period to the increasing life expectancy; the intensification of pension eligibility conditions, encouraging the permanence in the labour-force, in order to dampen the impact of population ageing on the dependency ratios; the adoption of systemic reforms in order to leave the old generous schemes in favor of more equal computation methods, able to provide similar treatment across different working categories and to reduce the perspective amount of unfunded pension liabilities[1]; the introduction of automatic indexation mechanisms linking pension benefits to key macroeconomic variables (e.g,. inflation, wage level) so as to protect their values from general unexpected exogenous shocks in the economy.

As a consequence, most of the EU governments started carrying out an increasing number of pension reforms aimed to improve financial stability, by modifying rules and parameters. As a future perspective, last available Eurostat estimates suggest that public pensions expenditure is projected to be close to 12.9% of GDP over the long run (2060) on average in EU 27. Figure 1.1 reports the time series of the number of pensions reform implemented in the EU from 1990 to 2014[2] : measures adopted to improve the retirement rules clearly show a growing path over time, with peaks after the financial crisis and during the sovereign debt crisis.

[1]The financial imbalance connected to pension expenses is valued using the concept of "unfunded pension liabilities", given by the difference between the present value of future pension benefits - that the government is committed to pay - and the present value of future payroll taxes (Bosi, 2015). Indeed, new rules introduced in the pension system don't have an immediate impact on present public debt but rather on future government cash flows.

[2]Most updated available elaboration. Even if it does not involve the last 4 years it anyway gives a good idea of how the trend moved over time.

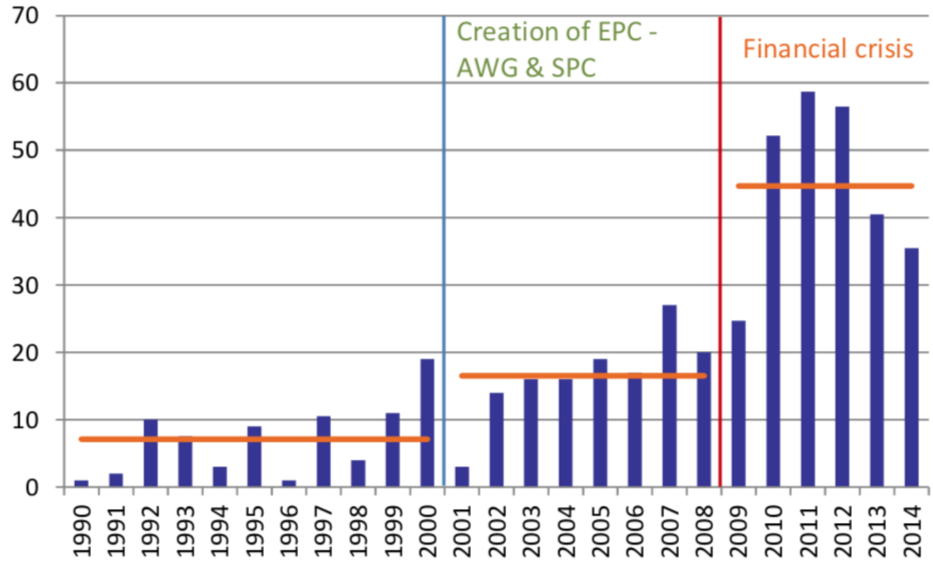

Figure 1.1: Number of Pensions Reforms implemented in EU countries in the period 1990-2014
Source: European Commission (2015)

However, reforms included a wide range of measure that affected social security systems of different countries in different ways according to specific needs. In order to have an idea of the specific configuration of the reforms, Figure 1.2 provides the decomposition of the main pension measures in EU over the early 2000s, depending on the particular intervention adopted (e.g., systemic reforms, changes in pension formula, new eligibility rules). Data show how the main changes carried out were referred to eligibility conditions – so as to increase retirement age coherently with demographic evolution – and to pensions formula for the benefits computations. Indeed, over last years all EU countries, except for Luxembourg, have increased both the statutory and early retirement age and countries as Italy, Sweden and Greece implemented systemic reforms gradually moving to NDC system.

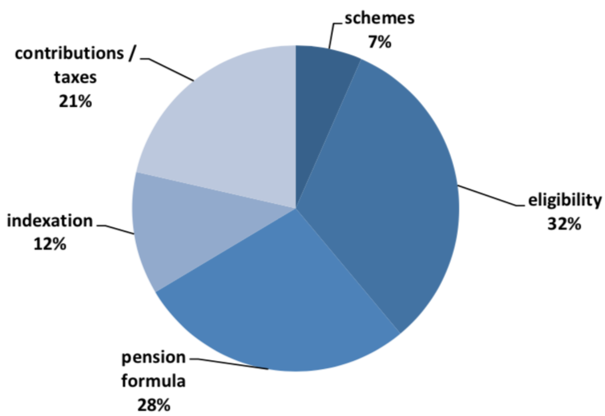

Figure 1.2: Decomposition of Pensions Expenditures by destination among EU Countries
Source: European Commission (2015)

1.1 Why is Italy an interesting case study?

Even if, as argued, the general path among EU countries seems to be homogenous, Italy has always been a particular case study to analyse regarding pension reforms. Indeed, Italian data about pension expenditure, population ageing and number of social security reform carried out are clearly far from the EU average, and also looking a little further to the main OECD countries there are not significant differences.

As already mentioned, Italy's percentage of pensions expenditure on GDP in 2015 was 16.3 %, the highest in Europe and among all OECD countries (see Figure 1.3). Furthermore, Italy has even one of the biggest percentages of overall public spending on GDP among OECD countries (50.2 % in 2015). It follows that about 32% of the total Italian public expenditure are allocated to retirement provision.

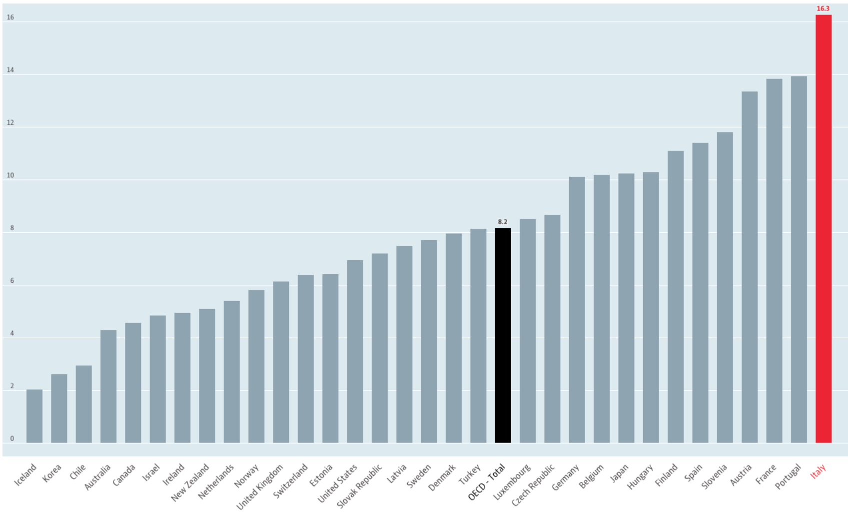

Figure 1.3: Pension Expenditure on GDP (%) among OECD countries in 2015
Source: https://data.oecd.org/socialexp/pension-spending.htm4

Moreover, the Italian demographic old-age dependency ratio in 2015 was about 37.8 %, well above the OECD average (27.9%) and the second highest among all OECD countries after Japan (46.2%), and projections at this regard are quite pessimistic, with a future expected dependency ratio of 72.4% in Italy in 2050 (53.2% on OECD average). However, even if projections on the average OECD ratio are strictly increasing, according to data, countries should converge to similar values in the next 50 years, dampening the huge heterogeneity we experience nowadays. The main factors that drive this ratio are, trivially, life expectancy and fertility rate[3].
Life expectancy nowadays is characterized by an increasing trend among all OECD countries which is expected to continue in the medium term. Surely it is a measure which expresses the level of well-being of a specific country. However, it may have some negative consequences in term of intergenerational financial imbalances and PAYG system is a clear example. Therefore,

[3]Of course, even migration has a key role in defining the dependency ratio, but for the sake of simplicity we will skip the analysis of migration data in this work, since they would require a separated and deeper elaboration.

more than the standard life expectancy measure it is useful to analyse the life expectancy at 65 years old, which represents a reasonable measure of the expected retiring period length for the representative pensioner in a particular country. Even at this point, Italy has a quite high value, 22.4 for women in period 2015-2020, about one year above the OECD average, and expected to reach about 25.4 in the period 2060-2065 (see Figure 1.4) .

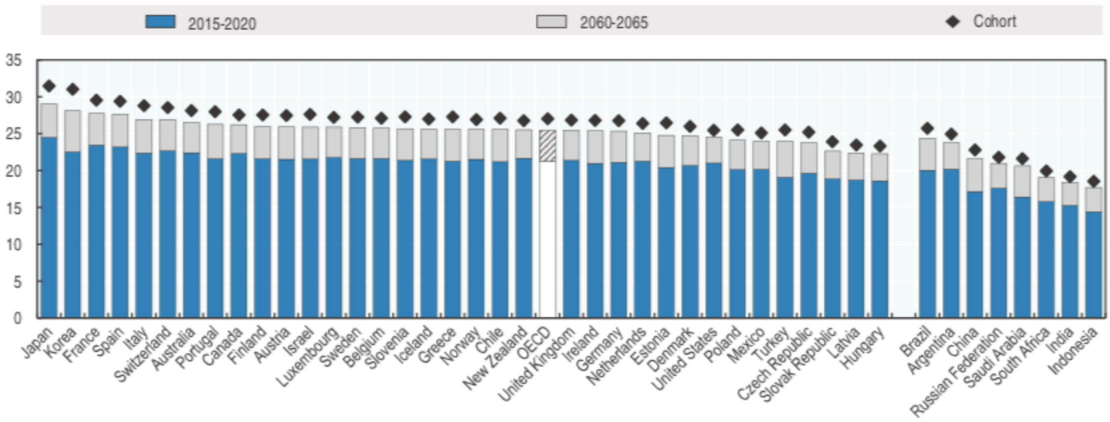

Figure 1.4: Life Expectancy at 65 in the main OECD countries
Source: OECD (2017)

Fertility rate[4] was on average among OECD countries 1.7 in 2015, well below the value necessary to maintain population replacement (constant number of individuals), estimated in developed countries at 2.1. Even in this measure, Italy is further below the average with a value of 1.49 but an expected increase to 1.64 in 2060. The impact of fertility rate on retirement scheme is quite important, because it contributes to population ageing dynamics which have to be considered when policy makers design pension rules.

Concerning proper retirement, data are available about current and future expected retirement age, gross/net replacement rate, percentage of private/public schemes and pension wealth. Generally, in the computation of current and expected future retirement age, the entry age in the labour market is normalized to 20, so as to make possible intertemporal comparison.
Figure 1.5 shows current and future expected retirement age in 2016 for the main OECD countries, with a specific remark for Italy. On OECD basis, the average retirement age in 2016 was 64.3 years old for men and 63.7 for women across all countries and all different pension schemes. Italy is located significantly above the mean, with values of 66.6 and 65.6 (for men and women respectively) in 2016, which are expected to grow to 67 and 66.6 in 2019 and to reach 71.2 for both gender starting from generations born in 1996. The latter it will be one of the highest thresholds among OECD countries and, together with Denmark and The Netherlands, it will be the unique value higher than 70. A retirement age above the standard further emphasises the particularity of the current Italian situation in pensions concerns with respect other countries.

[4] It is defined as the potential number of children who would be born to each woman if she was to pass through the childbearing years bearing children according to a current schedule of age-specific fertility rates.

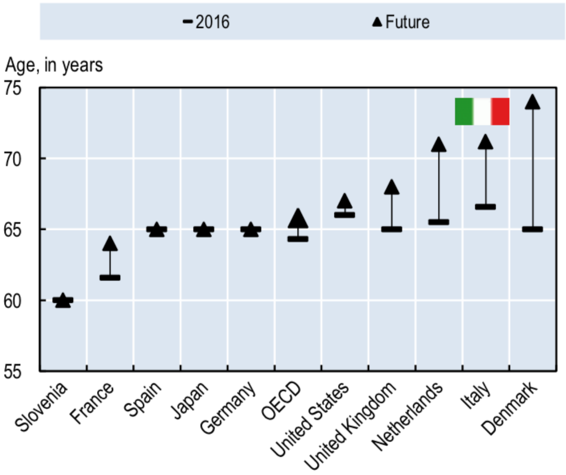

Figure 1.5: Current and Future Expected Retirement Age in 2016 in the main OECD countries
Source: OECD (2016)

Looking at the replacement rates, net rates (that is excluding personal taxes, income taxes and payroll contributions) are more significant from the individuals' point of view, since they reflects the comparison between their future disposable income in retirement and their labour income, while gross replacement rates are more useful from a policy maker prospective. For our purposes, will focus on net ones since their values provide a good measure of how much the pension system is generous in terms of benefits. The average net replacement rate from mandatory pension schemes among OECD countries was 63% in 2017 and expresses the fraction of the last individual labour income represented by the first public pensions earned. Italy presented in 2017, and will present in future, net replacement rates well above the mean, on average around 100% with significant differences across different cohorts. Future rates under NDC will be around 93% and workers with short and discontinuous careers will experience higher risk of poverty in the last part of the life-cycle. Generally speaking, replacement rates will continue to be pretty high for individuals with long tenure. Figure 1.6 reports net replacement rates in Italy and in the main OECD countries: only Netherlands in this group presents a higher value.

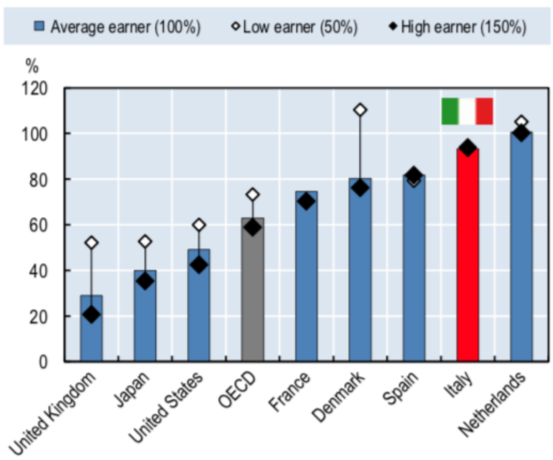

Figure 1.6: Current and Expected Future Net Replacement Rates in the main OECD countries
Source: OECD (2017)

Other two statistics provide support regarding the Italian situation:

- the percentage of average income of people older than 65 with respect the average income of all the population, which in Italy is almost 100 %, still 12 % above the OECD average (see Figure 1.7);

- the effective exit age from the labour market, whose value in Italy is pretty low with respect to the OECD average (62.1 years old for man and 61.3 years old for women), that in turns is reflected in longer retirement periods and higher financial burden (see Figure 1.8).

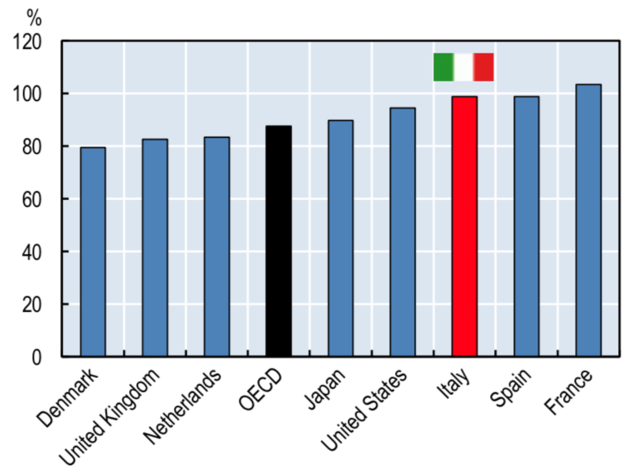

Figure 1.7: Average Income of people older than 65 on Average Income of all the population in the main OECD countries
Source: OECD (2017)

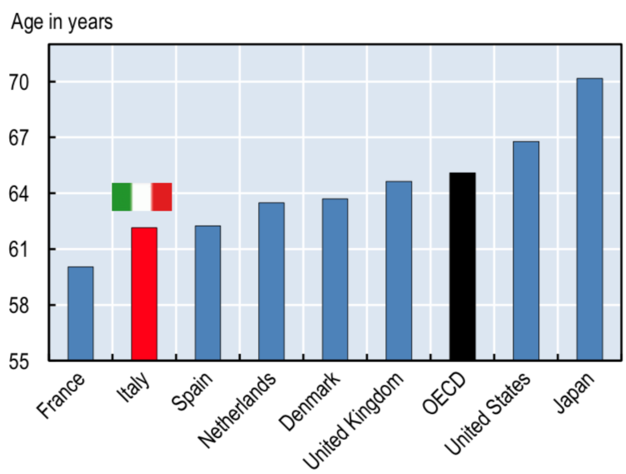

Figure 1.8: Effective Exit Age from the labour market in the main OECD countries
Source: OECD (2017)

Furthermore, even the participation rate to private pension schemes is a key variable to analyse in order to evaluate how interesting public pensions provision is in Italy, more than in other countries. In fact, in Italy does not exist any mandatory private pension plans, and the percentage of people covered by occupational and personal private plans was only 20% in 2016, well below the OECD average whose value in 2016 was 40%. On one hand, the low percentage of people who enter in private and voluntary schemes may increase the responsibility and the level of investment of the governments in term of old-age income provision for workers. However, on the other hand, such a strong public involvement in pensions provision may crowd out private saving accumulation by workers, discouraging them from getting access to private alternative schemes.

1.2 Pensions in Italy: a General Overview

The Italian pension system may be dived in three main pillars: one mandatory pillar and two voluntary pillars. The first pillar represents the compulsory old-age insurance (including insurance for survivors and disability benefits) which works according to the unfunded pay-as-you-go scheme since 1952. In a PAYG system, workers must pay compulsory contributions during the life-cycle in the form of pay-roll taxes and these are, in turn, used to finance pensions of the individuals that are retired at that time. As a consequence, this mechanism creates a strong intertemporal redistribution between generations and makes the system really prone to financial unsustainability and increasing public debt, under certain conditions[5] (ECB, 2018). The first pillar, then, provides a different eligibility treatment between public employees, private employees and self-employed.

The other two discretionary pillars refer, instead, to private and founded schemes that may be adopted both individually or collectively, like pension funds and private annuities. However, since pension reforms object of our analysis did not bring about any significant changes at this regard, during all the rest of the work we are not going to provide too much details about it.

The general objectives of all the Italian pension reforms, even if pursued through different measures, were to affect and modify the rules of the first pillar. Specifically, pension reforms were carried out in order to: increase the average retirement age introducing more severe eligibility requirements, given the growing life expectancy and the lower fertility rate that Italy has experienced; reduce the bounty of the system, in order to counter the increase in pension liabilities and enhance the long-term financial stability of the country, reducing the replacement rates. The latter is a key measure in order to assess the effectiveness and the generosity of a pension system. It is defined as the ratio between the last employee's pre-retirement working income and the amount of public pension he receives (or he will receive - in this case we refer to expected replacement rate) and is generally expressed as a percentage. In other words, the replacement rate indicates which fraction of labour earnings is guaranteed to an individual during his old-age in the form of retirement income.

[5]The main empirical measure regarding temporal instability is the age dependency ratio, computed as the rate of the dependents – individuals younger than 15 years and older than 64 years old – on the working population.

A key feature of public pension planes is the degree of certainty of benefits provision. In this respect, two classical schemes have been adopted in Italy: a Defined Benefits scheme (DB) and a Notional Defined Contribution scheme (NDC), which use different benefits computation methods. The DB is a pension scheme according to which the level of retirement income is precisely known from the beginning of the pension plan. Pensions benefits are calculated taking into account the average income earned by the individual during a specific number years spent in the labour market (e.g. the last 5 years). This "pensionable income" is then multiplied by an accrual factor which represents the rate of return of the years contributed. We will call this model *earnings model*. The earning-based formula in the DB scheme is:

$$P_{NB} = \sigma N \overline{w}_n \tag{1.1}$$

where σ represents the accrual rate, N indicates the number of years contributed and $\overline{w}_R$ is the average salary in the last n years of working life.
The NDC, instead, is a different pension scheme according to which the exact amount of social security contributions is known from the beginning of the pension plan while there is a degree of uncertainty concerning the level of future benefits. NDC provides a different methods of benefits calculation whereby pension is not proportional to worker's pensionable earnings, but it is rather dependent on the amount and numbers of years of contributions he has paid during his permanence in the labour market. Specifically, in order to obtain pension benefits, career contributions are capitalized at a factor given by the 5-years moving average growth rate of nominal GDP. The latter result is, in turn, multiplied by an "annuitization factor", which is an actuarially fair transformation coefficient positively correlated with retirement age[6].
The contributions-based formula in the NDC scheme is:

$$P_{NDC} = \mu\tau \sum_{t=0}^{N-1} Y_t (1+g)^{N-1-t} \tag{1.2}$$

where μ is the annuitization factor, τ is the contribution rate applied to earnings Y_t and g represents the GDP growth rate as described above.

Generally speaking, from a policy maker point of view, changes in (expected) retirement age are mainly caused by the introduction of new eligibility rules in the system while variations in the (expected) replacement rates are mostly connected to decisions about which pension scheme to use for benefits computations.
Concerning variations in the replacement rates, even if in the first instance may seem reasonable to conclude that DB scheme are characterized by higher replacement rates with respect to NDC, this is not always true. Looking at the formulas, indeed, if n in (1.1) is fixed such that earnings from the entire working carrier are considered, potentially there may always be values of the

[6]For a detailed description of the model see Guiso et al. (2013).

policy parameters (σ, μ and τ) leading the two schemes to provide exactly the same pension benefits.

In the following section, we will briefly go over the history of the Italian pension system illustrating the main changes introduced by the pension reforms carried out and their consequences.

1.3 History of the Italian Pension System up to 1992

The first old-age insurance plan in Italy was created in the second half of the nineteenth century in favor of the military force. Only in 1989, instead, a voluntary pension scheme was first introduced for private-sector blue collar workers and was made compulsory later in 1919. This new pensions plan was managed by the Factory Workers National Insurance Fund for Invalidity and Ageing (CNAS), renamed National Institute for Social Security (INPS) only in 1933, and was a fully funded scheme, financed by a payroll tax. Benefits were computed in proportion to paid contributions and with rules that were roughly in favor of workers with short contributions record and smaller earnings (Franco, 2002). Initially, the system provided old-age and disability benefits. Starting from 1939 then, unemployment insurance, tuberculosis benefits, widow pensions and family grants were established and in 1942 even survivor's benefits were introduced.

As time passes, the number of pensions financed started to increase and the funded scheme began being unable to sustain the financial burden of the benefits provision. After the II World War financial instability increased even more due to the effect of raising inflation and the necessity to use pension fund assets to support government finances. Given the situation, Italy shifted by need to a pay-as-you-go system (PAYGO) through a transitional period which came to end only in 1952 with the introduction of the new rules that also included the establishment of a guaranteed minimum level of pension.
In the following years, the system remained relatively stable until 1956, when seniority pension (namely a pension that can be claimed by individuals at any age conditional on having a certain minimum contributory period) were introduced for public employees with the number of minimum years contributed fixed at 35 years. Subsequently, during 1960s, small but key new measures were carried out in order to extend public pension coverage to self-employed, work-disable citizens and low-income elderly individuals. In 1965 the possibility to get a seniority pension after 35 years of contributions was extended to private employees as well.

