Prime-age labour supply responses to the transition from a DB to a NDC public pension system: evidence from Italy

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First draft: November 2017

This draft: September 2018

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Abstract

While pension reforms often comprise grandfathering clauses, meaning that cohorts affected by new provisions learn about them years before they come near retirement, whether changes in retirement rules affect prime-age labor supply is an under-explored question. In this paper I study prime-age labour supply responses to one of the most radical reforms of the public pension system: the transition from a defined-benedit (DB) to a notional defined-contribution (NDC) scheme. I focus on Italy's transition to the NDC system following the 1995 Dini pension reform, which tightened the link between benefits and contributions on top of reducing pension entitlements for most workers. By exploiting novel administrative data on workers' contribution histories and by comparing otherwise similar individuals who were either entirely (*fully DB* regime) or partially (*mixed DB-NDC* regime) grandfathered, I document mild positive effects on prime-age labour supply on the extensive and intensive margins, which emerge from the beginning and increase over time. Effects tend to be larger among low earners relative to high earners and, particularly in terms of labour earnings, among self-employed as opposed to employees. Female respond more than males and, although less robust as an evidence, responses tend to increase in the age at the reform.

JEL codes: J26, H55, M51, M12

Keywords: pension, social security, prime-age labour supply

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1 Introduction

How the architecture of public pension systems affects labour supply is a central question in labour and public economics. The interest in this topic has rekindled in recent years, as many countries have enacted pension reforms that aim at fostering elderly labour force participation and curtailing pension expenditures, to ensure the long-term financial sustainability of the system threatened by population aging (OECD (2017)). Pension reforms often comprise grandfathering clauses, meaning that pre-reform provisions continue to apply to older cohorts on the cusp of retirement. This implies that cohorts fully affected by the changes learn about them years before they come near retiring, sometimes in their prime-age. Despite this, the bulk of the literature has focused on evaluating the effects of pension reforms on older workers' labour supply decisions, namely the timing of retirement; not much attention has been devoted to study whether they trigger labour supply responses already during prime-age and how these responses unfold over time and the life-cycle.

It could be argued that during prime-age labour market attachment is so high and the salience of rules regulating an event far in time as retirement so low that labour supply responses would likely be negligible. I therefore address this question by studying whether prime-age labour supply reacts to one of the most radical reforms to the public pension system, which likely receives adequate echo among the general population: the transition from a defined-benefit (DB) scheme, whereby pension benefits are a fraction of average final or lifetime labour earnings, to a notional defined contribution (NDC) scheme, which instead tightly links entitlements to social security contributions. In particular, I study Italy's transition to the NDC scheme, started in the 1990s following the 1995 Dini pension reform. By tightening the link between pension benefits and contributions, transitions of this type could affect labour supply insofar as they reduce distortions from social security taxation (e.g. Liebman et al. (2009)). On top of that, given the parameters embedded in the computation of benefits according to DB and NDC rules, for most workers the NDC scheme yields less generous pension entitlements, which could affect labour supply as well.

The Dini pension reform entailed substantial grandfathering clauses. Specifically, individuals who had accumulated at least 18 years of contribution by 1995 were entirely grandfathered, meaning that their benefits would still be computed using DB rules (*fully DB* regime). Workers with less than 18 years of contributions were only partially grandfathered, as the new NDC method would apply to contributions accumulated from 1996 onward (*mixed DB-NDC* regime). Finally, individuals who entered the labour market after 1995 were entirely subject to the NDC method (*fully NDC* regime).

The existence of grandfathering clauses affording a different degree of exoneration generates changes in the tightness of the link between contributions and benefits as well as in the generosity of expected pension entitlements solely based on years of contributions accumulated by 1995. Moreover, most individuals around the threshold of 18 years of contributions were in their prime-age when the reform was announced. The design of the Dini pension reform thus provides an attractive setting to study whether substantial changes to retirement rules affect prime-age labour supply. In my empirical analysis I compare *treated* individuals who were barely assigned to the *mixed DB-NDC* regime, i.e. individuals with 17 to 18 (excluded) years of contributions by 1995, to *control* workers who barely remained subject the *fully DB* regime, i.e. those having 18 to 19 years of contributions by 1995. I restrict the attention to prime-age individuals aged 35 to 45 at the time of the reform.