Concerning the private sector, further important changes were introduced in 1969. Benefits computation shifted from the contributions-based formula to an earnings-based formula, becoming a "final salary" type referred to the average of the last five years of employment[7] (Brugiavini, 1987). Moreover, an income maintenance-scheme in favor of individuals who were more than 65 years old but not covered by old-age pensions was established (the Italian "pen-

[7]This measure represented the first actions toward guaranteeing pensioners the same standard of living they had during their working-life.

sione sociale"). Finally, social security benefits started to be automatically linked to a price grow index (this measure came into force only from 1971).

Over the 1970s, innovations added to the system were less radical than before and were mostly relative to the indexation mechanism. These measures were aimed at trying to make inflation protection less unequal among individuals, since the past decade of high inflation had had heterogeneous impacts on purchasing power across different pensioners' classes. Concerning eligibility rules, seniority pensions became much easier to get for public men employees, since their minimum mandatory number of years of contributions was decreased at 20 years.

All the innovations above described laid the foundations for the prospective increase in pension liabilities which characterized the subsequent years and led the government to make, in the 1980s, the first steps toward the rationalization of the pension rules. Regarding the minimum pension level, a mean test was introduced in order to assess if individuals qualified for the minimum assistance. Eligibility conditions for disability pension, instead, were restricted shifting the criteria from "loss of earning capacity" to "work disability" (Franco, 2002).
As a result, at the end of the 80s the Italian pension system was characterized by:

- a really generous mechanism of benefits computation: DB scheme that took into account the last 5 years spent in the labour market and an accrual factor of 2% for each year of contributions up to a maximum of 80%, so as to obtain a redistribution effect (Belloni et al., 2015)[8]

- quite soft eligibility rules to get retired: it was necessary to have accrued 35/20 years of contributions for private/public employees independently on the age (seniority pension) or to have reached 55/60 years old conditional on having paid at least 15 years of social contributions (old-age pension) for women/men respectively.

Furthermore, payroll taxes were shared between employer and employee such that the former contributed for two-third and the latter for one-third of the total amount and it did not exist any form of penalty for early retirement or any actuarial correction for age at retirement (Aben, 2011). Inside this landscape, the government started to be worried about the long-term financial sustainability of the system, since expenditure for social protection showed an increasing path and many workers were taking advantage of the opportunity to leave pretty early the labour market.

1.4 Amato Reform (1992)

Given this climate of weakness, and also due to the financial pressure caused by the exchange rate crisis that was hitting the country (with Italy leaving the European Monetary System

[8] The accrual factor is used in order to make earnings homogeneous w.r.t. inflation fluctuations. Intuitively, the maximum is 80% since it would be applied to an individual with 40 years of paid contributions

through the last large lira devaluation), the first important pension reform was implemented under the Amato's government in 1992[9].

At that time, the ratio of pensions expenditures over GDP had reached the 12,4 % (mainly due to the demographic trend and the generosity of the system) and a structural measure was necessary to mitigate the impact of pensions outlays on public finances and to update the social security system to the new demographic characteristics of the country. Working in the direction of the common goals above described, and being part of a larger fiscal package, the Amato Reform introduced new restrictive pension eligibility requirements while preserving the same mechanism of benefits calculation.
In details, the minimum age to become eligible for old-age pensions was increased progressively by one year of age every two years, starting from 1994, in order to reach 60/65 years old for women/men in 2000. The minimum years of contribution required was also increased by one year every two until reaching 20 years in 2001. However, the eligibility requirements for seniority pensions remain unchanged (35/20 years of contributions for private/public employees). Concerning benefits calculation, the earnings model's methodology was preserved, but the number of years considered to compute pensionable earnings was gradually increased in order to reach, in a few years, the entire individuals' working-life[10].

Moreover, another strong characteristic introduced by the reform was the indexation of pensions amount to prices, differently from what was done until that moment, when pensions were indexed to salaries. In this way, the automatic adjustment of pensions amount started to be related only to the percentage variation in the cost of living, expressed as the average value of the annual CPI (Consumer Price Index), as computed by ISTAT. In other words, pensions began being dynamically adapted to inflation movements over time. This system is generally called pension equalization (the Italian "perequazione") and its main goal is to protect and preserve pensioners purchasing power.
Finally, even the amount of compulsory payroll taxes was increased from 24,5% to 27,17% of gross earnings.

Generally speaking, from the main calculations performed before and after the reform, pension liabilities seemed to be reduced thanks to the new eligibility rules. However, given the structural characteristics of the reform, the burden of this reduction was mainly borne by the younger cohorts.

[9]D. Lgs. 503/92
[10]Annual earnings lower than the 20% of the mean could be excluded from the pensionable earnings up to one fifth of the total amount.

1.5 Dini Reform (1995)

Despite the Amato reform was realized with the right attitude, changes proposed were not enough to invert the increasing trend in public expenditures Italy was experiencing. Indeed, the ratio of pension expenditure over GDP was still around 13% in 1995 a new and stronger reform in the pension system was carried out under Dini's government[11].
The Dini Reform has been one of the most significant structural changes in social security schemes during the Italian history. Through its implementation, the Italian pension system started an important transitional phase from the earning model computation of pension benefits to the contributions model, creating an automatic mechanism aimed to accelerate the convergence process in the treatment across different cohorts. Old-age pension system gained flexibility, since now retirement was possible from 57 to 65 years old subject to individual decision and conditional on having at least 5 years of seniority[12] and the new scheme for benefits contributions (NDC) used a transformation coefficient positively correlated with retirement age (e.g., in 2010 the range was such that the coefficient was equal to 4.90% for a pensioner retiring at 57 and 6.36% for one retiring at 65).

However, as we said, this modification in benefits computation was not immediate and it opened a transitional period of time (that it was suppose to go until 2032) in which workers were divided in three cohorts with different treatments depending on the number of years contributed at the end of 1995. Specifically:

- DB was still completely applied for all workers with at least 18 years of contributions at the end of 1995. It follows that these individuals were not affected at all by the reform
- NDC was completely applied only for those workers that were still not entered in the labour market at the end of 1995, therefore they are totally affected by the reform
- For all the other workers, with a number of years contributed between 0 and 18 at the end of 1995, a pro-rata approach was adopted: benefits were computed through the earnings model concerning contributions paid before 1996 and with the contributions model otherwise. In practice, pension benefits were given by the average of the amount computed with DB and the amount computed with NDC, weighted for the years spent under the two regimes (Borella and Moscarola, 2006). In formula:

$$P_{prorata} = \frac{P_{DB}N_{DB} + P_{NDC}N_{NDC}}{N} \tag{1.3}$$

  where $N_{DB} + N_{NDC} = N$, which is the total number of years of contributions.

It is clear as such a change in computation had (and it is having) a negative impact on replacement rates of those categories of workers that have been affected by the reform.

[11] L. 335/95

[12] However, in order to obtain old-age pension before 65, accrued contributions must be higher than 1.2 times the minimum allowance.

Concerning these modifications, two main aspects are fundamental to point up. First, one of the reasons underlying these changes was the government's objective of shifting the risk associated to pensions (as in a standard insurance contract) from the SS system to individuals. Indeed, knowing how the NDC mechanism works, people should be more aware about their responsibilities in terms of intertemporal saving decisions and behave accordingly. Second, Dini reform clearly shows how Italian reforms in the 90's had embodied a "grandfathering approach", providing more protection for older cohorts to the detriment of younger ones (Belloni et al., 2015).

The reform also affected eligibility conditions in the transitional phase, for both seniority pensions and old-age pensions, by introducing new and stricter requirements to get retired regardless on the reference cohort. A form of early retirement was now possible, starting from 1996, at 52 years old conditional on having accumulated 35 years of contributions, and these limits were gradually increased in order to reach 57 years old and 35 years of contributions in 2002 for public and private employees and 58 years old and 35 years of contributions for self-employed. Furthermore, the threshold to obtain seniority pension was legislated so as to increase gradually from 36 to 40 years of contributions in 2008.
Old-age pensions, instead, was always possible to get at 65/60 years old respectively for men and women conditional on having paid 20 years of contributions.
Eventually, the amount of compulsory payroll taxes was increased from 27,7% to 32,7% of gross earnings.

1.6 Prodi Reform (1997)

Although Dini Reform provided a strong structural change in the system, its effects were expected to be perceptible only in medium-long term, according to the transitional phase just described. Therefore, introduced changes were insufficient to obtain an immediate stabilization of the ratio of pensions expenditure over GDP, whose value had increase to 13.7 % in 1997. The subsequent measure promoted by Prodi government[13] tried to accelerate this public saving process in the short-run.

The main reason that pushed the policy maker to adding new eligibility limits was the opportunity and the will expressed by the government of being part of the new European Monetary Union as one of the first members, that required specific financial criteria. In practice, the reform, while preserving the same contributions-based formula, acted on different levels introducing:

- further and tighter conditions regarding the access to seniority pensions, rising then the expected retirement age
- a gradual increase in contributions rate for self-employed individuals up to 19%

[13] L. 449/97

- a series of measures aimed at harmonising public and private pensions system by making treatments increasingly similar

1.7 Smaller Measures Pre-Maroni Reform (2000-2003)

In the following period up until 2004, the government intervened on social security with some minor actions. The measures carried out were mostly aimed at: incentivating retirement postponenment, even if without success; increasing minimum pensions; giving workers whose pensions were computed under NDC or pro-rata mechanism the possibility to cumulate their pensions with labour income, if and only if they had decided to retire over 58 years old and with at least 37 years of accrued contributions. The latter intervention, given the government's objective of striving workers to remain in the labour market after achieved the minimum eligiblity requirements, had an ambiguous effect. On one hand, it is possible that some workers may have decided to continue working until reaching more than 58 years old with 37 years of contributions. On the other hand, though, such a possibility may have displaced other additional incentives to postpone retirement above that specific threshold, affecting labour market participation in the opposite direction (Marano, 2006).

Furthermore, the policy maker introduced some specific thresholds inside the process of pensions equalization to inflation ("perequazione")[14]. Specifically, starting from the 1st January 2001, only pensions whose amount was at maximum 3 times the minimum treatment were adjusted at 100% of their value. Pension brackets between 3 times and 5 times the minimum treatment were adjusted only at 90% of their value and pensions higher than 5 times the minimum treatment were adjusted only at 75%.

1.8 Maroni Reform (2004)

The first pensions reform of the 2000s took place in 2004 thanks to the work of Welfare Minister Roberto Maroni[15].

The reasons behind the decision of changing some rules of the pensions system were pretty similar to the ones that had encouraged all the overhauls which characterized the 90s. However, the particularity of Maroni new pension rules was the introduction of a "sharp discontinuity" in the eligibility requirements for early retirement (Bertoni et al., 2018), aimed to accelerate and anticipate the transitional phase opened by the Dini Reform in 1995. For the first time, in fact, the increase in the age lower bound to get access to early retirement was not applied as a linear and gradual modification but involved a big jump for a particular group of individuals. This measure, became famous as the so called "*scalone*", increased minimum age necessary

[14] L. 388/2000
[15] L. 243/04

to obtain early retirement from 57 to 60 years old for public/private employees and from 58 to 61 years old for self-employed, and was applied for all those individuals retiring from January 2008 onwards. Requirements on years of contributions, instead, remained constant at 35 years. As a consequence, people that had planned to retire in 2008 (according to previous rules) experienced a theoretical increase in the residual work horizon of three years, being compelled either to work until 2011 or to wait without any source of labour income until they could get retired. Such a measure should have leaded, according to government forecast, a peak of 0.8% of public savings up until 2015 (Marano, 2006). Seniority pensions, instead, was always possible to get after 40 years of contributions regardless the individual's age.

The reform also tried to stimulate, again, retirement postponement, after the first attempts during late 90s which had little success. In order to give workers the incentive to remain in the labour market, the government introduced a super "bonus" for all those private employees that, even respecting all the requirements necessary to obtain seniority pensions/early retirement, decided to continue working. Those workers could ask an exemption from pensions contribution (with deadline fixed in December 2007) and benefit, therefore, of savings deriving from the payroll taxes they did not have to pay. Of course, tough, the amount of pension benefits remained "frozen" in this period of zero contributions and the right to claim retirement was preserved, independently of possible future changes in eligibility rules. However, since the final goal of retirement postponement was to contain the financial burden of pensions, the net effect of the bonus was ambiguous: on one hand, there was a positive effect on outlays (decrease in cost) due to those people who, considered the possibility to obtain the bonus, decided not to retire; on the other hand, there was a negative effect on outlays (in terms of less revenue in form of contributions) because there was a group of people who decided to apply for the bonus even if they would not have retired anyway. As a result, the foreseen savings by the government from this operation amounted "only" to 70 million per year in 2015-2017 (Marano 2006).

Eventually, the reform introduced new rules inside the framework of private pension schemes, considered by the government a necessary instrument to develop especially for younger cohorts. Indeed, the reform introduced the possibility for private employees to allocate their severance pays (the Italian TFR) to complementary occupational schemes (e.g. pension funds) instead of cumulating them so as to obtain financial coverage at the end of their working relation, as usual[16].

1.9 Damiano Reform (2009)

Nobody actually had the possibility to retire under the conditions introduced by Maroni reform. The "*scalone*", considered to be too abrupt as an economic policy, has been in fact overcame by the implementation of a new social security reform in 2007 under II Prodi's government, which

[16] L. 296/2006

introduced different and more forgiving eligibility rules. In particular, the strong 3-year jump was substituted with a gradual increase in retirement age - year-by-year or "*scalini*"- aimed to obtain the same results than before but with a better redistribution along time (the 3-years increase would have been reached in 2013).

The 2007 Reform was born in the context of a larger public measure called Welfare Protocol, which was aimed at introducing even some modifications in the arduous labour discipline, defining the amount of resources which would have allowed arduous workers to get retired three years early, and established the applications of new annuitization factors to the contributions model computation, starting from 2010[17]. Through the so called Damiano Reform[18], the change in the eligibility requirements mentioned inside the Welfare Protocol was applied by the introduction of the "quotas system". Basically, the access to early retirement started to be subordinated to the achievement of a certain threshold, given by the sum of the individual's age and the seniority contributions he has accrued, rather than to accumulated years of contributions (35 years) with respect to a minimum age (57/58). In details, starting from January 2009, in order to access to early retirement:

- public and private employees had to reach a quota of 95 with a minimum age of 59 years old (e.g., 59 years old and 36 years of contributions or 60 years old and 35 years of contributions)

- self-employed had to reach a quota of 96 with a minimum age of 60 years old (e.g., 60 years old and 36 years of contributions or 61 years old and 35 years of contributions)

with a planned increase in the quota of one year every two years, so as to reach quota 96/97 in 2011, respectively for public-private/self-employed. Moreover, the minimum age to be eligible for old-age pension was modified to:

- 65/60 (men/women) conditional on having paid 20 years of contributions, for those cohorts that were completely subject to DB or PR scheme

- 65/60 (man/women) conditional on having paid 5 years of contributions, for those cohorts that were subject to NDC scheme

however, the possibility to get retired after 40 years of contributions regardless the age was still in place (seniority pension).

Concerning annuitization factors, the reform restated the transformation coefficients used in the calculation of NDC pension benefits (which were in force since 2010), establishing that they must be updated every three years depending on demographic tables and long-term trend

[17]The Welfare Protocol should have been converted in law during the same year and, specifically, its execution was undertaken in December thanks to the work of the Labour Minister Damiano and the Economics and Finance Minister Padoa-Schioppa.

[18]L.247/07

of GDP according to ISTAT measures (Borella and Moscarola, 2015). Eventually, it's clear as the 2007 reform detached from the others due to its "expansive" nature, being aimed to partially cushion the rules introduced by the Maroni reform. Indeed, the related financial burden has been estimated to be around 10 billion over the following decade (Aben, 2011).

In the following years and before 2011, a remarkable measure in the context of public pensions was the introduction of the so called “floating window” (the Italian “finestra mobile”)[19]. It consists in a certain period of time (variable according to working categories) that must pass from the moment in which an individual reaches all the conditions required to claim his retirement status and the day in which he actually receives his first pension income. Initially, the length of the window was set to 12 months for private/public employees and to 18 months for self-employed.

1.10 Fornero Reform (2011)

The last major reform of the pensions system was carried out in 2011 under Monti's government, in the context of the “Decreto Salva Italia”, thanks to the work of the Labour and Social Policies Minister Elsa Fornero. At that time, after the great recession had hit the world economy starting from the 2008 financial crisis, a new threat for public debt was looming in the Euro area. The European Sovereign Debt Crisis started taking place in several European member states (Italy, Spain, Portugal, Greece and Cypro) and, as a response, the Italian government had announced its intention to embody an austerity approach that would have led public finance to save around 20 billion euros over subsequent years.

Through the Fornero Reform[20], Italian policy makers intervened on several grounds in order to obtain a considerable short-term impact on economic growth, inequalities and public finance consolidation. Clearly, social security was one of the most discussed themes, considering the possibility to reduce and better redistribute pensions expenses – already decreased throughout past measures but still above the target value.
Concerning pensions, the main objectives of this measure were roughly in line with past reforms, being aimed at reducing pensions' financial burden by decreasing expected retirement age and replacement rates. Specifically, Fornero Reform further tightened the eligibility requirements, always pursuing the uniformity treatment for different working categories, and contributed to anticipate the transitional phase opened by the Dini reform in the 90s. In practice, the manoeuvre acted on different levels that it is worth to analyse separately.
Early retirement, which was still possible by the Damiano "quota system" introduced in 2007, was abolished. Therefore, starting from 2012 it became possible to obtain the right to claim a pension only according to the two standard channels of old-age and seniority pensions. The latter remained always possible to get without any limits on individual's age, but with the mini-

[19]D.L. 78/10 converted into L.122/10
[20]D.L. 201/11 converted into L.214/11

mum mandatory number of years of contributions raised to 42 years and 1 month for men and 41 years and 1 month for women (and projected to rise up to 46 years for both categories in 2050). The legal requirement to become eligible for old-age pensions, instead, was increased by one year for those cohorts subject to DB and PR pension schemes and by 5 years for cohorts subject to NDC[21]. Moreover, requirements related to old-age pensions were set so as to become exactly equal for men and women starting from 2018 (66 years and 6 months).
Both old-age and seniority requirements remained linked to whatever possible increase in life expectancy, and the reform established that the systematic adjustment of eligibility conditions to this value must be carried out every two years, instead of every three, starting from 2019.

Concerning benefit computation, the Fornero Reform represents an important turning point in the convergence process of benefits treatment among different cohorts, since the pro-rata scheme introduced by Dini Reform (described in 1.3) was extended to all the individuals retiring from 2012 onwards. Indeed, NDC scheme started being applied to everybody regardless of the cohort of belonging but relatively only to seniority accumulated starting from 2012. Hence, even individuals that should have fall completely under the DB scheme will receive an amount of pension benefits computed as a hybrid between the two methods, if they retire after 2011. All individuals who, instead, respected the eligibility conditions required by previous rules until 2011, preserved the right to claim their pensions according to DB computation, but the reform established a penalty for those of them retiring before 62 years old, in order to stimulate retirement postponing[22]. As a consequence, the reform reduced of several years the transitional phase that will lead our system to be made up only by individuals whose pensions is totally computed with NDC scheme.

The reform also decreased the floating window for self-employed individuals from 18 months to 12 months, equating them to private and public workers at this regard. From the main features described so far, it's clear that, together with the financial stability, one of the main goals of the reform was the harmonization of the benefits treatment and of the eligibility conditions of different workers, according to gender, categories and cohorts, in order to eliminate the discriminations created by previous rules.
As major findings, Borella and Moscarola (2011) figured out that the main consequences of the Fornero Reform were an increase in average retirement age – rising over time – together with a sizeable increase in replacement rates with heterogenous effects among gender (being women more affected than men due to the convergence process).

Another point of the reform was actually source of discussion and critics during recent years. Regarding pensions equalization to inflation, in fact, the decree sanctioned the block of indexa-

[21] Individuals belonging to NDC had actually the possibility of a particular early retirement. They could retire at 63 - if check was at least 2.8 times the social allowance - or at 66 - if check was at least 1.5 times the social allowance - with a minimum seniority of 20 years of contributions.

[22] Specifically, the pension amount is decreased by 1.1% yearly if retirement age is between 60 and 62 years old and by 2% yearly if retirement age is lower than 60 years old.

tion to price level (that is an adjustment of 0%) for all those pensions whose amount was higher than 3 times the minimum treatment. Instead, all the other pensions were adjusted completely to inflation in 2012 and 2013 (100%). At this regard, a new intervention took place 2 years later through the law n.147/2013, which established, starting from 2014, 5 different tranches of pension income subjected to different percentage of inflation adjustment, with a minimum of 45% for those pensions being worth more than 6 times the minimum.
As end of the legal disputes generated by the reform concerning this theme, the Constitutional Court declared unconstitutional the biennial block (2012/2013) to inflation indexation for the highest pensions[23]. As response, a new measure provided a partial revaluation with retroactive effect for all those pensions between 3 and 6 times the minimum treatment[24].
Eventually, the 2016 stability law[25] extended the effects of the law n. 147/2013 until 31st December 2018.
Table 1.1 schematically outlines the evolution in eligibility rules, benefits computation, pensionable earnings and payroll taxes we have narratively presented over this chapter. The contribution of each reform is specified.

1.11 Quota 100 (2018-2019)

The possibility of a new intervention in the pension legislation has been at the center of the policy debate characterizing the last election campaign in Italy. One of the two political parties reaching a coalition agreement (in May 2018) promoted the so called Quota 100 reform, which has been accepted in the 2019 Budget Law in November as one of the measures envisaged for the current year. Even if the reform has been claimed as a solution to the too strict eligibility requirements introduced by the Fornero Reform, its technical features are still not totally clear[26].

From the best of our knowledge, through the implementation of the Quota 100 measure the eligibility requirements provided for the Fornero reform will not be eliminated. The new reform will rather introduce an alternative early retirement option available in the moment in which workers reach a *quota* (similarly to the one introduced by Damiano in 2007) equal to 100, conditional to being at least 62 years old (e.g., 62 years old and 38 years of contributions; 63 years old and 37 years of contribution). As a consequence, unlike to previous reform, Quota 100 will probably have a negative impact on the average retirement age and a positive effect on pension liabilities. Moreover, if the early retirement option is kept, no penalties on benefits amount computation are provided and the DB scheme will continue to be applied to workers with at least 18 years of contributions in 1995 up to 2011. However, the reform should work, as an experiment, until December 2021.

[23] Judgement of the Costitutional Court n.70/15
[24] L.D. n. 65/2015
[25] L. 208/15
[26] The proposal entered into force with the D.L. n. 4/2019 and started its journey in the Parliament aimed at the conversion into law. Therefore, the reforms may be still subject to potential modifications.

Table 1.1: Evolution of pension reforms over the last two decades
Source: Our own elaboration

	Pensionable Earnings	Seniority Pension	Old-age Pension	Benefits Computation	Payroll Taxes
Pre-1992	Average of the last 5 real labour earnings indexed to price level (DB)	M/W (Public): 20 years of contributions M/W (Private): 35 years of contributions	M: 60 years old with 15 years of contributions W: 55 years old with 15 years of contributions	not possible	24.5% of gross earnings
Amato (1992)	Average of all the real labour earnings indexed to price level plus 1% (DB)	M/W (Public): 20 years of contributions M/W (Private): 35 years of contributions	M: 65 years old with 20 years of contributions W: 60 years old with 20 years of contributions	not possible	27.17 of gross earnings
Dini (1995)	Carreer contributions capitalized at a 5-year moving average grwoth rate of nominal GDP (NDC)	36 years of contributions for all (Legislated so as to reach 40 years of contribution in 2002)	Same as previous reform but with flexibility:from 57 to 65 years old conditional on having paid 5 years of contributions	52 years old with 35 years of contributions (legislated so as to reach 57/58 years old with 35 years of contribtuions in 2002 for public-private employees/self employed)	32.7% of groos earnings
Prodi (1997)	No changes w.r.t. previous reform	37 years of contributions for all (Legislated so as to reach 40 years of contribution in 2002)	M: 65 years old with 20 years of contributions W: 60 years old with 20 years of contributions	53 years old with 35 years of contributions (legislated so as to reach 57/58 years old with 35 years of contribtuions in 2002 for public-private employees/self employed)	32.7% of gross earnings
Maroni (2004)	No changes w.r.t. previous reform	40 years of contributions	M: 65 years old with 20 years of contributions W: 60 years old with 20 years of contributions	60/61 years old with 35 years of contribtuions for public-private employees/self employed	32.7% of gross earnings
Damiano (2009)	No changes w.r.t. previous reform	40 years of contributions	M/W: 65/60 years old with 20 years of contributions if DB or PR scheme M/W: 65/60 years old with 5 years of contributions if NDC scheme	Public/private: quota 95 with a minimum 59 years old Self-employed: quota 96with a minimum of 60 years old	32.7% of gross earnings
Fornero (2011)	No changes w.r.t. previous reform	M: 42 years of contributions W: 41 years of contributions (legislated so as to reach 46 years for both in 2050)	M/W: 66/61 years old with 20 years of contributions if DB or PR scheme M/W: from 63 to 70 years old years old with specif thresholds on years of contributions and benefits value if NDC scheme	abolished	32.7% of gross earnings

Chapter 2

Literature Review

Our dissertation is related to the literature concerning the impact of pension reforms on individual behaviors and welfare. Several studies, both in the past and recently, tried to generate quasi-experimental frameworks exploiting the exogeneity created by pensions reforms in order to disentangle the causal effect of the introduction of new rules in pension legislation on specific individual comportments. The identification of these impacts turns out to be fundamental in the policy design process, since governments should always take into account each potential significant response of the individuals when they analyse the consequences of a specific reform in a costs-benefits scenario.

The bulk of this literature has provided empirical evidences conditionally to the assumption of exogeneity of the treatment (i.e., the pension reform) with respect to individual behavioral responses (e.g., saving, labour supply). However, in recent periods, a number of researches highlighted that there are misalignments between the classical theoretical model of rational agents and the real-world individual reactions to these policy measures. For instance, even if according to the standard life-cycle hypothesis changes in expected pension wealth (due to the introduction of new rules) should completely be offset by an increase in private wealth accumulation, existing microeconomic evidences point out that pension wealth crowds out discretionary wealth at a rate significantly less than one-for-one.
Among the possible explanations for these irrational individual responses, future policy changes plays a key role. In our analysis, precisely, we take the approach followed by a series of papers which consider subjective expectations about future pension reforms fundamental in order to understand individual's decisions and the related level of policy uncertainty a good motivation in explaining misalignments with the rational theory. Clearly, under these conditions the assumption of exogeneity of pension reforms with respect to individual behaviors doesn't hold, and it becomes crucial to estimate how future policy changes affect perceived policy uncertainty and which is, in turn, its impact on individual decisions.

Therefore, our work is also closely related to the research area analysing individual's expectations about future retirement outcomes[1] and the degree of accuracy of these subjective assessments, which directly depends on the quality of the informations agents collect. In this respect, one of the most important empirical measure used in the literature is the distribution of the individual expectation errors, from whose statistic properties and movements over time important insights can be capture about perceived policy uncertainty.

In the following sections we will provide and discuss the main results consolidated in the literature, distinguish between researches assuming exogeneity in the pension reforms and studies which, instead, shall take into account also the impact of expectations and policy uncertainty on individual decisions.

2.1 The Impact of Pension Reforms on Individual Behaviors

Papers assuming exogeneity in pension reforms with respect to individual behaviors measure the impact of reforms on different outcomes. Generally speaking, authors tested the effect of pension reforms on[2]:

- Employment outcomes
- Health and health-promoting behaviors
- Private wealth accumulation

From a methodological point of view, most of these papers try to exploit pension reforms to clearly identify two groups of individuals: those affected by the reform and those whose conditions remain constant despite the introduced changes. Former are used as treated and latter are used as controls. Degree of difference in individual characteristics plays then a key role in defining the identification strategy implemented.

2.1.1 Employment Outcomes

As argued, pension reforms implemented in recent years were aimed at enhancing fiscal sustainability. They were realized, among others, through the raise in statutory and early retirement age, which clearly caused an increase of individual work horizons to adequate the length of working carriers to the rapid population aging. Indeed, even if geared towards saving public resources, this kind of maneuvers has always been structured as measures encouraging the permanence of workers in labour market near retirement, avoiding them to claim pension benefits

[1]With retirement outcomes we always refer to retirement age and replacement rate, which directly contribute to define the level of expected pension wealth.

[2]Of course, the three macro themes presented are not comprehensive and other areas have been investigated. For instance, a small literature explored the effect of pension reforms on worker's training participation, finding that postponing retirement and reducing pension benefits significantly increase older worker's participation in training courses, especially in large organizations (see Basanini et al., 2005; Montizaan et al., 2009; and Brunello and Comi, 2013).

as soon as possible. As a consequence, plenty of studies tried to isolate and understand the impact of pension reforms on the main employment outcomes, such as labour supply, employment rate and participation rate. However, the literature provides mixed evidence.

Same of the first papers investigating the effect of social security reforms on employment outcomes analyse the impact of the increase in Normal Retirement Age (NRA) implemented by the U.S. Congress in 1983 on labour force participation.
Fields and Mitchell (1984) use U.S. pre-reform data about earnings, private pensions and Social Security profiles in order to simulate the effect of an increase in NRA on labour supply (they also consider a decrease in early retirement benefits, a delaying in the cost-living adjustment and an increase in late retirement benefits). The simulation is implemented through behavioral parameters estimated using a ordered logit model and the largest potential response is not observed for the increase in NRA, which is anyway positive, but rather for the cut in early retirement benefits.
On the same line, Gustan and Stainmeier (1985) implement a policy simulation using a structural life-cycle retirement model always starting from pre-reform data. They find that an increase of NRA to 67 years old reduces the peak in retirement at age 65 and increases the number of individuals working full-time at age 65-66 in U.S.
Further ex ante calibration papers simulated the effect of an NRA shift on employment outcomes even recently. Fehr et al. (2012) analyse the German Social Security reform increasing NRA by two years, simulating a realistic demographic transition and distinguishing three different groups of workers according to their level of skills and life expectancy. They find that the proposed change in NRA was suppose to delay the effective retirement of almost 1 year.
Moreover, exploiting the same German reform, Etgeton (2018) estimates a dynamic discrete choice model of work, unemployment and retirement taking into account labour market frictions. He measures the behavioral responses in terms of labour supply to an increase in NRA from 65 to 67, finding that the reaction is moderate (small average delay in employment) but old-age income inequality raise due to hetergeneous availability of jobs (poor and low educated are vulnerable groups in this respect).
Ex post evidences about NRA changes are instead relatively scarce. Pingle (2006), using a pooled panels of data from the Survey of Income and Program Participation (SIPP), points out that Social Security's Delayed Retirement Credit affect the labour force causing an increase in labour supply of workers aged over than 65. Song and Manchester (2007), using a difference-in-difference approach with different groups, look at the effect of the gradual increase of NRA in U.S. on the age at which individuals claim pension benefits. They find significant and positive changes (increase in age) but only at ages between 62 and 65.
A further contribution from Mastrobuoni (2009) measures the ex-post effect of the US reform increasing NRA of two months per year starting from 1983. Working with CPS monthly data, he posits that the average retirement age of the affected cohorts increased only about 50 % of the legislated increase in NRA, but this effect is larger adding more controls for labour supply.

Early Retirement Age (ERA) changes have been also source of investigation concerning their potential and realized effect on employment outcomes. In this respect, evidences are controversial. Baker and Benjamin (1999), by making use of the introduction of early retirement provisions in Canada in a difference-in-difference framework, document a positive increase in pension benefits due to higher ERA but a little effect on labour force participation. However, studies about Austrian increase in ERA from 60 to 62 for men (2000 and 2004 pension reforms), using matched administrative and private data, figure out a positive and non-negligible impact on the employment rate among older workers (Staubli and Zweimuller, 2012; Manoli and Weber, 2012). A spill-over effect is also documented due to the potential substitution effect between keep working and get access to insurance unemployment programs and disability programs, even if with mixed results (Røed and Haugen, 2003; Bratberg et. al, 2004).
Furthermore, a number of papers exploit the 2011 Norwegian reform of the early retirement system as exogenous variation in the eligibillity, disentangling its impact on labour market outcomes among elderly people. Findings suggest that an increase in work incentives through pension reforms have considerable positive effects on labour supply and public finances (Hernæs et al., 2016). However, also in this case, disability plays an important role as exit strategy in case of productivity shocks (Vestad, 2013).

From a global perspective, Arpaia et al. (2009) measure the impact of pension reforms implemented in several EU countries on participation rates of different groups of individual according to age, sex and sector of activity. They perform a difference-in-difference analysis taking as controls countries which did not implement any pension reforms in the period considered and classify reforms in three categories depending on the type of changes introduced. Results indicate that reforms affecting the bounty of the system lead to a significant increase in female participation rate near statutory retirement, while they negatively affect men participation rate, especially of individual aged between 50-59.

2.1.2 Health

Substantial research is aimed at exploring the casual effect of pension reforms on health and individual healthy behaviors near retirement. Evaluating the effect of higher retirement age (longer working horizon) on the individual propensity to engage in health-promoting comportments has in fact important policy implications. Indeed, especially in countries where healthcare services are almost entirely public provided, a higher level of health before retirement may imply higher future savings, that should be take into account analysing the effect of pension reforms on public finances.

Specifically, exogenous changes in the work horizon caused by pension reforms has been exploited a lot as indentification strategy in the literature, since previous studies demonstrate that simple cross-sectional analysis suffer too much of reverse causality (Tsai et. al, 2005; Dave et al., 2008). In other words, the direct comparison of the health status of early and later retirees turns out to be rather pointless given that health may affect work and viceversa, therefore controversial conclusions has been reached[3]. Furthermore, other unobserved confounders may contribute in explaining the relationship between health and retirement (omitted variable bias). Given these difficulties, alternative approaches have been undertaken so as to circumvent the esogeneity problem.

A series of papers use instrumental variable estimations exploiting pension reforms as exogenous variation in retirement status. Among them, Bound and Waidmann (2007) use institutional features of the UK pension system in order to understand the direction and the magnitude of every possible direct impact of retirement on health, finding no significant negative evidence (reduction in health due to retirement) and a positive but little effect for men. Coe and Zamarro (2011), working with the SHARE dataset (Survey of Health, Ageing and Retirement in Europe), take the European country-specific early and fully retirement ages as instruments and exploit the discontinuities of retirement behavior among different countries. Results indicate that retirement has a strong physical health-preserving effect but has no impact on mental health or cognitive ability. Moreover, Atalay and Barrett (2014), making use of the Australian 1993 pension reform, choose the eligibility condition as instrument in the regression and point out that retirement has not an adverse effect on health, but rather a significant positive impact on both objective and subjective health measures.
Similar results are obtained for UK also by Johnston and Lee (2009) in a regression discontinuity design approach, indicating that retirement may have positive short-term effect on mental health. Always in UK, non-parametric matching methods is used to disentangle the causal effect of retirement on health, reporting that retiring significantly increases the probability to end up in a chronic condition during the old-age (Behncke, 2009).

Regarding the impact of pension reforms on health-promoting behaviors, literature has provided empirical evidences for the causal effect on individual comportments both after and before retirement.
A number of papers investigate the causal effect of retirement on regular physical activity employing the eligibility age for early and normal retirement as instrumental variables and working with the SHARE dataset. Kämpfen (2013), exploiting discontinuities between social security incentives across different European countries, estimates positive effects (even if not always significant) of retirement on physical activity. Similarly, Eibich (2015), in a fuzzy regression discontinuity design, documents a positive and significant impact of retirement on regular leisure-time physical activity in Germany. Moreover, Celidoni and Rebba (2016) use a fixed effect two-stage last squares showing that, in Europe, the probability of not practicing any physical

[3]Tsai et al. (2005) make a comparison between mortality rate of different groups of individual according to their retirement age. Finding suggests that individuals who retired at 55, and who are still alive at 65, have mortality rate significant higher than the ones retiring at 65. Dave et al. (2008) indicate, instead, that retiring earlier considerably contributes in reducing post-retirement mental-health decline.

activity significantly decreases with retirement, especially in high educated individuals.

Recently, Bertoni et al. (2018), examined for the first time the effect of a pension reform increasing individuals' working horizon on health promoting behaviors before retirement. They exploit the sharp discontinuity caused by the Italian Maroni reform in 2004 to perform a difference-in-difference analysis using data from ISTAT ("Aspetti della vita quotidiana") and SHIW (Survey of Households Income and Wealth). They show that treated individuals (middle-aged men) respond to the increase in their potential work horizon - caused by the reform - raising regular physical exercise and reporting lower level of obesity and higher self-satisfaction with health.

2.1.3 Private Wealth

In all developed economies, especially where mandatory private pension plans are not provided, public pensions benefits represent a large fraction of the individuals' retirement income. Hence, social security reforms may have important consequences on households intertemporal decisions for saving and consumption which have been deeply investigated in the literature.

According to the standard Modigliani life-cycle hypothesis, individuals design their consumption plan by considering all available present and future resources and by accumulating income in high revenues periods and dis-saving during retirement. The key assumption is that agents are forward-looking, and their objective is to keep consumption roughly constant over time, investing or going into debt depending on liquidity constraints at each specific time (consumption smoothing).
Applied to our framework, the standard life-cycle hypothesis claims that exogenous changes in expected pension wealth due to social security reforms should completely offset the accumulation of private wealth. In other words, individuals should be perfectly rational and the introduction of new pension rules amending the retirement age or the amount of future pension benefits (replacement rate) should crowd out discretionary wealth in order to guarantee the same level of consumption during retirement.

Feldstein (1974) analyses this offset process with an "extended life-cycle model" which takes into account retirement age as individual and subjective economic decision. In his work, using time series data about US households, he figures out that the introduction social security reduces personal savings by 30-50%. The key explanation of this results is that retirement and saving decisions are simultaneously made and whatever exogenous variations in retirement affects propensity to save and viceversa. Specifically, he posits that this partial compensation is given by the jointly contribution of two effects: a "substitution effect", since future social security wealth is perceived by individuals as a good substitute for private assets investment - then personal saving decreases; a positive effect, since retirement period's length increases due to the introduction of early retirement options and therefore assets investment needs to be spread over a bigger number of years. Similar results have been reached by Feldstein and Pellechio

(1979) using U.S. microeconomic data. Their evidence confirms the existence of the displacement effect of pension wealth on national savings, even if less than one-for-one, emphasizing that social security plans significantly alter the individuals' life-time budget constraints.
According to these first studies, there are at least three important issues that may explain the lack of perfect replacement in pension wealth after a change in pension rules: (1) the illiquidity of pensions as a form of saving, which may imply discretionary wealth not to decrease in order to face households short-term liquidity problems (Hubbard, 1986); (2) individuals could increase discretionary savings for reasons different from retirement, like bequest motives; (3) short-sightedness, which may lead individuals to accumulate private wealth randomly, without a precise intertemporal plan.

Further researches concentrated their attention at exploring these ambiguities finding mixed results, though. Venti and Wise (1990) analyse the impact of increase in IRA (Individual Retirement Account) contributions in US on different form of savings finding, however, no significant substitutability between them. Dimond and Hausman (1984) indicate a significant offset but lower than the 20% while only Mireaux and King (1984) and Avery et al. (1986) estimate a displacement effect of almost 50-60 %. Moreover, Gale (1998), using data from the Survey of Consumer Finances (SCF), concludes that the direction in the offset found by previous studies was right but its magnitude was understated due to bias in the estimations. In Italy, Attanasio and Brugiavini (2003) exploit the 1992 Amato Reform to compute the impact of the related changes in future social security wealth on private wealth accumulation of the affected cohorts. They find a large but partial displacement effect in the long run. The latter result is confirmed by Attanasio and Rohwedder (2003) analysing the three major U.K. pension reforms with a different identification strategy[4].

2.2 Retirement Outcomes Expectations and Policy Uncertainty

All the researches presented in the previous section were based on the strong assumption of exogeneity of the treatment (i.e., pension reforms or pension wealth variation) with respect to individual responses (i.e., labour supply, health behaviors or private wealth accumulation). However, a number of papers has recently pointed out that individual real-world reaction to pension reforms is not in line with the rational theory and that economic agents may take decisions motivated by reasons other than the standard consumption smoothing assumption.
Specifically, besides the factors described by Feldstein (1974) and Feldstein and Pellechio (1979), also individual expectations about future policy measures (policy uncertainty) has a key role in explaining irrational behaviors in response to changes in pension rules. Under these conditions, though, the assumption of exogeneity of pension reforms with respect to individual behaviors doesn't hold and it becomes crucial to estimate how future policy changes modify the perceived policy uncertainty and which is, in turn, the impact of the latter on individual

[4]Instead of employing a difference-in-difference estimation as most of the previous papers, they use time-series and cross-sectional data to theoretically model the variations expressing individual responses.

decisions. The literature provides in this respect contributions aimed at: assessing the accuracy of individual subjective expectations about retirement outcomes and their level of policy uncertainty (expectation errors); disentangling the effect of pension reforms on individual behaviors considering to what extent the degree and quality of information perceived may play a role.

2.2.1 Individual Expectations of Retirement Outcomes

Barnheim (1989) was one of the first to make a comparison analysis between individual expectations and ex-post realizations of retirement outcomes. Employing data from the Social Security Retirement History Survey (RHS) he evaluates the degree of accuracy of individuals' subjective assessments about retirement timing in U.S. His main findings suggest that retirement age expectations are not significantly bias and reflect the mode of the realized outcomes. Moreover, they vary systematically across subgroups of individuals, since men's expectations are more accurate. From these first results, therefore, individuals appeared to be roughly competent to anticipate social security legislations of the early 70s. A similar investigation was conducted by Disney and Tanner (1999) using two waves of the UK Retirement Survey in order to compare point expectations about retirement age and the following actual realizations. In line to what was found out before, their evidence indicates that individuals tend to report, as expectation, the most likely outcome and for more than one half of the sample expectations are at the end full-filled. However, they identify a really high percentage of people answering "don't know" and show that the propensity to be confused is not random but strictly related to factors expressing the level of uncertainty about future retirement timing.

There are at least two important remarks concerning this kind of analysis. First, asking individuals to report a point expectation starting from a distribution of subjective probabilities may lead to misunderstand their level of rationality. Indeed, expectations reflect, as a result, the mode and not the mean of the outcomes distributions. Second, the high number of "don't know" answer, even assuming that a small fraction of them was due to respondents' laziness, is a clear indication that pension uncertainty about both past and expected future policy measures is very relevant, especially among younger workers.
Concerning social security benefits, Gustman and Steinmeier (2005), employing data from Health and Retirement Study, compare expectations about pension benefits with the ones computed through the use of the employer description of pension plans. They find that individuals are typically misinformed about their future retirement income, since more than one half of their expectations are wrong. Furthermore, this lack of information is significantly higher for those who are more dependent on social security benefits.

As argued, individual expectations about retirement outcomes are the main source to account for in order to empirically measure pension uncertainty. Same of the first papers investigating the level of subjective policy uncertainty used telephone and Internet surveys (Manski, 2004;

Dominitz and Manski 2006; Delavande and Rohwedder, 2008), finding a significant high uncertainty in the answers and large heterogeneity across the sample.
Guiso et al. (2013), using the 2006 Unicredit Customer Survey (UCS), try to measure the pension uncertainty perceived by Italian investors relying on replacement rates expectations. According to their view, pension wealth uncertainty is mainly caused by replacement rate uncertainty, since retirement age is an individual decision within a range of possible values (therefore it is partially under control) and it often coincides with the minimum statutory age. The data employed elicit information about subjective probability distributions of pension benefits[5] that they use to find the distribution of subjective pension wealth uncertainty. Results suggest that pension uncertainty significantly vary across the sample coherently with sociodemographic characteristics and pension rules in place: uncertainty decreases near retirement and is higher for self-employed and professionals. However, the average expected replacement rate is close to the statutory one.
Recently, Baldini et al. (2015) checked the evolution over time of individual expectations about future retirement benefits and retirement age by using data from the Bank of Italy SHIW in the period 2000-2012. They compute what they call "pension errors" (expectation errors) as the absolute value of the difference between the statutory and the subjective expected measures of retirement age and pension benefits. Findings indicate that for 40% of the individuals pension errors is within an interval of $\pm 10\%$ of the statutory value while for the remain 60% "pension errors ranges from $\pm 10\%$ to $\pm 50\%$". Moreover, people clearly show a tendency to become pessimists over time, with an increase in the percentage of those who underestimate the true value from 30.4% to 51,7% in the selected period.

Exploiting survey questions about future policy changes is only one of the strategies developed in the empirical literature aimed at estimating the degree of policy uncertainty. Alternatives rely on: the estimation of the level of uncertainty as residuals of a vector auto-regressive model (Skinner, 1998); the utilization of past reforms variability (McHale, 2001; Shoven and Slavov, 2006; Blake (2008); the construction of uncertainty indexes based on the simultaneous frequency of specific words - e.g., uncertain, policy, economic - inside the main political newspapers' article (Baker et al., 2016); the computation of a "risk premium of the policy uncertainty" by comparing individual expectations of future policies and their valuation about an hypothetical asset that has not policy uncertainty (Luttmer and Samwick, 2018).

2.2.2 The Effects of Uncertainty on Individual Behaviors

Policy uncertainty may have remarkable consequences on individual welfare, especially when the policy at hand is mandatory and characterized by non diversifiable or insurable risks (Luttmer and Samiwick, 2018). Social security has, therefore, the necessary features to be considered a major source of uncertainty, particularly in countries where pensions represent the biggest

[5]This methodology of eliciting expectations is different from the simple point expectations. Specifically, individuals are called upon to state different thresholds for the replacement rate according to subjective probabilities.

source of income for the elderly and retirement benefits are not clearly defined from the beginning of the pension plan. Moreover, since expectations provide a clear representations of people's understanding, part of the literature has considered the degree of perceived policy uncertainty an important determinant in order to assess how individuals react to pensions reforms.