I leverage previously unexploited full contribution histories for a random sample of Italian workers provided by the National Institute of Social Security (INPS). These records contain detailed information about all contribution spells of a given worker. Information about the length of each contribution episode allows to compute contributions accumulated by the end of 1995, thus distinguishing workers assigned on either the *fully DB* or the *mixed DB-NDC* regime. Moreover, I can derive measures of labour supply along both the extensive and the intensive margin, because I observe the number of days worked, and the associated labour income, as well as the number of days not covered by contributions, which I use as a proxy of inactivity. Figurative contributions accrue on workers' notional accounts in case of events such as unemployment or sickness episodes, which are therefore recorded as well.

I estimate a generalized difference-in-difference model over the period 1990-2011. I also present a fully dynamic specification that provides a compact and compelling way to display the dynamic pattern of labour supply responses over time, as well as to check the plausibility of the parallel trend assumption. Preliminary findings suggest that the switch from a DB to a NDC public pension system leads to mild labour supply responses during prime age, along both the extensive and the intensive margin. In particular, it leads to a slight increase of the probability of working at least one day in a given year. It also modestly increases the number of days worked, while decreasing days not covered by contributions. As a consequence, yearly labour earnings increase as well. Interestingly, the dynamic specification reveals that responses emerge already in the first years after the reform and then gradually increase over time.

I perform heterogeneity analysis along several dimensions. Because the accrual rate in the DB system declines as labour earnings increase, the switch to a NDC contribution-based formula entails a lower cut of pension entitlements, or event a gain, for high-earners. I indeed document that labour supply responses, always in absolute terms and in most case in percentage terms, are larger for individuals at the bottom and middle of the earnings distribution in the reform year. This could suggest that suggesting that individuals affected to a greater extent are more reactive. Because the social security tax rate is lower for self-employed than for employees, the switch affects the former more than the latter. I find that, whilst labour supply responses in terms of days worked or days of inactivity are only modestly larger for self-employed than for employees, the difference in the response of yearly labour earnings is far larger. While data do not provide information to ascertain the reason of such pattern, it could be that the tighter link between benefits and contributions induce self-employed, who could more easily under-report income, to declare more labour earnings. I also find that women are more responsive than men. Although the evidence is less robust, I also document that labour supply responses tend to increase with age at the time of the reform. This could be due by the fact that older cohorts among prime-age workers have fewer years left ahead during which they can adjust labour supply. It could also be the case that retirement rules become more salient as an individual ages. Finally, by proxying education with the age of the worker when she has her first year-round job spell, I finally document larger responses among high-educated workers.

This paper speaks to the literature that studies how public pension systems affect labour supply. Starting from the contribution of Krueger and Pischke (1992), who study how the elderly labour supply of the U.S "notch generation" changed in response to pension benefit cuts, a literature that exploits differential changes in retirement provisions among otherwise similar individuals induced by grandfathering clauses has developed (e.g. Mastrobuoni (2009), Liebman et al. (2009) Behaghel and Blau (2012), Staubli and Zweimüller (2013), Vestad (2013), Cribb et al. (2016), Seibold (2016), Lalive et al. (2017)). I build upon and add on this literature by looking at the anatomy and dynamics of prime-age labour supply responses.

The remainder of the paper is organized as follows. Section 2 provides an overview of the provisions contained in the pension reform; Section 3 describes the data and the master sample; Section 4 outlines the empirical strategy; Section 5 discusses the main findings; Section 6 concludes.

2 Setting: the 1995 Dini pension reform

The 1995 pension reform, named Dini after the then Prime Minister, was implemented against a backdrop of surging pension spending (totaling 14.9% of GDP in 1992, up from 5% in 1960) and large deficits, driven by an aging population and increasingly generous pension benefits (Brugiavini and Galasso (2004); Billari and Galasso (2009)).[1] The reform radically changed the architecture of the social security system, with the aim of curtailing expenditures and ensuring its long-term financial soundness. The main provision ushered the switch from a defined benefit (DB) to a notional defined contribution (NDC) scheme, whilst retaining a pay-as-you-go (PAYG) system.