In the analysis of the displacement effect between pension wealth and private wealth, Jappelli (1995) was one of the first to build a measure for social security benefits starting from individual subjective expectations about retirement outcomes. Using two waves of the Bank of Italy SHIW (1989-1991), he find that the changes in pension legislations occurring in the 70s and in the 80s are able to explain about the 20% of the reduction in private wealth accumulation Italy has experienced.
In one of the study closest to ours, Bottazzi et al. (2006) measure the impact of frequent pension reforms in Italy on individuals' point expectations about retirement age and replacement rate. Starting from two specific questions of the SHIW dataset, they compute the individual expectation errors and perform a difference-in-difference analysis exploiting the exogeneity caused by the reform. Their evidence suggests that households have revised their expectations coherently to the new pension rules introduced by the reforms. Finally, they use expectations in order to provide an empirical measure for the individual expected pension wealth and relate the latter to private wealth accumulation. They confirm the existence of a substantial offset, in line with previous papers, but pointing out that the level of policy uncertainty matters (the displacement is significantly higher for more informed individuals). Starting from the latter results, Bottazzi et al. (2010) also investigate the effect of these changes in the Italian Social Security system on the specif households' portfolio composition. Results suggests that the reduction in future pension wealth brought about by the reform is mainly offset by an increase in real estate investment, and that the response is significantly stronger among individuals that better perceived the introduced innovations. In other words, the the degree of accuracy of people expectations about replacement rates has a causal effect on their private investment behavior.

Retirement outcomes expectations can also affect the empirical set-up of the analysis if they serve to identify significant differences between treated and control groups except for the treatment (i.e., the effect of the reform). Indeed, De Grip et al. (2011), analysing the effect of a Dutch pension reform on mental health of workers near retirement, show that individuals affected by the new pension rules report a significantly lower expectations about replacement rates with respect to those who has not been affected.

Effects of policy uncertainty on employment outcomes have also been explored. Giavazzi and McMahon (2012) set a quasi-natural experiment to measure the effect of policy uncertainty on labour supply and saving responses by workers. To do so, they use some of the forward-looking questions from the German Gfk consumer survey as proxy for the uncertainty. In this way, they were able to obtain an exogenous variation in its value and overcome the typical identification problem. Specifically, they monitor the increase in uncertainty in the proximity of particular political events (i.e., elections, reforms) showing as these occurence clearly represents peaks in the distribution. Part of the effect is explained by the so called "war for attrition": uncertainty about future policies is significantly risen by delay in the implementation of public policies due to disagreement between political parties. They then perform a difference-in-difference analysis using fixed effect estimators finding a smaller but significant labour supply reaction among workers.

More recently, Okumura and Usui (2014) conducted a similar analysis using data from the Japanese Study of Ageing and Retirement (JSTAR) survey. Working with the same identification strategy implemented by Bottazzi et al. (2006), they find that pension reforms increasing retirement age from 60 to 65, carried out between 1994 and 2000, had a positive effect on individual expectations about future pension claiming age which was exactly equal to the statutory change. Moreover, the reforms negatively affected subjective expectations about future social security benefits, even if this effect is not statistically significant. Finally, the reported decrease in expectations about pension benefits had also a role in increase individual private savings.
Ciani et al. (2017) investigate, instead, the expectations formation process among ten European countries using six waves of SHARE dataset. They exploit the variation of uncertainty over time linked to specific events to measure how people beliefs change in the proximity of pension reforms. Descriptive statistics suggest that expectations about pension reforms are roughly consistent with macroeconomic developments and are more heterogeneous among younger cohorts (elderly tend to be less uncertain about future changes given their shorter work horizon). Furthermore, they analyse the impact of pension reforms announcements and realizations on expectations formation, pointing out that the pre-reform period (anticipation effect) affects as much as the post-reform period the way in which individuals perceived the introduced changes. Specifically, the longer is the period between the announcement and the realization of a specific reforms, the higher is the level of uncertainty perceived.

Chapter 3

Pension Reforms and Perceived Policy Uncertainty

Starting from the idea that pension reforms may have a remarkable impact on individual expectations, the objectives of our dissertation are basically two. First, we want to provide an empirical measure for pension-related policy uncertainty perceived by individuals. For this purpose, we employ an innovative big data source called Google Trends in order to develop a Pension Uncertainty Index for Italy in the period 2004-2018. Second, we exploit the created proxy to perform a regression model estimated with ARCH errors aimed at disentangling the effect of the introduction of the main Italian pension reforms on pension-related policy uncertainty.

3.1 Pension Uncertainty Index

Google Trends is an innovative on-line instrument, based on the most-used search engine in the world Google, which provides and summarizes data on the frequency of users' web searches about a specific keywords or argument over time. Data are available since 2004 and different filters may be inserted to focus the research on a particular category, geographical area and time-period. Results are always represented graphically and time series data are easily downloadable in csv format to make own elaborations, logging in with a Google account at https://trends.google.it/trends/explore.

Given the rapid increase in the number of people using Google as powerful source of information gathering, recently researchers in different fields (e.g., health, economics, finance) started to exploit the usefulness of Internet search-behavior data in the understanding of social phenomena[1]. In the economic context, the intensity of Google queries has been mainly used in the development of indicators able to improve the forecasting and nowcasting procedure of official economic and financial measures and to describe economic activity. D'Amuri and Marcucci (2017) use the volume of job-related on-line searches as leading indicator in predicting unem-

[1] One of the first work employed Google Trends data in epidemiology, using the share of health-seeking web queries to monitor the level of illness in the population and pinpoint influenza epidemics (Ginsberg et al., 2009).

ployment in U.S. and, similarly, Naccarato et al. (2018) use Google Trends data in time series models in order to forecast Italian youth unemployment rate. In the financial context, Presi et al. (2013) select 98 different terms semantically related to the concept of stock markets to predict trading behavior of financial investors while Bijl et al. (2016) study the relation between Google queries volume and stock returns implementing different portfolio strategies.
Moreover, central banks are also supporting the validity of Google data as alternative source of information complementary to the more standard economic indicators. Contributions come, in particular, from the Bank of England (McLaren and Shanbhorge, 2011) and the Reserve Bank of Australia (Troy et al., 2012).
To the best of our knowledge, there are no past studies using Google Trends to empirically estimate pension-related policy uncertainty.

Technically, Google Trends does not provide any absolute values of the number of researches actually carried out for a specific query or argument. What is reported, instead, is the search share S of a particular keywords k within a certain week w and in a given geographical area g. The latter is computed as the ratio between the number of Google searches containing that specific keyword ($N_{k,w,g}$) over the total number of Google queries undertaken in the same area during the same week ($T_{w,g}$) , i.e.:

$$S_{k,w,g} = \frac{N_{k,w,g}}{T_{w,g}} \tag{3.1}$$

When the length of the set time-period exceeds 5 years, Google Trends provides monthly data, where each observation is trivially given by the simple average of the weekly shares. For the month m we have:

$$S_{k,m,g} = \frac{1}{4}\sum_{w=1}^{4} S_{k,w,g} \tag{3.2}$$

However, even the latter result is not exactly what Google Trends indicates to users. In fact, in order to provide a benchmark and make results comparable, the shares are scaled from 0 to 100, where 100 is assigned to the week/month with the highest share, 50 is assigned to the share equal to one half of the maximum and the rest is rebased accordingly. In formula, the final value of the Google share for the keyword k of a specific month m in the area g will be:

$$GS_{k,m,g} = \frac{100}{max_m(S_{k,m,g})} S_{k,m,g} \tag{3.3}$$

There are two main reasons why Google trends data are appropriate for our final purpose. First, the empirical measure we want to end up with is a index able to measure the level of *perceived* pension-related policy uncertainty. In other words, we are interested in capturing individuals' degree of information about pension reforms already implemented the country, or at least discussed. To this extent, personal web searches are more significant than other data often used to assess the level of general economic uncertainty, like the number of newspaper articles containing particular words (see Baker et al., 2011; Baker et al., 2016; Hardouvelis et al., 2018). For our purpose, in fact, what matters are not the news in them-selves about pension reforms but how these news are interpreted by individuals and which is their following behavioral responses. Second, the increasing spread of web search engines as source of private information gathering allow us to consider Google users a quite significant sample of the Italian population. Indeed, according to ISTAT data, almost 70% of the total Italian households had Internet access in 2016[2] and, looking at the type of activities carried out on-line, collecting information by reading articles and newspapers and consulting a "wiki page" (finding clarification about a specific topic) are the most frequent actions together with reading and sending e-mail. On the basis of the latter data, our main assumption is that individuals searching on Google means they are questioning about pensions, which often represents a clear signal of uncertainty.

However, Google Trends data have of course some limits that are mainly related to the actual aim of each specific research. The incidence of a certain keyword includes all the queries containing that word and may therefore incorporate web searches that are not semantically linked to the phenomenon which is object of the analysis. Moreover, there is no monitoring about who is carrying out the Google research (but only from where) and this may lead to ambiguous results since different individual categories could have searched the same word but for different purposes. However, we try to circumvent these problems by making the keywords always more specific, even accepting a small degree of inaccuracy due to outliers.

3.1.1 Data

Given the innovative source we decided to use, the data collection requires a careful preliminary analysis aimed at selecting the keywords whose trend is then used in the construction of the pension-uncertainty index. Unlike with some of the previous studies building Google indexes[3], we believe that analysing pension-related uncertainty choosing only one generic term would be reductive with respect the variety of the phenomenon. Indeed, pension reforms carried out in Italy introduced modifications in the retirement legislation concerning several aspects (i.e., eligibility rules, benefits computation, pension equalization, pension scheme, payroll taxes), therefore web searches including different terms should anyway be tracked back to pension uncertainty. As a consequence, we use a combination of more pension-related keywords.

We distinguish between generic keywords and reform-specific keywords. Generic keywords are words widely used in almost all the web searches regarding pensions, since they are identifying terms included in multiple queries. We have first drown up a list of queries starting from the term "*pensioni*" (pensions) and looking at the most-typed related queries suggested by Google Trends together with the use of a Google suggest toll called Merlinox[4]. Afterwards, we have pooled the queries in groups containing the same keyword and used the comparison function provided by Google Trends (which allows users to contemporary confront the popu-

[2]The percentage increases to more than 90% if we consider all households containing at least one minor.

[3]Specifically D'Amuri and Marcucci (2017) for three out of four index considered, Naccarato et al. (2018) and Bijl et al. (2016).

[4]Freely available at https://www.suggestmrx.com

larity of two up to five queries) to identify the most popular ones. The full list of queries and an example of comparison are provided in the Appendix A. Finally, we came up with four generic keywords that are:

- *Pensioni* [Pensions] (e.g., Riforma pensioni, Ultime pensioni, Ultime sulle pensioni, Pensioni notizie, Penioni minime, Tassa sulle pensioni)

- *Pensione* [Pension] (e.g., Quando vado in pensione, Differenza tra pensione di anzianita e vecchiaia, Calcolo pensione)

- *Pensionamento* [Retirement] (e.g., Pensionamento anticipato, Età pensionamento, Pensionamento donne)

- *Contributi* [Contributions] (e.g., Contributi inps, Quanti anni di contributi, contributi per pensione)

Reform-specific keywords are, instead, technical terms semantically linked to one particular pension reform undertaken or discussed in the past. They must be considered to completely analyse pension uncertainty volume since their trend is generally characterized by peaks during months around the moment in which the measure is carried out and is nearly zero elsewhere. However, not all of them has been searched enough to become visible on Google Trends[5]. Hence, in this case our collection has been mainly driven by data availability and leads to the following four reform-specific keywords[6]:

- *Scalone* - related to the sharp discontinuity in the eligibility rules introduced by Maroni Reform (2004), but actually more searched on Google around the implementaiton of the Damino reform (2009) that abolished it.

- *Fornero* - the Fornero Reform (2011) was clearly the pension reform most discussed in Italy among the ones of the 2000s, both around its implementation and during the following election campaign.

- *Quota 100* - the new eligibility option pursued as main campaign promise by the political parties entered into the government in 2018 (and still not realized). Its trend is practically non-existent before 2018 but it is nowadays one of the most-searched terms regarding pension among Italian citizens.

- *Indicizzazione* [Indexation] - it is the unique technical keyword which does not show clear peaks, but whose search volume has been always modest over time.

[5]Data are actually available only if the required values are above a certain threshold, which is not clearly specified though.

[6]Other terms have been instead excluded because their related queries were almost entirely linked with one "biggest" keyword. For instance, the word "esodati" shows an interesting trend that becomes almost null if we exclude from the research all the queries including also "quota 100".

Unlike with the papers using newspaper articles, we did not consider terms like "uncertain" or "uncertainty" because in our case they are meaningless: we can reasonably conclude that an individual who is confused about pensions will not type "pension uncertainty" in a web search engine.

Using generic and reform-specific terms allows our research to include, theoretically, users of different educational level. On one hand, low-educated individuals will tend to concentrate their target-searches on basic words or sentences. On the other hand, high-educated users may decide to deeper analyse the phenomenon looking at technicalities. Furthermore, reform-specific terms are often the ones most reported by media and newspapers, so they may trigger confusion and, in turn, wiki searches.

In order to build our Pension Uncertainty Index we use monthly[7] data starting from January 2004 up to December 2018, therefore we work with a total of 180 observations. Since Google Trends volumes are computed on the basis of samples of IPs which vary daily and depending on the IP address, as already done in the literature (D'Amuri and Marcucci, 2017), data have been downloaded in 5 different days from two different IPs. The simple average is then computed to obtain each monthly observation.

3.1.2 Methodology: Construction of the Index

As argued, the majority of the studies employing Google Trends data to build economic indicators have used only the search shares of one particular term, considered to be the most representative of the pheneomenon they wanted to describe. Therefore, since our purpose is to jointly use several keywords, we look at the unique paper employing a combination of more terms, in particular two, which has exploited the "plus" function provided by Google Trends (D'Amuri and Marcucci, 2017). Indeed, on GT it is also possible to retrieve the search shares related to the sum of more different keywords[8] over time, where the additive function indicates that the queries taken into account have to include *at least* on of the term selected.
In formula, the equation (3.1) with two keywords k_a and k_b will be:

$$S_{k_a+k_b,w,g} = \frac{N_{k_a,w,g} + N_{k_b,w,g}}{T_{w,g}} \tag{3.4}$$

which is exactly what Google Trends provides searching for "$k_a + k_b$" (conditional to the 0-100 normalization above explained). However, we do not simply apply the sum function to all our 8 keywords together. We do, instead, proceed as follow:

- we first obtain from Google Trends the sum of the web search shares for all the generic keywords, i.e, "*pensioni* + *pensione* + *pensionamento* + *contributi*" over the period Jan-

[7]The employment of weekly data would have gained in terms of precision due to the higher frequency of the observations but, as argued, if the time-span considered is longer than 5 years, only monthly data are available
[8]The function can be applied up to a maximum of 25 terms.

uary 2004 - December 2018. Let's call these shares $S_{G,m,It}$ and the related final values, according to the equation (3.3), $GS_{G,m,It}$ with $m \in [Jan, 2004; Dec, 2018]$

- we then obtain the web search shares individually for each of the 4 reform-specific keywords (i.e., *"Scalone","Fornero","Quota 100"* and *"Indicizzazione"*). For the sake of simplicity we call these shares $S_{1,m,It}; S_{2,m,It}; S_{3,m,It}; S_{4,m,It}$ and the related final values, according to the equation (3.3), $GS_{1,m,It}; GS_{2,m,It}; GS_{3,m,It}; GS_{4,m,It}$ with $m \in [Jan, 2004; Dec, 2018]$.

- we finally compute the values of our Pension Uncertainty Index as the simple average between these five terms, as following:

$$PU_t = \frac{1}{5}(GS_{G,m,It} + GS_{1,m,It} + GS_{2,m,It} + GS_{3,m,It} + GS_{4,m,It}) \tag{3.5}$$

It is fundamental to specify that, in order not to include one research two times, from the search shares of reform-specific keywords we have excluded the generic terms via the "minus" function of Google Trends (which works similarly to the "plus" one illustrated above). Moreover, from the searches shares of the keyword "*indicizzazione*" have also excluded the researches containing the term "*outlook*" because they represent an important fraction of the total searches but are not semantically liked to pension reforms[9].
The decision to separate specific keywords shares from the generic ones is key. Given that what Google Trends reports is not the absolute number of researches but a trend which is scaled depending on the number and type of worlds included, pooling together specific words and generic ones would have lead our index to lose part of the variability due the former. In fact, even if it is true that generic terms are typically more searched than the technical ones, the total sum on Google Trends of our eight terms would almost not consider their contribution. A graphical representation is provided in the Appendix A to clearer explain our choice.

The Pension Uncertainty Index as computed in the equation (3.5) is actually still not efficient for statistical analysis because Google Trends data suffer of a particular form of seasonality during the last months of the year. Indeed, in November and December the total number of Google searches (which is our denominator in all the equations above presented) are significantly higher due to Christmas holidays, causing therefore systematic troughs in the index values. In order to eliminate this problem, we seasonally adjust the series by assuming an additive functional form and by using the moving average procedure to get rid of the seasonal component. The algebra behind the seasonal adjustment is presented in the Appendix B.

3.1.3 Statistical Properties and Stationarity

Once seasonally adjusted, the times series of our Pension Uncertainty Index is the one represented in Figure 3.1. It does not show a clear trend but different peaks are present at specific

[9]The objective is to avoid to take into account meaningless data.

points in time close to the reform introductions (2004, 2007, 2011, 2016). However, working with the index in order to understand if the introduction of pension reforms have had a remarkable impact on its behaviour requires a preliminary analysis of its statistical properties. Specifically, the possibility of unit roots that may compromise the stationarity of the series has to be tested so as to eliminate it, whether present, by applying specific transformations.

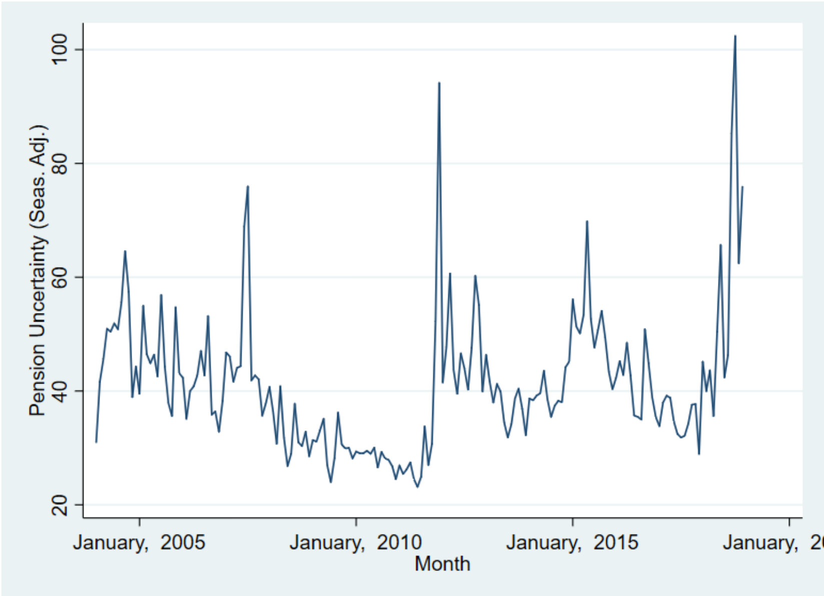

Figure 3.1: Line Plot of the Seasonally Adjusted Pension Uncertainty Index
Source : Our own elaboration

The definition of weakly stationarity relies on the time-independence of the first two moments and may be formally detected by performing several econometric tests. However, to a first approximation, insights about stationarity may be also captured from the autocorrelogram and the partial autocorrelogram of the time series (see Figure 3.2 and Figure 3.3 respectively).
The autocorrelogram graphically reports the autocorrelation function, that is the correlations between the time series and its own lags. The partial autocorrelogram, instead, reports the partial autocorrelation function, that is the correlations between the time series and its own lags computed taking into account all the shorter lags. From this first informal investigation, the series appears to be not weakly stationary and weakly dependent. In our case, the nonstationarity of the Pension Uncertainty Index is shown both by the autocorralation function, which exhibits a slow and decay pattern, and by the partial autocorrelation function, which presents a significant first order partial autocorrelation while the others are not high enough. Moreover, even if the series has not a clear trend, from the line plot we can easily conclude that it does not fluctuate around a constant mean due to structural breaks, which is another clear signal of potential non-stationarity.

Even if the informal analysis conducted exploiting the basic characteristics of our index suggests that it behaves as a non-stationary time series, we need to formally check if this is true by using some standard unite root tests. In particular, we perform the Augmented Dickey-Fuller test, the Augmented Dickey-Fuller GLS test and the Zivot-Andrews test: the first is a standard unit root test that must be applied in case of serially correlated errors (as in our case); the second is a modified version of the first which actually transforms the series via Generalized Least Square (GLS) before the test is performed[10]; the latter is instead a particular unit root test that check for non-stationarity of the series by allowing for possible structural breaks in the trend, in the intercept or in both.

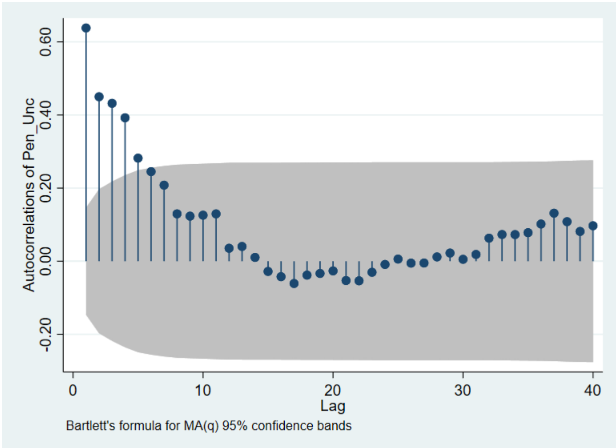

Figure 3.2: Sample Autocorrelation Function of the Seasonally Adjusted Pension Uncertainty Index
Source : Our own elaboration

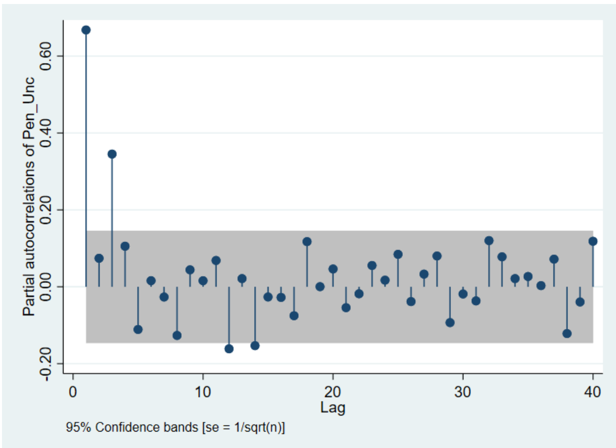

Figure 3.3: Sample Partial Autocorrelation Function of the Seasonally Adjusted Pension Uncertainty Index
Source : Our own elaboration

The results of the three unit root tests we performed are reported in Table 3.1 3.2 and 3.3. together with the critical values for the standard significance levels. Looking at the Augmented Dickey-Fuller Test, for three out of four functional specifications assumed, we fail to reject the null hypothesis that a unit root exists (only in the model with drift we reject the null hypothesis at 5%). Concerning the Augmented Dickey-Fuller GLS test, the optimal number of lags to in-

[10]Elliott, Rothenberg and Stock (1992) demonstrate that in this case the asymptotic distribution of the statistic is the same, but the test is more powerful in discriminate between a real unit root and others that are close but not exactly equal to one.

clude in the test regression has been computed with the Schwert Criterion[11] and is actually equal to 13. Here for the sake of simplicity we present only the statistics for the first 4 lags, however the Appendix C reports all the STATA outputs relative to the stationarity analysis conducted. Also in this case, for twelve out of thirteen lags we fail to reject the null hypothesis that a unit root exists (only for the first lag we reject the null hypothesis at 1%). Finally, even allowing for potential structural breaks in the intercept, in the trend or in both we always fail to reject the null hypothesis of nonstationarity. Indeed, the Zivot-Andrews test statistics are always lower than the 10% critical value in all three specifications.

Table 3.1: Augmented Dickey-Fuller Test for the Seasonally Adjusted Pension Uncertainty Index
Source: Our own elaboration

Test	Test Statistic	1% Critical Value	5% Critical value	10% Critical value
ADF	-2.191	-3.488	-2.886	-2.576
ADF with trend	-2.229	-4.018	-3.441	-3.141
ADF with drift	-2.191	–2.351	-1.655	-1.287
ADF w/constant	0.150	-2.591	-1.950	-1.614

Table 3.2: Augmented Dickey-Fuller GLS test for the Seasonal Adjusted Pension Uncertainty Index
Source: Our own elaboration

Test	Test Statistic	1% Critical Value	5% Critical value	10% Critical value
ADF GLS lag 1	-4.734	-3.484	-2.948	-2.659
ADF GLS lag 2	-2.718	-3.484	-2.939	-2.651
ADF GLS lag 3	-2.264	-3.484	-2.930	-2.642
ADF GLS lag 4	-2.516	-3.484	-2.920	-2.633

Table 3.3: Zivot-Andrews test for the Seasonally Adjusted Pension Uncertainty Index
Source: Our own elaboration

Test	Test Statistic	1% Critical Value	5% Critical value	10% Critical value
ZA trend	-3.452	-4.93	-4.42	-4.11
ZA intercept	-3.644	-5.34	-4.80	-4.58
ZA both	-3.802	-5.57	-5.08	-4.82

Given the informal and the formal stationarity analysis conducted, and given the nature of our data, we therefore conclude that our Pension Uncertainty Index is described by a non-stationary process. However, in order to consistently estimate a time series regression model, data should be all drawn from stationary time series. Among the possible strategies aimed at eliminating nonstationarity, one way is to apply a linear transformation to the original series and check how

[11] $maxlags = int[12(\frac{T}{100})^{\frac{1}{4}}]$

the new process behaves. In our case, first differentiating the data leads to the desirable result, hence from now on we are going always to use the first difference of our index, that is:

$$dPU_t = PU_t - PU_{t-1} \tag{3.6}$$

This technique makes us lose one observation (so we know have 179 observations) but on the other hand allows us to work with a stationary process for the Pension Uncertainty Index. The stationarity analysis for the differentiated process, similar to the one conducted for the variable in level form, is presented in the Appendix C.

3.2 Empirical Analysis

As argued, our approach is based on the assumption that individual behavioural responses to pension reforms are far to be perfectly rational. Indeed, subjective expectations about future policy changes plays a key role and, depending on the level of perceived policy uncertainty, individuals may take decisions that are partially motivated by policy risk hedging (Giavazzi and McMahon, 2012). In order to completely analyse how individuals react to changes in pension legislation that affect their future work horizon or retirement income (e.g., in terms of labour supply, healthy behaviour or private wealth accumulation), it becomes therefore fundamental to understand if the introduction of pension reforms has actually a significant impact on the individual degree of information about future policy changes and if this effects may vary according to specific characteristics of the introduced changes.

In our empirical analysis we exploit the index developed in the previous section as proxy for perceived pension-related policy uncertainty in Italy and we estimate the effect of the implementation of the main Italian pension reforms on its level over time. Hence, differently from previous studies, our uncertainty level is a macro index, which does not take into account individuals' expectations errors.

3.2.1 Identification Strategy

The identification strategy we adopt in order to model the introduction of pension reforms in a time series regression analysis makes use of dummy variables.
Applying the procedure invented by Gregory Chow (1960) for the detection of structural breaks when the dates of the hypothesized breaks are known, we create one binary variable for each pension reforms that takes value zero up to the month in which the reform has been carried out and starts to take value one from that specific month onwards. In particular, we take as break dates the months in which the decrees relative to each reform have been published. Using the announcement dates would have been another good strategy since anticipation effect could play a role for some of the reforms. However, it is really difficult to establish with certainty when the implementation of a particular measure has been announced by political parties. We de-

cide therefore to first estimate the model using as break dates the months of the implementation and to perform later a sensibility analysis aimed at understanding whether and how moving the break dates leads to significantly differences in the results.

As additional controls we add two regressors: the monthly Italian gross public debt and the monthly 10 year spread between Italian and German bonds. Most of the reforms, in fact, have been carried out inside more complex fiscal packages of measures aimed at the stabilization of public finances. As a consequence, both variables may be useful in smoothing the effect of the reforms on pension uncertainty from peaks in total Google searches due to more general economic uncertainty. Moreover, being pension expenditures the biggest part of the total public expenses of the country, controlling for movement in public debt allows us to capture the part of pension uncertainty fluctuations which is due to public debt worries, that shifts individuals' interest on different themes.

3.2.2 The model

A time series regression model can be consistently estimated if and only if some specific conditions hold. In particular, with respect to a standard linear regression model, the i.i.d. conditions for the variables is here replaced by the necessary stationarity of the processes from which all data employed are drawn. Moreover, potential cointegration between the regressors needs to be tested if variables are integrated of the same order.

Concerning stationarity, we have already analysed the behaviour of the process describing our Pension Uncertainty Index concluding that, given its non-stationarity, we are going to use his first-difference as dependent variable of the model. However, both the monthly Italian gross public debt and the monthly 10 year spread between Italian and German bonds also behave, like all the typical economic and financial variables, in a non-stationary manner[12]. In order to eliminate the time-dependence of the first moments, even in this case it is sufficient to apply a first difference transformation working with:

$$dPublicDebt_t = PublicDebt_t - PublicDebt_{t-1} \tag{3.7}$$

$$dSpread_t = Spread_t - Spread_{t-1} \tag{3.8}$$

Since for all the three variables described (the dependent and the two regressors) nonstationarity is eliminated by applying a first difference transformation, we conclude they are all integrated

[12] All the stationarity analysis already performed for the Pension Uncertainty Index has been replicated for both the independent variables, STATA output are reported in the Appendix C.

of order one. Formally:

$$\begin{aligned} PU_t &\sim I(1) \\ PublicDebt_t &\sim I(1) \\ Spread_t &\sim I(1) \end{aligned} \tag{3.9}$$

Whenever two or more time series variables have the same order of integration d - higher than zero - a problem of cointegration may arise. Technically, cointegration is a statistical property of a collection of non-stationary time series variables, integrated in the same series sense, whose linear combination is instead integrated of a lower order. Under this condition, the variables may appear to move together really closely in the long-term but only because they have the same stochastic trend in common. If this is the case, we said there is spurius correlation between them and we must take into account cointegration adding a specific term in the model we estimate. To this extent, one of the best strategy is the Stock and Watson DOLS procedure. Fortunately, in our case the three variables in the equation (3.9) do not present any form of cointegration[13], therefore we can easily proceed to estimate the model with the differentiated series.

The final model we estimate is the following:

$$\begin{aligned} dPU_t = \sum_{i=1}^{3} \beta_i dPU_{t-i} + \sum_{i=0}^{2} \gamma_i dPublicDebt_{t-i} + \pi_1 dSpread_t + \alpha_1 Maroni_t + \alpha_2 Damiano_t + \\ + \alpha_3 Fornero_t + \alpha_4 Stabilita'_t + \alpha_5 Quota100_t + \mu_t \end{aligned} \tag{3.10}$$

Given that the autocorrelogram of the differentiated Pension Uncertainty Index shows a significant autoregressive part, we also insert in the model 3 lags of the dependent variable. The number of lags to insert has been computed using the BIC criterion, according to which the optimal number is the ρ minimizing the function:

$$BIC(\rho) = \ln \frac{SSR(\rho)}{T} + (\rho + 1) \frac{\ln T}{T} \tag{3.11}$$

Concerning lags of the regressors, instead, we use the F-statistic approach starting with a model including three lags of both Public Debt and Spread and performing hypothesis testing on the larger ones so as to understand which one was the optimal order. Finally, we include no lags of the differentiated Spread while we include 2 lags of the differentiated Public Debt, according to their statistical significance.

[13]The brief analysis aimed at checking for cointegration is presented in the Appendix D.

The dummy variables isolating the impact of the reforms, as described in section 3.2.1, are the following:

$$Maroni_t = \begin{cases} 0 & t < Aug,\ 2004 \\ 1 & t \geq Aug,\ 2004 \end{cases} \quad Damiano_t = \begin{cases} 0 & t < Dec,\ 2007 \\ 1 & t \geq Dec,\ 2007 \end{cases} \tag{3.12}$$

$$Fornero_t = \begin{cases} 0 & t < Dec,\ 2011 \\ 1 & t \geq Dec,\ 2011 \end{cases} \quad Stabilita'_t = \begin{cases} 0 & t < Jan,\ 2016 \\ 1 & t \geq Jan,\ 2016 \end{cases} \tag{3.13}$$

$$Quota100_t = \begin{cases} 0 & t < May, 2018 \\ 1 & t \geq May, 2018 \end{cases} \tag{3.14}$$

In addition to the reforms already implemented, we also include in the model the Quota 100 measure, which has been at the center of the past election campaign as one of the economic policy proposed by the winning parties. Being a pension reforms not still implemented, we take as break date the month in which the political parties winning the elections reached an agreement that lead them going to the government, that is May 2018.

3.2.3 Main Results

As a first step, we estimate the model with the standard OLS method (results are reported in Figure 3.4). However, being our errors serially correlated (they show significant autocorrelations), we know that OLS estimates are inconsistent and they can not be used for hypothesis testing procedures. Standard errors and the relative confidence intervals are, in fact, misleading. We perform, in confirmation to what we argued, two different heteroskedasticity tests (the Breusch-Pagan test and the White test) considering both linear and non-linear form of heteroskedasticity. Results confirm the presence of heteroskedasticity in our regression since in both cases we reject the null hypothesis of constant variance (homoskedasticity) at the 1% significance level (see Figure 3.5).

A potential solution to this problem would be the re-estimation of the model with OLS using robust or HAC standard errors that takes into account heteroskedasticity. However, the path of our index over time is clearly characterized by periods of pretty high volatility - close to pension reforms introduction - alternating with period in which values are more stable. This behaviour suggests that, as in many economic time series, volatility clustering may be present and therefore that errors may exhibits a time-varying form of heteroskedasticity.

Source	SS	df	MS			
				Number of obs	=	176
				F(14, 161)	=	5.33
Model	5681.27837	14	405.805598	Prob > F	=	0.0000
Residual	12248.9577	161	76.0804827	R-squared	=	0.3169
				Adj R-squared	=	0.2575
Total	17930.2361	175	102.458492	Root MSE	=	8.7224

D.Pen_Unc	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Pen_Unc						
LD.	-.4539313	.0762922	-5.95	0.000	-.6045937	-.3032689
L2D.	-.5685443	.0776581	-7.32	0.000	-.7219042	-.4151844
L3D.	-.2443778	.0847848	-2.88	0.004	-.4118115	-.0769441
Pub_Dbt_It						
L2D.	3.90e-06	.0000435	0.09	0.929	-.000082	.0000898
LD.	5.16e-06	.0000445	0.12	0.908	-.0000827	.000093
D1.	.0000448	.0000432	1.04	0.301	-.0000405	.0001302
Spread_IT_DE						
D1.	-.0084141	.0256191	-0.33	0.743	-.0590068	.0421787
Maroni	-4.673946	5.30996	-0.88	0.380	-15.1601	5.812206
Damiano	-3.195317	2.689786	-1.19	0.237	-8.507127	2.116494
Sp_Damiano	.0276398	.0143278	1.93	0.055	-.000655	.0559345
Fornero	2.469244	3.5964	0.69	0.493	-4.632954	9.571443
Sp_Fornero	-.0215493	.017629	-1.22	0.223	-.0563632	.0132646
Stabilità	-.0012492	2.290203	-0.00	1.000	-4.52396	4.521462
Quota100	11.58991	3.858836	3.00	0.003	3.969453	19.21038
_cons	3.81615	5.170142	0.74	0.462	-6.393889	14.02619

Figure 3.4: OLS estimation of equation (3.10)
Source : Our own elaboration

```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of D.Pen_Unc

         chi2(1)      =    31.45
         Prob > chi2  =   0.0000

. estat imtest, white

White's test for Ho: homoskedasticity
         against Ha: unrestricted heteroskedasticity

         chi2(89)     =    156.60
         Prob > chi2  =    0.0000

Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	156.60	89	0.0000
Skewness	30.46	14	0.0066
Kurtosis	1.46	1	0.2275
Total	188.52	104	0.0000

Figure 3.5: Breusch-Pagan and White test for the model in equation (3.10) with OLS
Source : Our own elaboration

In order to formally detect volatility clustering, we perform an Arch Disturbance test with STATA whose result confirms the presence of a significant first order autoregressive conditional heteroskedasticity at 1% significance level.

```
. estat archlm
LM test for autoregressive conditional heteroskedasticity (ARCH)
```

lags(p)	chi2	df	Prob > chi2
1	10.601	1	0.0011