The DB and NDC schemes entail different methods for computing yearly pension benefits (b), as explained in Bottazzi et al. (2006). Under the DB scheme pension entitlements are a percentage of a worker final L-year average labour earnings ($\bar{w}_L$).[2] The replacement rate depends on years of contributions (N) and on the accrual rate (p, *aliquota di rendimento*). The earnings-based formula therefore reads:

$$b = \rho N \bar{w}_L \tag{1}$$

Under the NDC scheme yearly pension benefits are tightly linked to contributions. Specifically, contributions ($\tau_t w_t$) accrue into a notional account, where they are first capitalized based on a 5-year moving average of the nominal GDP growth rate (g_t, *coefficiente di capitalizzazione*) and then transformed into yearly benefits according to a transformation coefficient (λ, *coefficiente di trasformazione*) that depends positively on age at retirement and negatively on life expectancy. The contribution-based formula therefore reads:

$$b = \lambda M = \lambda \Big\{ \sum_{t=0}^{t=R-1} \tau_t w_t \Big[\prod_{j=t+1}^{j=R} (1 + g_j) \Big] + \tau_R w_R \Big\} \tag{2}$$

[1]The provisions were contained in the law *335/1995*, which was passed on August 8th, 1995.

[2]Before being averaged, labour earnings are converted into year R euros, where R is the year of retirement, based on coefficients (ϕ, *coefficienti di rivalutazione*) that are released with a yearly frequency by the National Institute of Social Security (INPS).

where R is the retirement year.

Due to the existence of grandfathering clauses, the transition from the DB to the NDC regime affected different workers to a different extent. Workers were assigned to either of three regimes, depending on years of qualifying retirement contribution (N) accrued by December 1995:[3] *i) fully DB* regime if $N \geq 18$; *ii) mixed DB-NDC* regime if $0 < N < 18$; *iii) fully NDC* regime if $N = 0$, i.e. if they started working in 1996 or after. The first group of workers was entirely grandfathered, as the law prescribed that their pension benefits would still be computed according to DB rules; the second group of workers was partially grandfathered, according to a *pro-rata* method: DB rules would apply to contributions accumulated up to 1995, whereas NDC rules would apply to contributions accumulated from 1996 onward; the third group of workers was, on the other hand, fully affected: their pension entitlements would be entirely computed according to NDC rules. The existence of grandfathering clauses therefore generated discontinuities in the way pension benefits are computed that depended uniquely on years of contribution accrued by the end of 1995. In this paper I focus on the discontinuity around the threshold of 18 years of contributions.

In 2011 a far-reaching pension reform (the Fornero reform) prescribed that, only for the part of pension entitlements that depends on contribution spells starting in 2012, the NDC method would apply also to workers who were entirely grandfathered by the 1995 pension reform. For notational convenience I still define those workers as being subject to the *fully DB* regime; moreover, I restrict my analysis to the period 1990-2011.

Before the 1995 pension reform, and neglecting changes brought about by the 2011 pension reform, benefits would be computed according to the following formula:

$$b = \underbrace{\rho_A N_{t_0:1992} \bar{w}_A}_{\text{DB - Quota A}} + \underbrace{\rho_B N_{1993:R} \bar{w}_B}_{\text{DB - Quota B}} \tag{3}$$

According to pre-reform rules, pension entitlements are the sum of two "quotas". *Quota A* depends on the final 260-week (520-week) average labour earnings ($\bar{w}_A$) for employees (self-employed), on years of retirement contributions accumulated from the first working year (t_0) to the end of 1992 ($N_{t_0:1992}$) and on the accrual rate ρ_A. Earnings that concur to define $\bar{w}_A$ are converted into year R euros based on the inflation rate. ρ_A is 2% as long

[3] Qualifying retirement contributions include also contributions arising from figurative events (see Section 3), as well as contributions arising from episodes of *riscatto* (workers pay additional contributions to make years spent acquiring tertiary education count toward determining their retirement date.)