```
H0: no ARCH effects      vs.  H1: ARCH(p) disturbance
```

Figure 3.6: Arch Disturbance test for the model in equation (3.10) with OLS
Source : Our own elaboration

As a consequence, we estimate an Autoregressive Conditional Hetorskedasticity model. A general $ARCH(p)$ is a model first introduced by Robert Engle (1982) in which the residuals are assumed to be normally distributed with zero mean and variance ${\sigma^2}_t$, which linearly depends on past squared values of the error terms. In our context, given the optimal number of arch lags estimated with the Arch Disturbance test, the model we use is an $ARCH(1)$ represented by the following two equations:

$$dPU_t = \sum_{i=1}^{3} \beta_i dPU_{t-i} + \sum_{i=0}^{2} \gamma_i dPublicDebt_{t-i} + \pi_1 dSpread_t + \alpha_1 Maroni_t + \alpha_2 Damiano_t + \\ + \alpha_3 Fornero_t + \alpha_4 Stabilita'_t + \alpha_5 Quota100_t + \mu_t \tag{3.15}$$

$$\begin{cases} \mu_t \sim N(0, {\sigma^2}_t) \\ {\sigma^2}_t = \alpha_0 + \alpha_1 {\mu^2}_t \end{cases} \tag{3.16}$$

Finally, we also consider non-linear terms between the dummies and the regressors which have been estimated to be significant for our specification: the interactions between the Spread and the Damiano and Fornero reforms. The estimated results are reported in Figure 3.7.

ARCH family regression

Sample: May, 2004 - December, 2018	Number of obs = 176
Distribution: Gaussian	Wald chi2(14) = 416.27
Log likelihood = -579.4454	Prob > chi2 = 0.0000

D.Pen_Unc	Coef.	OPG Std. Err.	z	P>|z|	[95% Conf.	Interval]
Pen_Unc						
Pen_Unc						
LD.	-.4963564	.0498939	-9.95	0.000	-.5941466	-.3985661
L2D.	-.4345081	.0464469	-9.35	0.000	-.5255425	-.3434738
L3D.	-.2413759	.0469951	-5.14	0.000	-.3334846	-.1492672
Pub_Dbt_It						
L2D.	-.0000629	.0000175	-3.59	0.000	-.0000973	-.0000286
LD.	-.0000397	.0000199	-2.00	0.046	-.0000786	-7.10e-07
D1.	.0000471	.0000188	2.51	0.012	.0000103	.0000838
Spread_IT_DE						
D1.	-.0361278	.0107419	-3.36	0.001	-.0571814	-.0150741
Maroni	4.841105	.6418977	7.54	0.000	3.583009	6.099202
Damiano	-7.305055	.9629429	-7.59	0.000	-9.192388	-5.417721
Sp_Damiano	.0250702	.0033708	7.44	0.000	.0184636	.0316768
Fornero	2.483843	1.32729	1.87	0.061	-.1175987	5.085284
Sp_Fornero	-.0298923	.0061541	-4.86	0.000	-.0419541	-.0178306
Stabilità	2.047983	.7908864	2.59	0.010	.4978737	3.598092
Quota100	12.23867	1.393156	8.78	0.000	9.50813	14.9692
ARCH						
arch						
L1.	1.878413	.2880089	6.52	0.000	1.313926	2.4429
_cons	6.94104	2.262496	3.07	0.002	2.50663	11.37545

Figure 3.7: ARCH(1) estimation results equations (3.15) and (3.16)
Source : Our own elaboration

3.2.4 Discussion

Looking at the estimated results, the parameters of interest (the $\alpha' s$ on Pension Reforms' dummies) are all statistically significant at 1% level except for the Fornero reform, whose effect is significant at 10% level. Each pension reform introduction represents, therefore, a significant structural break in the time series of our index, confirming the idea that they all have a remarkable impact on the perceived level of pension-related policy uncertainty in Italy.

Once established that pension reforms are significantly able to generate a climate of uncertainty, the direction of each individual effect may provide insights about the role played by technical characteristics of the introduced changes. Indeed, not all the reforms lead to an increase in the level of pension uncertainty. According to the signs of the estimated parameters (Table 3.4), the introduction of the Damiano reform has a significant and strong negative effect on the level of perceived uncertainty, while all the other effects are positive. The latter result is far to be random. Ruling out for a while the Quota 100 reform and considering only the measures already implemented, our results suggest that policy interventions which caused an increase in the individual potential work horizon - by raising the average retirement age - contribute in increasing the perceived level of uncertainty and vice versa. The Maroni Reform, which introduced a sharp discontinuity in the eligibility rules (*scalone*), has in fact a strong positive effect (4.8411) while the impact of the measure promoted by Damiano, which mitigated the effect of the first, goes in the opposite direction (-7.3050). Afterwards, the implementation of the Fornero Reform, which abolished the quota system and tightened even more the eligibility requirements for seniority pension, leads to a significant increase in the level of pension uncertainty (2.4838). The latter impact is then confirmed by the 2016 Stability Law (2.04979) that, by affecting only the indexation system, was perceived as a confirmation of the eligibility rules introduced before.

Table 3.4: Estimated Parameters for Pension Reforms effects

Pension Reform	Paramter of Interest ($\alpha' s$)
Maroni Reform (2004)	4.8411***
Damiano Reform (2007)	-7.3050***
Fornero Reform (2011)	2.4838*
Legge di Stabilità (2016)	2.0479***
Quota 100 (2018)	12.2386***

At first glance, the Quota 100 measure represents a paradox in our framework. Indeed, despite its future introduction has been claimed as a "solution" to the the too strict retirement rules established by the Fornero reform, it actually has a really strong and positive effect on the level of perceived pension uncertainty (12.2386). However, there are at least three reasons why pension uncertainty reaches its historical peak from the moment in which the political parties promoting Quota100 went to the government. First, it is not totally clear yet how the reform will be designed and whether it will actually mitigate the rules introduced by the previous measures. Therefore, the level of confusion around its technical features is much higher with respect to past pre-reform periods. Second, the introduction of a valid alternative in the pension eligibility rules has been one of the focus points of the last election campaign and has been questioned a lot by political parties claiming the financial unsustainability of a measure reducing individuals' work horizon. Hence, there have always been doubts about the credibility of the political parties promoting the reform.

Third and last, the Quota 100 reform will be, if carried out, the fifth policy measure affecting Italian pension legislation in the last 15 years. There is a chance that too many pension reforms implemented in a small time interval may lead to lose individuals' expectations anchoring and cause, therefore, a reduction in the government credibility. If this is the case, the implementation of a new pension reform would always cause an increase in perceived uncertainty regardless the contributions provided, because individuals can not be sure about its long-term effectiveness. The latter is a key issue to face for the policy makers because an optimal policy measure design should always be able to take into account individuals' behavioural responses, but if people stop "believing" in what the government does, this becomes really challenging.

Our results, even if partially, support the third reason:

- the impact of Quota 100 reform is positive and definitively bigger than the others, therefore it is reasonable to think that it embodies a more general increase in pension uncertainty caused by the succession of several measures in a very few years.
- since the parameters of interest isolate the impact of each specific pension reforms on perceived uncertainty, the sum of them gives us the *cumulated* effect, which is indeed positive:

$$4.8411 - 7.3050 + 2.4838 + 2.0479 + 12.2386 = 14.3064 \tag{3.17}$$

Concerning the other regressors, they behaves how we have expected. The estimated parameters for the differentiated spread and for the two lags of the differentiated public debt are, in fact, significantly negative at the 1% level. These results confirm their contribution in smoothing variations in pension uncertainty from fluctuations caused by a more general economic uncertainty: periods of high spread and public debt are usually characterized by a low, or anyway standard, values of our pension uncertainty index. This is consistent with the idea that our empirical measure only wants to focus its attention on *pension-related* policy uncertainty. Indeed, as can be noticed from Figure 3.1, years around the 2008 great financial crisis do not present any significant peaks, while in all the other general policy uncertainty index these periods reports the highest values of the series (e.g., EPU index, VIX index).

3.2.5 Sensibility Analysis

As argued, using the months of the announcement of the reforms as break dates in the construction of the dummies could be a good alternative identification strategy. Anticipation effect may in fact take place and should be considered in order to correctly isolate the impacts on perceived pension uncertainty. However, since it is really difficult to assess with certainty the months in which the government has announced the implementation of the reforms, we limit our investigation to the re-estimation of the model by changing, whether reasonable, the break dates.

Specifically, not for all the five reforms considered we can sensibly move the break date:

- we can not change the break date for the Maroni reform for statistical reasons: the date of the implementation is already quite close to one of the extremes of our sample, therefore shifting it backwards we would almost lose all pre-reform values of the index
- we can not change also the break date for the Fornero reform, since it was suddenly implemented by the government without any previous discussion, therefore we can easily conclude that the Fornero reform could not be anticipated by individuals

As a consequence, the changes we can reasonable make are two: we move the break date for the Damiano reform from the month of the implementation - December, 2007 - to the month in which the political parties promoting the measure won the elections - April, 2006; we shift the break date for the Quota 100 measure from the moth in which the coalition agreement was closed - May, 2018 - to the month in which the related Budget law was accepted - November, 2018. However, moving the break dates our model suffers of huge statistical problems since most of the parameters of interest are not significantly estimated anymore. Therefore, it becomes difficult to asses if the differences they report in terms of direction (signs) are economical meaningfull for our purposes. STATA outputs of the three further estimations are reported below.

ARCH family regression

Sample: 532 - 707 Number of obs = 176
Distribution: Gaussian Wald chi2(14) = 248.22
Log likelihood = -590.8886 Prob > chi2 = 0.0000

D.Pen_Unc	Coef.	OPG Std. Err.	z	P>|z|	[95% Conf.	Interval]
Pen_Unc						
Pen_Unc						
LD.	-.564191	.0803705	-7.02	0.000	-.7217142	-.4066677
L2D.	-.5028771	.0559768	-8.98	0.000	-.6125896	-.3931646
L3D.	-.3126296	.0710434	-4.40	0.000	-.4518722	-.1733871
Pub_Dbt_It						
L2D.	-.0000177	.0000281	-0.63	0.528	-.0000727	.0000373
LD.	.0000106	.0000241	0.44	0.660	-.0000367	.0000579
D1.	.0000474	.0000244	1.94	0.052	-4.13e-07	.0000952
Spread_IT_DE						
D1.	.6395523	.3561525	1.80	0.073	-.0584937	1.337598
Maroni	-2.324511	.922224	-2.52	0.012	-4.132037	-.5169852
Damiano	3.170678	.9552076	3.32	0.001	1.298506	5.042851
Sp_Damiano	-.6822322	.3547513	-1.92	0.054	-1.377532	.0130676
Fornero	-2.03314	1.963696	-1.04	0.300	-5.881913	1.815633
Sp_Fornero	-.0056911	.0073367	-0.78	0.438	-.0200708	.0086886
Stabilità	2.561571	1.571028	1.63	0.103	-.5175881	5.64073
Quota100	13.17981	1.871823	7.04	0.000	9.511103	16.84851
ARCH						
arch						
L1.	1.405583	.3381916	4.16	0.000	.7427395	2.068426
_cons	16.49635	4.591782	3.59	0.000	7.496622	25.49608

Figure 3.8: ARCH(1) estimation results changing Damiano reform break date
Source : Our own elaboration

ARCH family regression

Sample: 532 - 707	Number of obs	=	176
Distribution: Gaussian	Wald chi2(14)	=	221.46
Log likelihood = -584.3546	Prob > chi2	=	0.0000

D.Pen_Unc	Coef.	OPG Std. Err.	z	P>|z|	[95% Conf.	Interval]
Pen_Unc						
Pen_Unc						
LD.	-.1431319	.0567248	-2.52	0.012	-.2543106	-.0319533
L2D.	-.3319554	.043328	-7.66	0.000	-.4168767	-.2470342
L3D.	-.3734878	.0488894	-7.64	0.000	-.4693094	-.2776663
Pub_Dbt_It						
L2D.	-3.81e-06	.0000202	-0.19	0.851	-.0000434	.0000358
LD.	-.0000202	.0000195	-1.04	0.300	-.0000585	.000018
D1.	.0000725	.0000166	4.37	0.000	.0000399	.0001051
Spread_IT_DE						
D1.	-.7855141	.2971441	-2.64	0.008	-1.367906	-.2031224
Maroni	1.458412	.5445143	2.68	0.007	.3911836	2.52564
Damiano	-2.099136	.847812	-2.48	0.013	-3.760817	-.4374548
Sp_Damiano	.7622288	.2977076	2.56	0.010	.1787327	1.345725
Fornero	1.895479	1.57204	1.21	0.228	-1.185663	4.97662
Sp_Fornero	-.0076514	.0047416	-1.61	0.107	-.0169448	.0016419
Stabilità	-.0095242	.9945752	-0.01	0.992	-1.958856	1.939807
Quota100	-.69122	21.00504	-0.03	0.974	-41.86035	40.47791
ARCH						
arch						
L1.	1.68797	.3463518	4.87	0.000	1.009133	2.366807
_cons	8.814399	2.618337	3.37	0.001	3.682554	13.94624

Figure 3.9: ARCH(1) estimation results changing Quota 100 reform break date
Source : Our own elaboration

ARCH family regression

Sample: 532 - 707	Number of obs	=	176
Distribution: Gaussian	Wald chi2(14)	=	225.50
Log likelihood = -593.1245	Prob > chi2	=	0.0000

D.Pen_Unc	Coef.	OPG Std. Err.	z	P>|z|	[95% Conf.	Interval]
Pen_Unc						
Pen_Unc						
LD.	-.4800803	.0764332	-6.28	0.000	-.6298867	-.3302739
L2D.	-.5850368	.0617391	-9.48	0.000	-.7060432	-.4640303
L3D.	-.2160007	.0483995	-4.46	0.000	-.3108618	-.1211395
Pub_Dbt_It						
L2D.	1.95e-06	.0000271	0.07	0.943	-.0000511	.000055
LD.	-2.16e-06	.0000211	-0.10	0.919	-.0000435	.0000392
D1.	.0000722	.0000236	3.06	0.002	.000026	.0001184
Spread_IT_DE						
D1.	.983772	.3069259	3.21	0.001	.3822083	1.585336
Maroni	-2.107541	.9709994	-2.17	0.030	-4.010664	-.2044167
Damiano	2.66008	.9349094	2.85	0.004	.8276916	4.492469
Sp_Damiano	-1.023685	.3073488	-3.33	0.001	-1.626077	-.4212921
Fornero	-1.924708	1.536262	-1.25	0.210	-4.935726	1.08631
Sp_Fornero	-.0046651	.0065114	-0.72	0.474	-.0174272	.0080971
Stabilità	2.657893	1.184178	2.24	0.025	.3369467	4.97884
Quota100	4.419361	20.29251	0.22	0.828	-35.35322	44.19194
ARCH						
arch						
L1.	1.538049	.321486	4.78	0.000	.9079484	2.16815
_cons	14.47988	3.767023	3.84	0.000	7.096648	21.86311

Figure 3.10: ARCH(1) estimation results changing both Damiano and Quota 100 reforms break dates
Source : Our own elaboration

Conclusions

The main objectives of this dissertation were to provide an empirical measure for pension-related policy uncertainty in Italy and to estimate the impact that the main 2000s pension reforms could have had on its level over time.
We have built a proxy for pension-related policy uncertainty in Italy using Google Trends data about pension related queries selecting specific keywords to insert in our sample. Afterwards, we have analysed how this particular level of policy uncertainty has been affected by the introduction of the main 2000s pension reforms by estimating an ARCH(1) model with dummy variables. Results indicates that all the reforms considered had a significant effect on the level of perceived uncertainty. In particular, considering only the ones already implemented, measures increasing the individual potential work horizon lead to increase in the perceived level of uncertainty and vice versa. Furthermore, our estimations suggest that there is a chance that implementing too many reform in a short time interval may decoupling individual expectations and decrease government credibility about the long-term effectiveness of the policies promoted.

Of course our work has some limits and is based on strong assumptions. First, we have assumed, looking at data describing household's behaviour in the digital environment, that individuals searching online about pensions theme are questioning on something they are not totally sure about. Therefore, we assumed peaks in the search shares to be peaks in the level of perceived uncertainty, which in turn indicates bad quality in the individuals degree of information. However, since Google Trends allows user to know from where the researches have been undertaken but not by who, peaks may also be interpreted only as periods of pretty high interest around the pension issue, compromising the validity of our Pension Uncertainty Index. Moreover, our measure of uncertainty is an aggregate index that should describe individual behaviors.

As a consequence, further research is needed in order to asses the external validity of the index, matching our search shares with micro data on subjective expectations about retirement outcomes. If peaks in our index were, in fact, associated with periods of higher volatility in individual expectations errors about retirement age and replacement rate, the PU Index could be considered a good proxy for uncertainty in the estimation of individual behavioral responses to pension reform.

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Index of Law

D.L. May 21th 2015, n. 65

D.Lgs. December 30th 1992, n. 503

L. August 8th 1995, n. 335

L. December 27th 1997, n. 449

L. December 23th 2000, n. 388

L. August 23th 2004, n. 243

L. December 26th 2006, n. 296

L. December 24th 2007, n. 247

L. July 30th 2010, n. 122

L. December 22th 2011, n. 214

L. December 27th 2013, n. 147

L. December 28th 2015, n. 208

Appendix A

Textual Analysis

A.1 Pools of queries for generic keywords

Pensioni
pensioni inps
pensioni donne
pensioni d'oro
pensioni minime
pensioni notizie
pensioni news
pensioni novità
pensioni oggi
ultime pensioni
ultime notizie pensioni
riforma pensioni
riforma pensioni 2018
riforma pensioni
riforma pensioni ultime notizie
riforma pensioni oggi ultime notizie
riforma pensioni
riforma pensioni oggi
riforma pensioni news
riforma pensioni ultime notizie 2018
riforma pensioni precoci
riforma pensioni ultima ora

Pensione
quando vado in pensione calcolo
calcolo quando vado in pensione
calcolo pensione

calcolo pensione netta
calcolo pensione inps
calcolo pensione sistema misto
calcolo pensione contributiva
calcolo pensione contributiva
calcolo pensione online
calcolo pensione reversibilità
calcolo pensione anticipate
calcolo età pensione
cedolino pensione
differenza tra pensione di anzianità e vecchiaia
fondo pensione
pensione anzianità e vecchiaia
pensione completa
pensione invalidità
pensione minima
pensione quando
pensione sociale
quando vado in pensione
requisiti pensione

Contributi
contributi figurativi
contributi minimi
contributi volontari
inps contributi
quanti anni di contributi
quanti contributi ho versato
quanti contributi servono

Pensionamento
età pensionamento Italia
età pensionamento vecchiaia
età pensionamento anzianità
età pensionamento Europa
pensionamento Anticipato
pensionamento donne
pensionamento anticipato
pensionamento significato

A.2 Google Trends Comparison: Example

We provide an example of a generic keyword we decided to exclude from our dataset: the word *pensionabile* (pensionable). Using the comparison function of Google Trends among the trends of the most searched general keyword *Pensione*, the word *Pensionabile* and the sum of the two (representing the shares of all the web searches including one term OR the other), the impact of the second is practically null. The trend of the sum almost coincides with the one of the keyword *Pensione* alone, therefore we consider negligible the qualitative contribution of the world *Pensionabile*, dropping it out from our data.

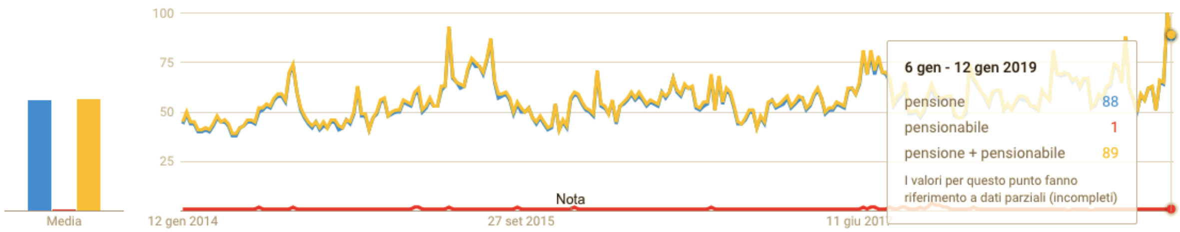

Figure A.1: Google Trends comparison between the keywords "Pensione" and "Pensionabile"
Source: Google Trends

A.3 Pooling generic and specific keywords

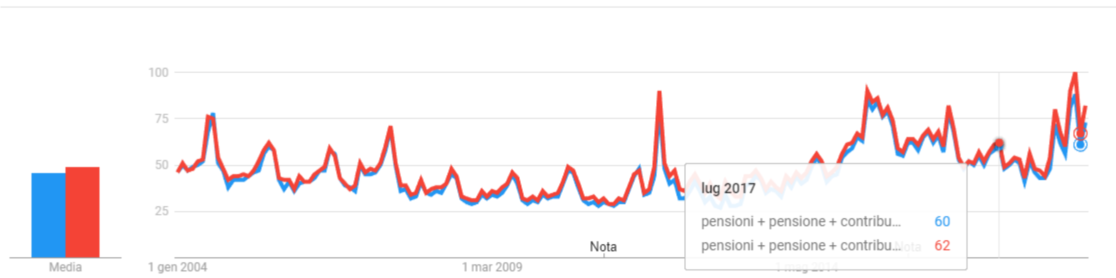

Figure A.2: Google trends comparison between generic and specific keywords pooled and only generic terms
Source: Google Trends

Figure A.2 shows a comparison between the search shares relative to the sum of the generic keywords (blue line) and the search shares of all the 8 keywords pooled together (red line). As can be noticed, there is not significant difference between the two, which demonstrates that actually the contribution of specific terms to the general trend is almost null when keywords are all polled together. This happens for one key reason: generic keywords are always more searched than the specific one because they are often includes in the queries together with them.

A.3.1 Trends of the reform-specific keywords

However, the trend of technical terms when it is individually analysed is more representative of individual's interest about pensions. Figure from A.3 to A.6 shows the individual trends of specific keywords.

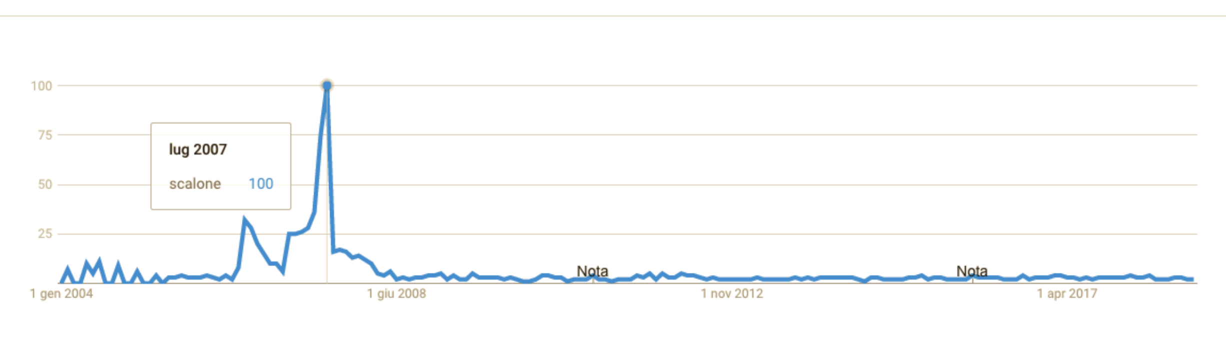

Figure A.3: Google Trends search shares for the keyword "*scalone*"
Source : Our own elaboration

Figure A.4: Google Trends search shares for the keyword "*Fornero*"
Source : Our own elaboration

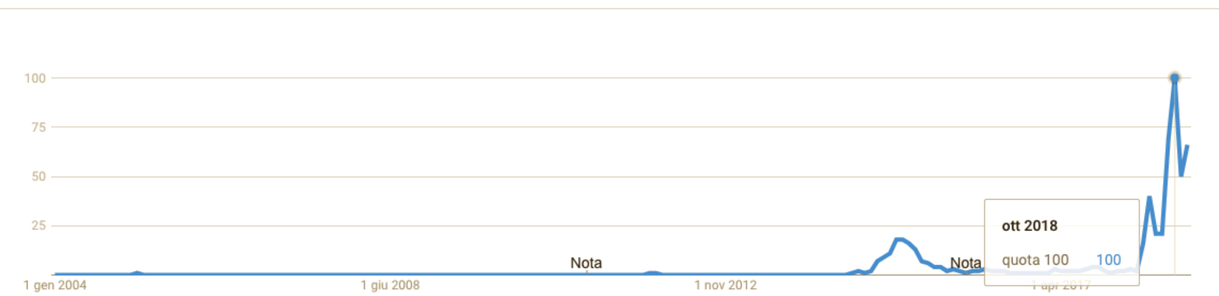

Figure A.5: Google Trends search shares for the keyword "*quota 100*"
Source : Our own elaboration

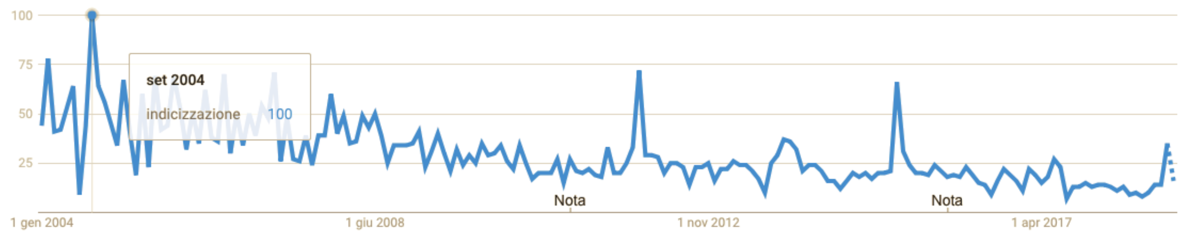

Figure A.6: Google Trends search shares for the keyword "*indicizzazione*"
Source : Our own elaboration

Appendix B

Seasonal Adjustment

As in one of the classical approach, the time series is assumed to follow a linear additive functional form as following:

$$Y_t = T_t + S_t + E_t \tag{B.1}$$

where Y_t is the general time series (in our specific case PU_m), T_t is the trend component, S_t is the seasonal component and E_t represents the irregular component (errors or residuals).
Among all the possible methods that may be applied to smooth the series by getting rid of the S_t component, we decide to use the moving average procedure. The latter is a simple decomposition method that replaces each observation of the series with the average of all the n values around it (include the value itself). According to the value of n used, the moving average is defined as "centered in n terms". In order to obtain the adjusted series we proceed as follow:

- First, we compute a moving average series centered in 12 terms starting from the original series PU_m, called MA_{12}:

$$MA_{12} = \frac{1}{2}\left(\frac{1}{12}\sum_{i=-6}^{5} PU_{m-i} + \frac{1}{12}\sum_{i=-5}^{6} PU_{m-i}\right) \tag{B.2}$$

- Subtracting this smoothed series from the original one, we obtain a new series which includes both the seasonal component and the errors, called seasonality-error mixed series:

$$SE_m = PU_m - MA_{12} \tag{B.3}$$

- Given the characteristics of our time series, we assume the seasonality to be constant from year to year. Therefore, we compute 12 seasonal factors (one for each month) S_m (with $m = 1, 2, .., 12$) given by the arithmetic mean of the SE_m component taken each year for the same month ($SE_m, SE_{m+12}, SE_{m+24}...$)

- Eventually, subtracting from the original series the seasonal factors we retrieve the seasonal adjusted index, that is:

$$PU_{m-seasonaladjusted} = PU_m - S_m \tag{B.4}$$

Appendix C

Stationarity Analysis

C.1 Pension Uncertainty Index

```
Augmented Dickey-Fuller test for unit root         Number of obs   =       166

                               ---------- Interpolated Dickey-Fuller ----------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
-------------------------------------------------------------------------------
 Z(t)             -2.191            -3.488            -2.886            -2.576
-------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.2096

. dfuller Pen_Unc, trend lags(13)

Augmented Dickey-Fuller test for unit root         Number of obs   =       166

                               ---------- Interpolated Dickey-Fuller ----------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
-------------------------------------------------------------------------------
 Z(t)             -2.229            -4.018            -3.441            -3.141
-------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.4735

. dfuller Pen_Unc, drift lags(13)

Augmented Dickey-Fuller test for unit root         Number of obs   =       166

                               ----------- Z(t) has t-distribution -----------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
-------------------------------------------------------------------------------
 Z(t)             -2.191            -2.351            -1.655            -1.287
-------------------------------------------------------------------------------
p-value for Z(t) = 0.0150

. dfuller Pen_Unc, noconstant lags(13)

Augmented Dickey-Fuller test for unit root         Number of obs   =       166

                               ---------- Interpolated Dickey-Fuller ----------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
-------------------------------------------------------------------------------
 Z(t)              0.150            -2.591            -1.950            -1.614
```

Figure C.1: Augmented Dickey-Fuller test for the Seasonally Adjusted Pension Uncertainty Index
Source : Our own elaboration

```
. dfgls Pen_Unc

DF-GLS for Pen_Unc                                         Number of obs =   166
Maxlag = 13 chosen by Schwert criterion

               DF-GLS tau      1% Critical       5% Critical      10% Critical
  [lags]     Test Statistic       Value             Value             Value
------------------------------------------------------------------------------

    13          -2.689           -3.484            -2.804            -2.527
    12          -2.431           -3.484            -2.819            -2.540
    11          -2.543           -3.484            -2.833            -2.554
    10          -2.281           -3.484            -2.847            -2.566
    9           -2.426           -3.484            -2.860            -2.579
    8           -2.452           -3.484            -2.873            -2.591
    7           -2.579           -3.484            -2.886            -2.602
    6           -2.399           -3.484            -2.898            -2.613
    5           -2.429           -3.484            -2.909            -2.623
    4           -2.516           -3.484            -2.920            -2.633
    3           -2.264           -3.484            -2.930            -2.642
    2           -2.718           -3.484            -2.939            -2.651
    1           -4.734           -3.484            -2.948            -2.659

Opt Lag (Ng-Perron seq t) = 13 with RMSE  8.352751
Min SC   =  4.418283 at lag  2 with RMSE  8.696747
Min MAIC =  4.453044 at lag  3 with RMSE  8.660917

.
end of do-file
```

Figure C.2: Augmented Dickey-Fuller GLS test for the Seasonally Adjusted Pension Uncertainty Index
Source : Our own elaboration

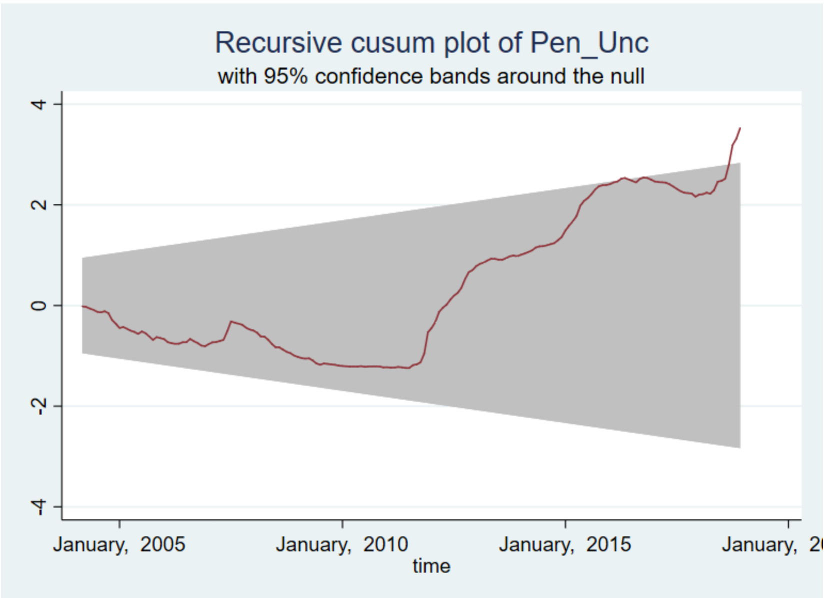

Figure C.3: Parameters Stability test for the Seasonally Adjusted Pension Uncertainty Index
Source : Our own elaboration

```
. zandrews Pen_Unc, break(trend)

Zivot-Andrews unit root test for  Pen_Unc

Allowing for break in trend

Lag selection via TTest: lags of D.Pen_Unc included = 2

Minimum t-statistic -3.452 at July,  2009  (obs 67)

Critical values: 1%: -4.93 5%: -4.42 10%: -4.11

. zandrews Pen_Unc, break(intercept)

Zivot-Andrews unit root test for  Pen_Unc

Allowing for break in intercept

Lag selection via TTest: lags of D.Pen_Unc included = 2

Minimum t-statistic -3.644 at August,  2007  (obs 44)

Critical values: 1%: -5.34 5%: -4.80 10%: -4.58

. zandrews Pen_Unc, break(both)

Zivot-Andrews unit root test for  Pen_Unc

Allowing for break in both intercept and trend

Lag selection via TTest: lags of D.Pen_Unc included = 2

Minimum t-statistic -3.802 at August,  2011  (obs 92)

Critical values: 1%: -5.57 5%: -5.08 10%: -4.82

.
end of do-file
```

Figure C.4: Zivot-Andrews test for the Seasonally Adjusted Pension Uncertainty Index
Source : Our own elaboration

C.2 First Difference of the Pension Uncertainty Index

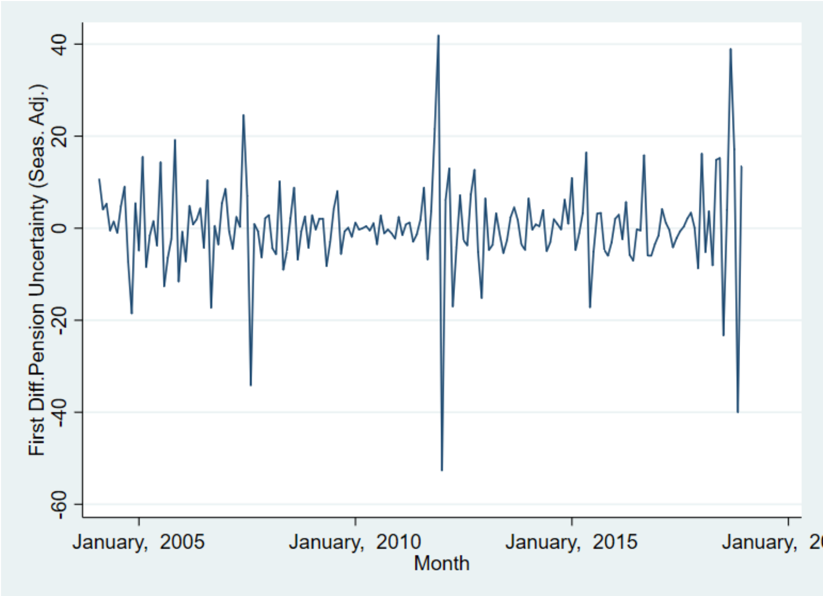

Figure C.5: Line Plot of the First Differentiated Pension Uncertainty Index
Source : Our own elaboration

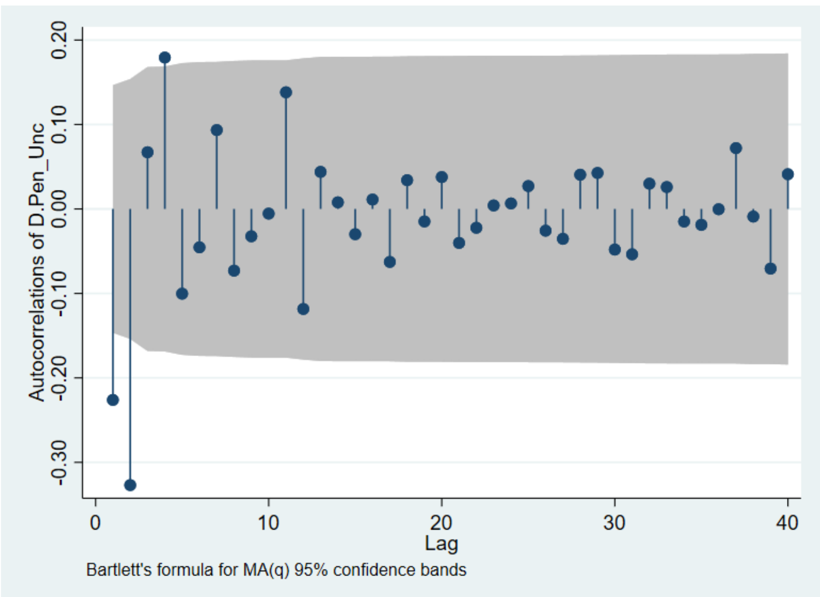

Figure C.6: Sample Autocorrelation Function of the First Differentiated Pension Uncertainty Index
Source : Our own elaboration

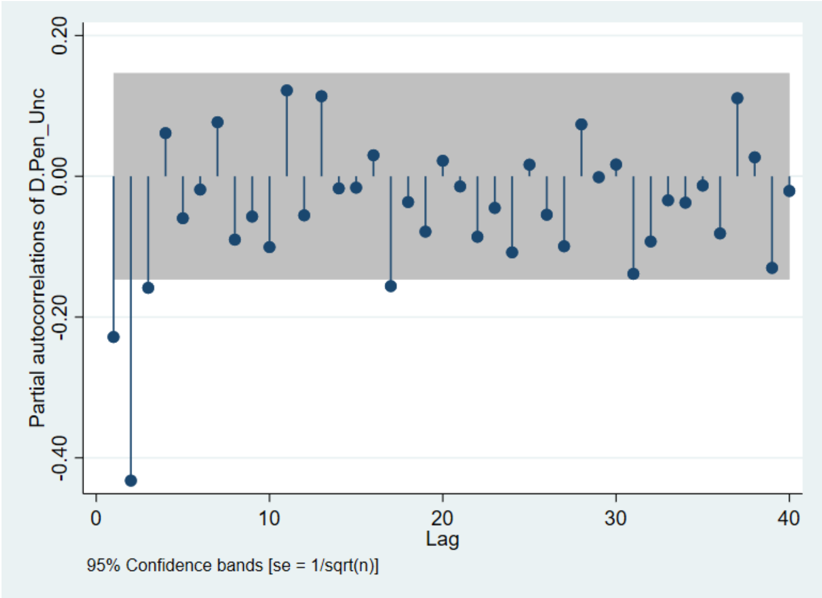

Figure C.7: Sample Partial Autocorrelation Function of the First Differentiated Pension Uncertainty Index
Source : Our own elaboration

```
. dfgls D.Pen_Unc

DF-GLS for D.Pen_Unc                                     Number of obs =   165
Maxlag = 13 chosen by Schwert criterion

               DF-GLS tau      1% Critical       5% Critical      10% Critical
  [lags]     Test Statistic        Value             Value             Value
------------------------------------------------------------------------------

    13           -1.407           -3.485            -2.803            -2.526
    12           -1.437           -3.485            -2.818            -2.540
    11           -1.562           -3.485            -2.833            -2.553
    10           -1.596           -3.485            -2.847            -2.566
    9            -1.803           -3.485            -2.860            -2.579
    8            -1.874           -3.485            -2.873            -2.591
    7            -2.051           -3.485            -2.886            -2.602
    6            -2.193           -3.485            -2.898            -2.613
    5            -2.683           -3.485            -2.909            -2.624
    4            -3.182           -3.485            -2.920            -2.634
    3            -4.004           -3.485            -2.930            -2.643
    2            -6.570           -3.485            -2.940            -2.651
    1           -10.845           -3.485            -2.949            -2.659

Opt Lag (Ng-Perron seq t) = 12 with RMSE  8.776524
Min SC   =  4.673491 at lag  6 with RMSE  9.285348
Min MAIC =  4.648524 at lag 12 with RMSE  8.776524
```

Figure C.8: Augmented Dickey-Fuller GLS test for the First Differentiated Pension Uncertainty Index
Source : Our own elaboration

```
. dfuller D.Pen_Unc, lags(13)

Augmented Dickey-Fuller test for unit root         Number of obs   =       165

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.693            -3.488            -2.886            -2.576
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0752

. dfuller D.Pen_Unc, trend lags(13)

Augmented Dickey-Fuller test for unit root         Number of obs   =       165

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.924            -4.018            -3.441            -3.141
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.1547

. dfuller D.Pen_Unc, drift lags(13)

Augmented Dickey-Fuller test for unit root         Number of obs   =       165

                               ----------- Z(t) has t-distribution ----------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.693            -2.351            -1.655            -1.287
------------------------------------------------------------------------------
p-value for Z(t) = 0.0039

. dfuller D.Pen_Unc, noconstant lags(13)

Augmented Dickey-Fuller test for unit root         Number of obs   =       165

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.703            -2.591            -1.950            -1.614
```

Figure C.9: Augmented Dickey-Fuller test for the First Differentiated Pension Uncertainty Index
Source : Our own elaboration

```
. zandrews D.Pen_Unc, break(trend)

Zivot-Andrews unit root test for  D.Pen_Unc

Allowing for break in trend

Lag selection via TTest: lags of D.D.Pen_Unc included = 2

Minimum t-statistic -12.404 at September,  2016  (obs 153)

Critical values: 1%: -4.93 5%: -4.42 10%: -4.11

. zandrews D.Pen_Unc, break(intercept)

Zivot-Andrews unit root test for  D.Pen_Unc

Allowing for break in intercept

Lag selection via TTest: lags of D.D.Pen_Unc included = 2

Minimum t-statistic -12.258 at August,  2007  (obs 44)

Critical values: 1%: -5.34 5%: -4.80 10%: -4.58

. zandrews D.Pen_Unc, break(both)

Zivot-Andrews unit root test for  D.Pen_Unc

Allowing for break in both intercept and trend

Lag selection via TTest: lags of D.D.Pen_Unc included = 2

Minimum t-statistic -12.632 at June,  2015  (obs 138)

Critical values: 1%: -5.57 5%: -5.08 10%: -4.82
```

Figure C.10: Zivot-Andrews test for the First Differentiated Pension Uncertainty Index
Source : Our own elaboration

C.3 Italian Gross Monthly Public Debt

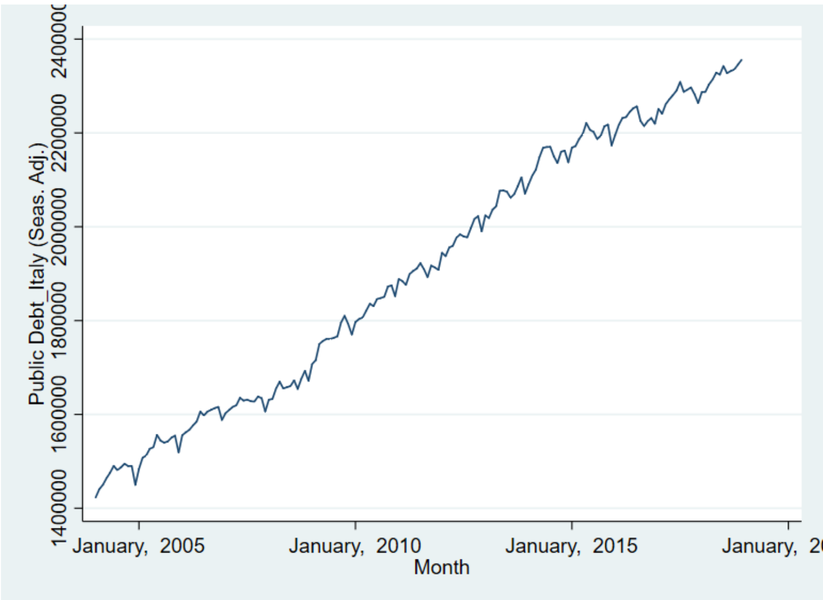

Figure C.11: Line Plot of the Italian Gross Monthly Public Debt
Source : Our own elaboration

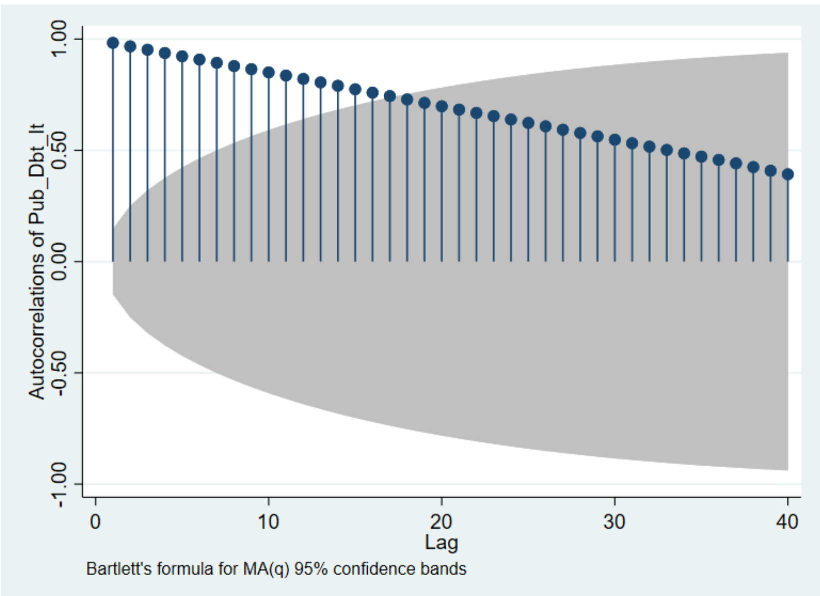

Figure C.12: Sample Autocorrelation Function of the Italian Gross Monthly Public Debt
Source : Our own elaboration

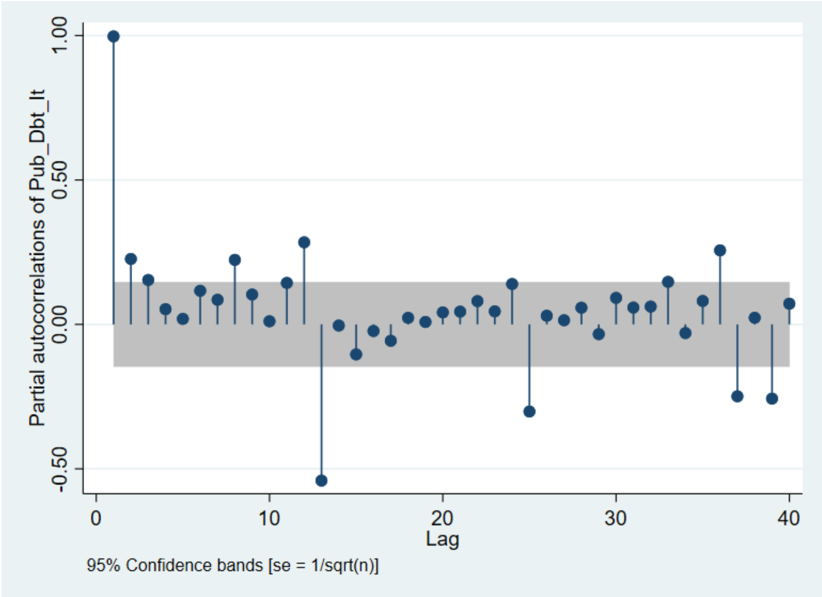

Figure C.13: Sample Partial Autocorrelation Function of the Italian Gross Monthly Public Debt
Source : Our own elaboration

```
. dfgls Pub_Dbt_It

DF-GLS for Pub_Dbt_It                                  Number of obs =   166
Maxlag = 13 chosen by Schwert criterion

               DF-GLS tau     1% Critical       5% Critical      10% Critical
  [lags]     Test Statistic      Value             Value             Value
------------------------------------------------------------------------------
    13           -1.899          -3.484            -2.804            -2.527
    12           -1.867          -3.484            -2.819            -2.540
    11           -0.759          -3.484            -2.833            -2.554
    10           -1.170          -3.484            -2.847            -2.566
    9            -1.372          -3.484            -2.860            -2.579
    8            -1.363          -3.484            -2.873            -2.591
    7            -1.501          -3.484            -2.886            -2.602
    6            -1.900          -3.484            -2.898            -2.613
    5            -2.034          -3.484            -2.909            -2.623
    4            -2.312          -3.484            -2.920            -2.633
    3            -2.308          -3.484            -2.930            -2.642
    2            -2.395          -3.484            -2.939            -2.651
    1            -2.772          -3.484            -2.948            -2.659

Opt Lag (Ng-Perron seq t) = 12 with RMSE  11364.86
Min SC   =   19.0769 at lag 12 with RMSE  11364.86
Min MAIC =  18.88804 at lag 12 with RMSE  11364.86
```

Figure C.14: Augmented Dickey-Fuller GLS test for the Italian Gross Monthly Public Debt
Source : Our own elaboration

```
Augmented Dickey-Fuller test for unit root          Number of obs   =       166

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -0.304            -3.488            -2.886            -2.576
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.9250

. dfuller Pub_Dbt_It, trend lags(13)

Augmented Dickey-Fuller test for unit root          Number of obs   =       166

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -1.891            -4.018            -3.441            -3.141
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.6593

. dfuller Pub_Dbt_It, drift lags(13)

Augmented Dickey-Fuller test for unit root          Number of obs   =       166

                               ----------- Z(t) has t-distribution -----------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -0.304            -2.351            -1.655            -1.287
------------------------------------------------------------------------------
p-value for Z(t) = 0.3808

. dfuller Pub_Dbt_It, noconstant lags(13)

Augmented Dickey-Fuller test for unit root          Number of obs   =       166

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)              2.754            -2.591            -1.950            -1.614
```

Figure C.15: Augmented Dickey-Fuller test for the Italian Gross Monthly Public Debt
Source : Our own elaboration

```
. zandrews Pub_Dbt_It, break(trend)

Zivot-Andrews unit root test for  Pub_Dbt_It

Allowing for break in trend

Lag selection via TTest: lags of D.Pub_Dbt_It included = 1

Minimum t-statistic -3.683 at April,  2015  (obs 136)

Critical values: 1%: -4.93 5%: -4.42 10%: -4.11

. zandrews Pub_Dbt_It, break(intercept)

Zivot-Andrews unit root test for  Pub_Dbt_It

Allowing for break in intercept

Lag selection via TTest: lags of D.Pub_Dbt_It included = 1

Minimum t-statistic -3.955 at January,  2012  (obs 97)

Critical values: 1%: -5.34 5%: -4.80 10%: -4.58

. zandrews Pub_Dbt_It, break(both)

Zivot-Andrews unit root test for  Pub_Dbt_It

Allowing for break in both intercept and trend

Lag selection via TTest: lags of D.Pub_Dbt_It included = 1

Minimum t-statistic -4.403 at January,  2013  (obs 109)

Critical values: 1%: -5.57 5%: -5.08 10%: -4.82
```

Figure C.16: Zivot-Andrews test for the Italian Gross Monthly Public Debt
Source : Our own elaboration

C.4 First Difference of the Italian Gross Monthly Public Debt

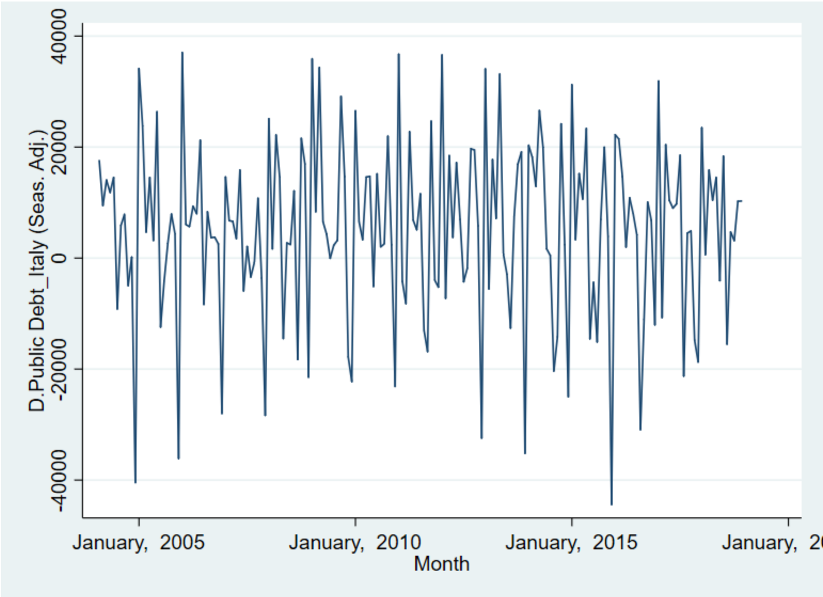

Figure C.17: Line Plot of the First Difference of the Italian Gross Monthly Public Debt
Source : Our own elaboration

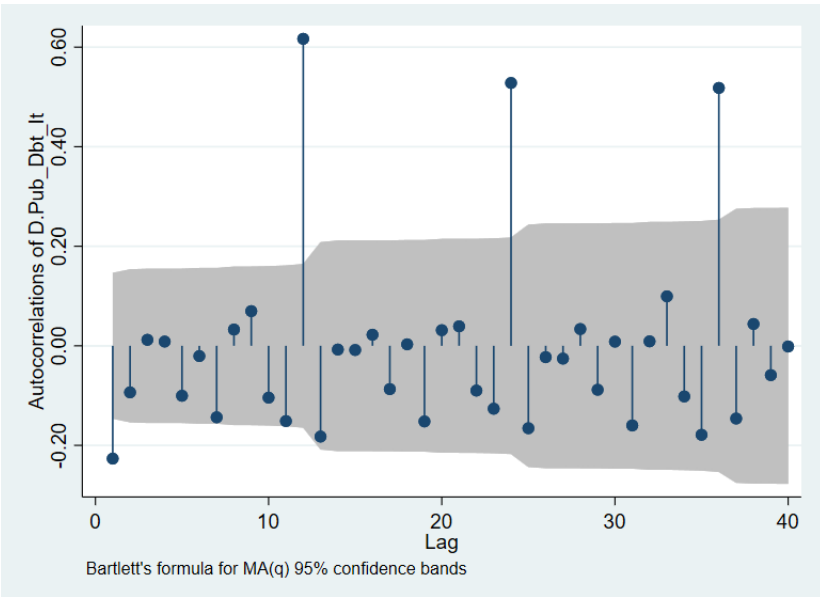

Figure C.18: Sample Autocorrelation Function of the First Difference of the Italian Gross Monthly Public Debt
Source : Our own elaboration

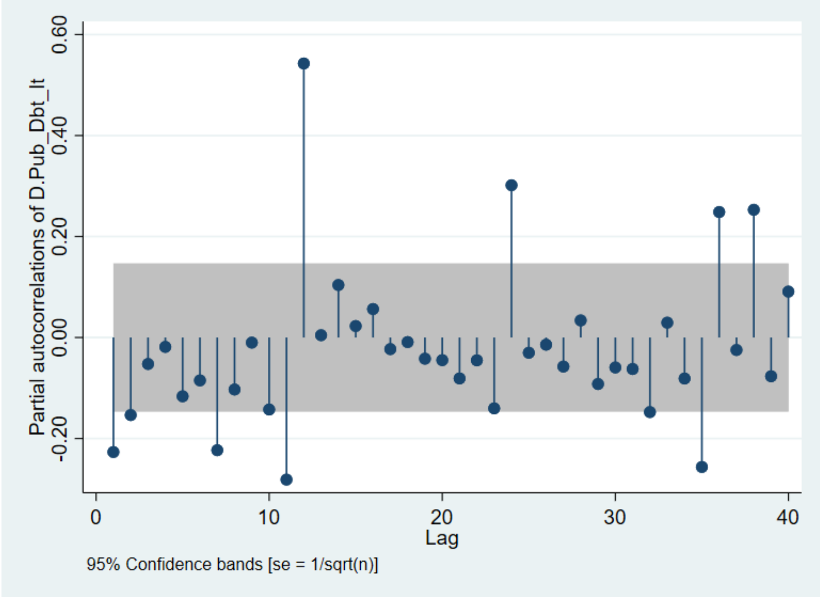

Figure C.19: Sample Partial Autocorrelation Function of the First Difference of the Italian Gross Monthly Public Debt
Source : Our own elaboration

DF-GLS for D.Pub_Dbt_It   Number of obs =   165
Maxlag = 13 chosen by Schwert criterion

[lags]	DF-GLS tau Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
13	-1.685	-3.485	-2.803	-2.526
12	-1.771	-3.485	-2.818	-2.540
11	-1.831	-3.485	-2.833	-2.553
10	-3.333	-3.485	-2.847	-2.566
9	-3.158	-3.485	-2.860	-2.579
8	-3.328	-3.485	-2.873	-2.591
7	-3.994	-3.485	-2.886	-2.602
6	-4.607	-3.485	-2.898	-2.613
5	-4.610	-3.485	-2.909	-2.624
4	-5.271	-3.485	-2.920	-2.634
3	-5.751	-3.485	-2.930	-2.643
2	-7.402	-3.485	-2.940	-2.651
1	-10.151	-3.485	-2.949	-2.659

Opt Lag (Ng-Perron seq t) = 13 with RMSE 11697.28
Min SC   = 19.13191 at lag 11 with RMSE 11852.36
Min MAIC = 19.30958 at lag 13 with RMSE 11697.28

Figure C.20: Augmented Dickey-Fuller GLS test for the First Difference of the Italian Gross Monthly Public Debt
Source : Our own elaboration