as $\bar{w}_A$ does not exceed a certain threshold (*tetto alla retribuzione pensionabile*), which is adjusted yearly to take into account inflation, and then declines for the exceeding portion of labour income until it halves (1%).[4] As far as *Quota B* is concerned, $\bar{w}_B$ is the final 520-week (780-week) average labour earnings for employees (self-employed) with at least 15 years of contributions by 1992; for other individuals is the average labour earnings over the last 260 workweeks (520 workweeks for self-employed) before 1993 as well as over the entire period spanning from 1993 to retirement. $N_{1993:R}$ indicates years of contributions from 1993 to retirement, while ρ_B is the accrual rate. Similarly to quota A, earnings that concur to define $\bar{w}_B$ are converted into year R euros based on the inflation rate, increased by a premium that is larger for earnings farther in time. Similarly to ρ_A, ρ_B is 2% as long as $\bar{w}_B$ does not exceed a certain time-varying threshold, while it declines until it more than halves (0.9%) for the portion of $\bar{w}_B$ over that cutoff.[5]

Following the 1995 Dini pension reform, pension entitlements for workers subject to the *fully DB* system are still computed according to formula (3). For workers subject to the *mixed DB-NDC* system, on the other hand, pension benefits are computed according to the following formula:

$$b = \underbrace{\rho_A N_{t_0:1992} \bar{w}_A}_{\text{DB - Quota A}} + \underbrace{\rho N_{1993:1995} \bar{w}_B}_{\text{DB - Quota B}} + \underbrace{\lambda M_{N_{1996:R}}}_{\text{NDC}} \tag{4}$$

Notably, *Quota B* concurs with a much lower weight into the determination of pension entitlements, as it only takes into account contributions accumulated between 1993 and 1995. On the other hand, the NDC computation method applies to all contributions accumulated from 1996 onward. The social security tax rate τ that determines the amount of contributions is currently 33% for employees, while it is 24% for self-employed. The transformation coefficient λ is updated regularly to take into account increasing life expectancy. In 2018, for example, it is 4.589% for individuals retiring at age 60 and 5.326% for those retiring at age 65.

The tight link between contributions and pension entitlements embedded in the NDC

[4] In 2018, ρ_A is 2% as long as $\bar{w}_A \leq 46630$ euros; it then declines to 1.5% for the portion of labour earnings between 46630 and 62017.90 euros and to 1.25% for the portion between 62017.90 and 77405.8 euros. On the fraction of earnings exceeding the last threshold it halves to 1%.

[5] In 2018, ρ_B is 2% as long as $\bar{w}_B \leq 46630$ euros; it then declines to 1.6% for the portion of labour earnings between 46630 and 62017.90 euros, to 1.35% for the portion between 62017.90 and 77405.8 euros, and to 1.10% for the portion between 77405.8 and 88597 euros. The accrual rate on the part of $\bar{w}_B$ that exceeds the last threshold is 0.9%.

computation method yields for most workers less generous pension benefits than the DB method, which instead is based on average labour earnings over a given period of time. Only high earners workers may gain from the NDC method, due to the decreasing accrual rate that applies to high average labour earnings in the DB regime. In Section 3 I simulate the expected change in yearly pension for workers subject to the *mixed DB-NDC* regime: according to my computations, around 3% of workers in my master sample would expect a reduction of their pension entitlements. Grandfathering clauses therefore generate variations in expected social security wealth among individuals that, around the threshold of 18 years of contributions, would otherwise be similar. Moreover, most workers around such threshold are prime-age, allowing to study the dynamic of their labour supply responses over the life-cycle.