```
                         ——————————— Interpolated Dickey-Fuller ——————————
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.788            -3.488            -2.886            -2.576
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0600

. dfuller D.Pub_Dbt_It, trend lags(13)

Augmented Dickey-Fuller test for unit root         Number of obs   =       165

                         ——————————— Interpolated Dickey-Fuller ——————————
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.775            -4.018            -3.441            -3.141
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.2063

. dfuller D.Pub_Dbt_It, drift lags(13)

Augmented Dickey-Fuller test for unit root         Number of obs   =       165

                         ——————————— Z(t) has t-distribution ——————————
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.788            -2.351            -1.655            -1.287
------------------------------------------------------------------------------
p-value for Z(t) = 0.0030

. dfuller D.Pub_Dbt_It, noconstant lags(13)

Augmented Dickey-Fuller test for unit root         Number of obs   =       165

                         ——————————— Interpolated Dickey-Fuller ——————————
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -0.821            -2.591            -1.950            -1.614
```

Figure C.21: Augmented Dickey-Fuller test for the First Difference of the Italian Gross Monthly Public Debt

Source : Our own elaboration

```
. zandrews D.Pub_Dbt_It, break(trend)

Zivot-Andrews unit root test for  D.Pub_Dbt_It

Allowing for break in trend

Lag selection via TTest: lags of D.D.Pub_Dbt_It included = 1

Minimum t-statistic -12.095 at 634  (obs 107)

Critical values: 1%: -4.93 5%: -4.42 10%: -4.11

. zandrews D.Pub_Dbt_It, break(intercept)

Zivot-Andrews unit root test for  D.Pub_Dbt_It

Allowing for break in intercept

Lag selection via TTest: lags of D.D.Pub_Dbt_It included = 1

Minimum t-statistic -12.315 at 654  (obs 127)

Critical values: 1%: -5.34 5%: -4.80 10%: -4.58

. zandrews D.Pub_Dbt_It, break(both)

Zivot-Andrews unit root test for  D.Pub_Dbt_It

Allowing for break in both intercept and trend

Lag selection via TTest: lags of D.D.Pub_Dbt_It included = 1

Minimum t-statistic -12.288 at 654  (obs 127)

Critical values: 1%: -5.57 5%: -5.08 10%: -4.82

.
```

Figure C.22: Zivot-Andrews test for the First Difference of the Italian Gross Monthly Public Debt
Source : Our own elaboration

C.5 10 Years Spread between Italian and German bonds

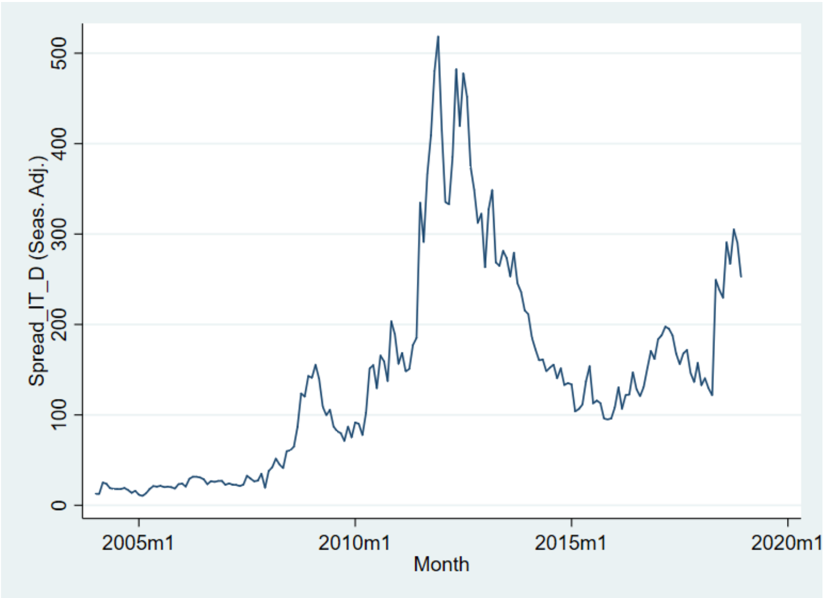

Figure C.23: Line Plot of the 10 Years Spread between Italian and German bonds
Source : Our own elaboration

Figure C.24: Sample Autocorrelation Function of the 10 Years Spread between Italian and German bonds
Source : Our own elaboration

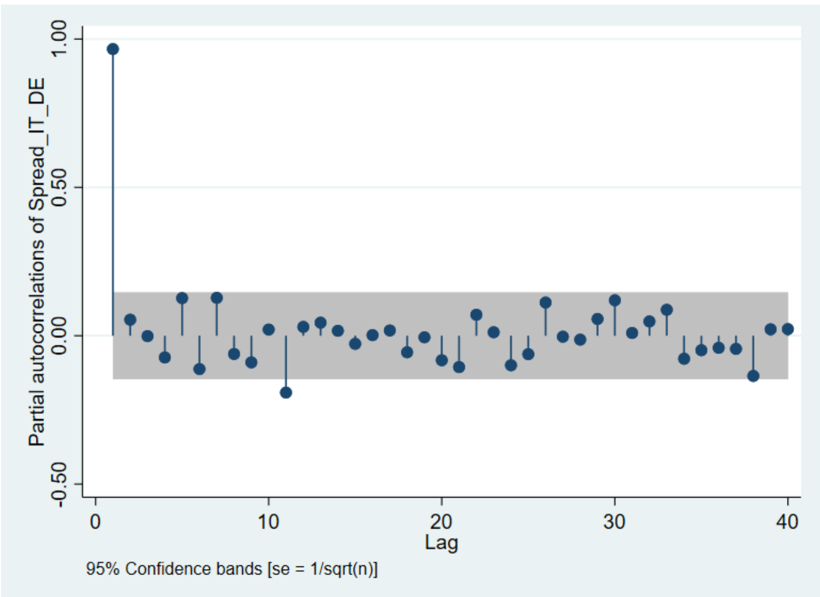

Figure C.25: Sample Partial Autocorrelation Function of the 10 Years Spread between Italian and German bonds
Source : Our own elaboration

```
. dfgls Spread_IT_D

DF-GLS for Spread_IT_DE                              Number of obs =   166
Maxlag = 13 chosen by Schwert criterion

               DF-GLS tau      1% Critical       5% Critical      10% Critical
  [lags]     Test Statistic        Value             Value             Value
------------------------------------------------------------------------------
    13           -2.018           -3.484            -2.804            -2.527
    12           -2.063           -3.484            -2.819            -2.540
    11           -2.166           -3.484            -2.833            -2.554
    10           -2.243           -3.484            -2.847            -2.566
    9            -1.868           -3.484            -2.860            -2.579
    8            -1.917           -3.484            -2.873            -2.591
    7            -1.762           -3.484            -2.886            -2.602
    6            -1.671           -3.484            -2.898            -2.613
    5            -1.910           -3.484            -2.909            -2.623
    4            -1.722           -3.484            -2.920            -2.633
    3            -1.972           -3.484            -2.930            -2.642
    2            -1.849           -3.484            -2.939            -2.651
    1            -1.862           -3.484            -2.948            -2.659

Opt Lag (Ng-Perron seq t) = 10 with RMSE  28.81853
Min SC   =   6.88228 at lag  1 with RMSE  30.27569
Min MAIC =   6.87603 at lag  1 with RMSE  30.27569
```

Figure C.26: Augmented Dickey-Fuller GLS test for the 10 Years Spread between Italian and German bonds

Source : Our own elaboration

```
                          ---------- Interpolated Dickey-Fuller ----------
                 Test        1% Critical      5% Critical     10% Critical
              Statistic         Value            Value            Value
--------------------------------------------------------------------------
 Z(t)           -1.750          -3.488           -2.886           -2.576
--------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.4058

. dfuller Spread_IT_D, trend lags(13)

Augmented Dickey-Fuller test for unit root         Number of obs   =      166

                          ---------- Interpolated Dickey-Fuller ----------
                 Test        1% Critical      5% Critical     10% Critical
              Statistic         Value            Value            Value
--------------------------------------------------------------------------
 Z(t)           -2.032          -4.018           -3.441           -3.141
--------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.5836

. dfuller Spread_IT_D, drift lags(13)

Augmented Dickey-Fuller test for unit root         Number of obs   =      166

                          ----------- Z(t) has t-distribution -----------
                 Test        1% Critical      5% Critical     10% Critical
              Statistic         Value            Value            Value
--------------------------------------------------------------------------
 Z(t)           -1.750          -2.351           -1.655           -1.287
--------------------------------------------------------------------------
p-value for Z(t) = 0.0411

. dfuller Spread_IT_D, noconstant lags(13)

Augmented Dickey-Fuller test for unit root         Number of obs   =      166

                          ---------- Interpolated Dickey-Fuller ----------
                 Test        1% Critical      5% Critical     10% Critical
              Statistic         Value            Value            Value
--------------------------------------------------------------------------
 Z(t)           -0.473          -2.591           -1.950           -1.614
```

Figure C.27: Augmented Dickey-Fuller test for the 10 Years Spread between Italian and German bonds
Source : Our own elaboration

```
. zandrews Spread_IT_D, break(trend)

Zivot-Andrews unit root test for  Spread_IT_DE

Allowing for break in trend

Lag selection via TTest: lags of D.Spread_IT_DE included = 0

Minimum t-statistic -2.791 at 2011m10  (obs 94)

Critical values: 1%: -4.93 5%: -4.42 10%: -4.11

. zandrews Spread_IT_D, break(intercept)

Zivot-Andrews unit root test for  Spread_IT_DE

Allowing for break in intercept

Lag selection via TTest: lags of D.Spread_IT_DE included = 0

Minimum t-statistic -3.677 at 2013m10  (obs 118)

Critical values: 1%: -5.34 5%: -4.80 10%: -4.58

. zandrews Spread_IT_D, break(both)

Zivot-Andrews unit root test for  Spread_IT_DE

Allowing for break in both intercept and trend

Lag selection via TTest: lags of D.Spread_IT_DE included = 0

Minimum t-statistic -3.403 at 2013m4  (obs 112)

Critical values: 1%: -5.57 5%: -5.08 10%: -4.82
```

Figure C.28: Zivot-Andrews test for the 10 Years Spread between Italian and German bonds
Source : Our own elaboration

C.6 First Difference of the 10 Years Spread

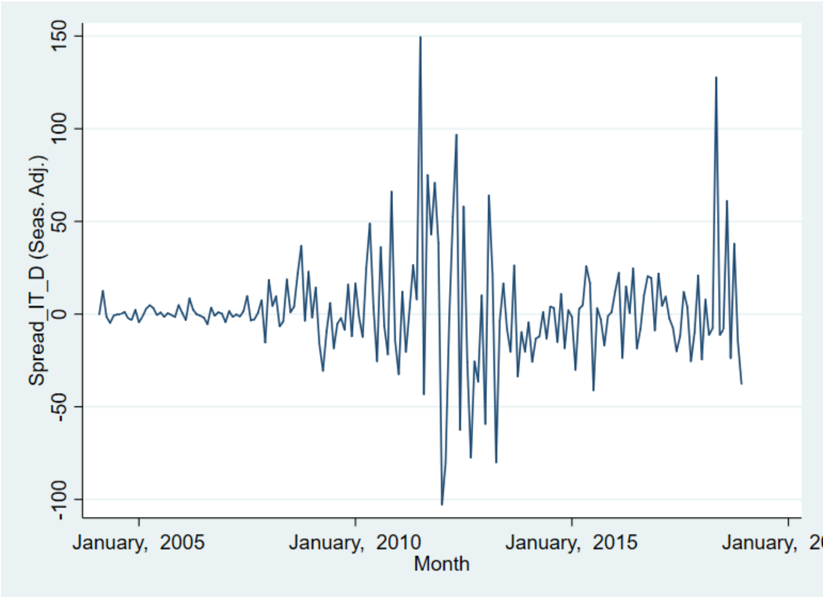

Figure C.29: Line Plot of the First Difference of the 10 Years Spread between Italian and German bonds
Source : Our own elaboration

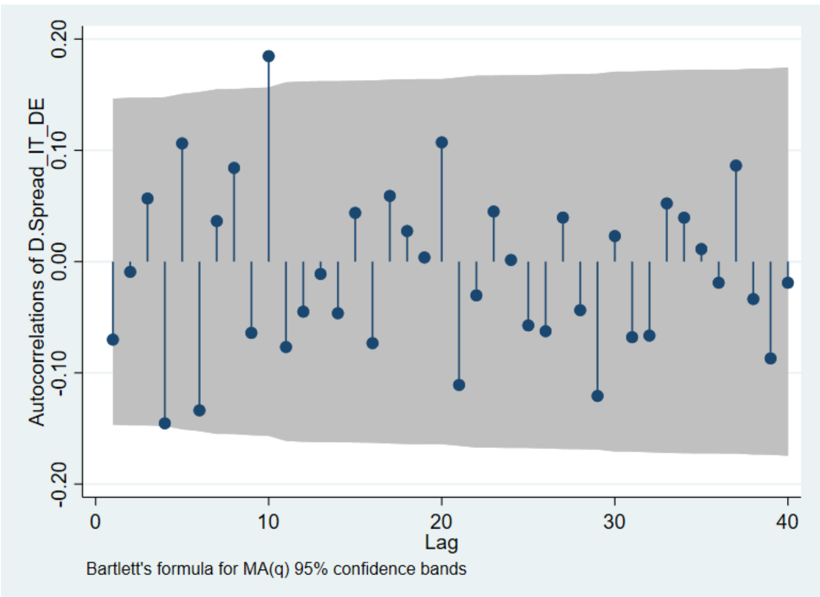

Figure C.30: Sample Autocorrelation Function of the First Difference of the 10 Years Spread between Italian and German bonds
Source : Our own elaboration

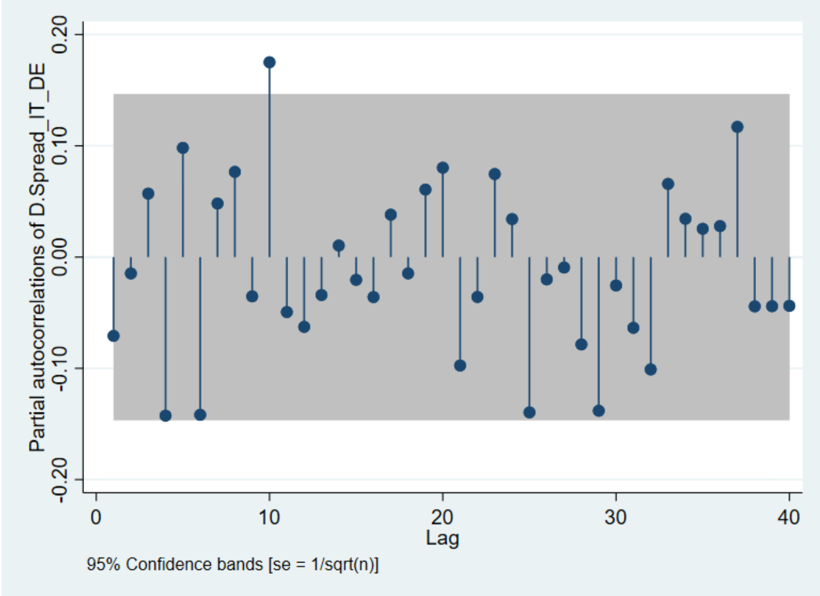

Figure C.31: Sample Partial Autocorrelation Function of the First Difference of the 10 Years Spread between Italian and German bonds
Source : Our own elaboration

DF-GLS for D.Spread_IT_DE Number of obs = 165
Maxlag = 13 chosen by Schwert criterion

[lags]	DF-GLS tau Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
13	-2.679	-3.485	-2.803	-2.526
12	-2.865	-3.485	-2.818	-2.540
11	-2.918	-3.485	-2.833	-2.553
10	-2.874	-3.485	-2.847	-2.566
9	-2.870	-3.485	-2.860	-2.579
8	-3.731	-3.485	-2.873	-2.591
7	-3.891	-3.485	-2.886	-2.602
6	-4.659	-3.485	-2.898	-2.613
5	-5.475	-3.485	-2.909	-2.624
4	-5.287	-3.485	-2.920	-2.634
3	-6.780	-3.485	-2.930	-2.643
2	-6.855	-3.485	-2.940	-2.651
1	-9.125	-3.485	-2.949	-2.659

Opt Lag (Ng-Perron seq t) = 9 with RMSE 29.61948
Min SC = 6.930507 at lag 1 with RMSE 31.00996
Min MAIC = 8.053907 at lag 9 with RMSE 29.61948

Figure C.32: Augmented Dickey-Fuller GLS test for the First Difference of the 10 Years Spread between Italian and German bonds
Source : Our own elaboration

```
Augmented Dickey-Fuller test for unit root          Number of obs   =       165

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -3.174            -3.488            -2.886            -2.576
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0215

. dfuller D.Spread_IT_D, trend lags(13)

Augmented Dickey-Fuller test for unit root          Number of obs   =       165

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -3.159            -4.018            -3.441            -3.141
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0929

. dfuller D.Spread_IT_D, drift lags(13)

Augmented Dickey-Fuller test for unit root          Number of obs   =       165

                               ----------- Z(t) has t-distribution -----------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -3.174            -2.351            -1.655            -1.287
------------------------------------------------------------------------------
p-value for Z(t) = 0.0009

. dfuller D.Spread_IT_D, noconstant lags(13)

Augmented Dickey-Fuller test for unit root          Number of obs   =       165

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -3.116            -2.591            -1.950            -1.614
```

Figure C.33: Augmented Dickey-Fuller test for the First Difference of the 10 Years Spread between Italian and German bonds
Source : Our own elaboration

```
. zandrews D.Spread_IT_D, break(trend)

Zivot-Andrews unit root test for  D.Spread_IT_DE

Allowing for break in trend

Lag selection via TTest: lags of D.D.Spread_IT_DE included = 3

Minimum t-statistic -7.412 at December,  2014  (obs 132)

Critical values: 1%: -4.93 5%: -4.42 10%: -4.11

. zandrews D.Spread_IT_D, break(intercept)

Zivot-Andrews unit root test for  D.Spread_IT_DE

Allowing for break in intercept

Lag selection via TTest: lags of D.D.Spread_IT_DE included = 3

Minimum t-statistic -8.967 at January,  2012  (obs 97)

Critical values: 1%: -5.34 5%: -4.80 10%: -4.58

. zandrews D.Spread_IT_D, break(both)

Zivot-Andrews unit root test for  D.Spread_IT_DE

Allowing for break in both intercept and trend

Lag selection via TTest: lags of D.D.Spread_IT_DE included = 3

Minimum t-statistic -8.947 at January,  2012  (obs 97)

Critical values: 1%: -5.57 5%: -5.08 10%: -4.82
```

Figure C.34: Zivot-Andrews test for the First Difference of the 10 Years Spread between Italian and German bonds
Source : Our own elaboration

Appendix D

Cointegration Analysis

In order to check for cointegration between our variables we need to understand if a linear combination of them is described by a process of a lower order of integration. We aplly, for this puropose, a two step procedure called Engle-Granger Augmented Dickey-Fuller test for cointegration (EG-ADF test).
First, we need to estimate a linear OLS regression including only our independent variables in level form (integrated of order 1) and a constant. Basically:

$$PU_t = \beta_0 + \beta_1 PublicDebt_t + \beta_2 Spread_t + \mu_t \tag{D.1}$$

From the previous model's estimations, we predict the residuals and we perform a unit root test so as to assess the stationarity of their process. If residuals are stationary, then we need to develop a longer procedure aimed at estimating the cointegration factor and add it to our model (Stock and Watson DOLS procedure), otherwise we simply conclude that cointegration is not present and we can work with differentiated series (if they are integrated of order zero). However, critical values are not the standard values that STATA computes for the Augmented Dickey-Fuller but they have been specifically taken from an econometrics book which summarizes the critical values for residuals stationarity test, according to the number of variables included in the OLS regression.

Formally, we predict the residuals:

$$u_t = PU_t - \hat{PU_t} \tag{D.2}$$

where $\hat{PU_t}$ are the fitted values of our model (D.1), that is:

$$\hat{PU_t} = \hat{\beta}_0 + \hat{\beta}_1 PublicDebt_t + \hat{\beta}_2 Spread_t \tag{D.3}$$

and we perform an ADF test on the time series of the u_t looking at the following critical values:

Table D.1: Critical values for ADF test on residuals of a two variables linear time series regression

Test	Test-Statistic	1% Critical Value	5% Critical value	10% Critical value
ADF for residuals	-2.325	-4.36	-3.80	-3.52

Since the ADF statistic on the predicted residuals is higher than all the three critical values, we conclude that the process describing u_t is non-stationary therefore our variables do not suffer of cointegration. STATA output is reported below.

```
. reg Pen_Unc Pub_Dbt Spread_IT_DE

      Source |       SS           df       MS      Number of obs   =       180
-------------+----------------------------------   F(2, 177)       =      1.49
       Model |   444.22152         2  222.11076   Prob > F        =    0.2276
    Residual |  26342.2904       177   148.8265   R-squared       =    0.0166
-------------+----------------------------------   Adj R-squared   =    0.0055
       Total |  26786.5119       179  149.645318   Root MSE        =    12.199

------------------------------------------------------------------------------
     Pen_Unc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  Pub_Dbt_It |   3.04e-06   3.87e-06     0.79   0.433    -4.59e-06    .0000107
Spread_IT_DE |    .008028   .0094317     0.85   0.396    -.0105851    .0266411
       _cons |   34.35277   6.785993     5.06   0.000      20.9609    47.74464
------------------------------------------------------------------------------

. drop res

. predict res, residuals

. dfuller res, lags(13)

Augmented Dickey-Fuller test for unit root         Number of obs   =       166

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.325            -3.488            -2.886            -2.576
------------------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.1640
```

Figure D.1: Cointegration test: OLS estimation of the equation (D.1) and ADF on predicted residuals (D.2)