3 Data and sample

The paper leverages previously unexploited high-quality administrative data provided by the Italian Institute of Social Security (INPS), consisting in the full contribution histories for a random sample of Italian workers.[6] The unit of observation is the single contribution spell within any given year. The information provided is the following: the number of qualifying weeks of contributions; the event triggering the payment of contributions and the monetary value of the contribution; the retirement fund where the contribution is paid (e.g. the fund for private sector employees, for public sector employees, for self-employed). The events that trigger the payment of contributions are of two types: *effective* and *figurative*. *Effective* events consists in paid work, on which the social security tax is levied; *figurative* events are circumstances under which the the employer and/or the employee do not pay social security taxes, but contributions are nonetheless accumulated on workers' notional accounts. The main *figurative* events are maternity, sickness or injury, unemployment and short-time work. The importance of observing contribution histories is twofold: first, it allows to define *treated* and *control* workers by computing weeks of retirement contribution accumulated by 1995; second, it allows to track yearly labour earnings and weeks worked, as well as periods of absence from work, unemployment and inactivity.[7]

[6] I will soon have access to records for the universe of workers around the threshold of 18 years of contributions.

[7] A person is defined inactive in a given period if there exist no contribution record. This is different from the official definition of inactivity that can be recovered from Labour Force Surveys. The main

For workers employed in the private non-agricultural sector also matched employer-employee records are available. They contain additional information about the occupation of the worker (blue-collar, white-collar or manager), whether she works full-time or part-time, as well as match-specific yearly earnings and days worked. This dataset is available for the period 1990-2015.[8] The worker register finally allows to retrieve the main demographic characteristics.

Drawing on this information, I build the master sample for the analysis in the following way. First, I compute for every worker total weeks of retirement contributions accrued by the end of 1995. I then restrict the attention to the sample of workers who lie in a 1-year window on either side of the threshold that determines being subject to either the *fully DB* regime or the *mixed DB-NDC* regime. I therefore compare *treated* workers who were barely assigned to the *mixed* regime, i.e. individuals who had accumulated from 17 to 18 (excluded) years of retirement contribution by 1995, to *control* workers who were barely assigned to the *fully DB* regime, i.e. individuals who had accumulated 18 (included) to 19 years of retirement contributions by 1995. Second, I restrict the attention to prime-age workers aged between 35 and 45 years old in 1995. This restriction also implies that the analysis will be carried out on a sample of workers with a relatively high labour market attachment in the pre-reform period.

Table 1 reports a set of descriptive statistics about baseline characteristics as of the reform year for workers in the master sample. The sample consists of 40173 workers, equally divided among the *treated* (19691) and the *control* group (20482). Consistently with the fact that they have very similar contribution histories up to 1995, workers in the *treated* and *control* group look very similar in the reform year. They are equally likely to be male and be born in Italy, as well as to have worked most of the time as employees in the 5-year period prior to the reform. Individuals subject to the *fully DB* regime are only 1 month older on average than workers subject to the *mixed DB-NDC* regime. While *controls* workers have higher yearly labour earnings and work more days during 1995, the difference is small. Around half of the workers classified as employees are found in the matched employer-employee dataset. Among those, the percentage of individuals working part time and the distribution of workers across the main occupation groups (blue-collar,

difference is that a person who actively looks for a job but is not eligible for non-work subsidies would be counted as inactive.

[8]This section draws heavily on the description of workers' contribution histories provided by Bovini and Paradisi (2017).

white-collar or manager) is very similar. Overall, Table 1 shows that workers subject to either regime in a small window around the threshold look very similar in the reform year.

Figure 1 displays the probability density function of contributions in the [16,20] interval. Concerns about the possible manipulation of weeks of contribution to strategically fall on either side of the threshold seem modest. The spike observed at exactly 18 years of contribution is not of very different magnitude with respect to the spikes observed at other integer years of contributions. This is likely due to the fact that most job relationships start in January, so that a disproportionate share of individuals will have an integer number of years of contributions by the end of a given year.[9] To further assuage concerns about both manipulation, due to strategic workers' behaviour, or mis-classification, due to possible measurement errors in my measure of contributions, in a robustness check I also re-run the analysis on a sample which excludes workers on a 4-week window on either side of the threshold.

For *treated* workers in the master sample I also provide an estimate about the extent to which yearly pension benefits are affected by the switch from the *fully DB* to the *mixed DB-NDC* regime. Specifically, I compute the ratio between post- and pre-reform entitlements stemming from contributions accrued in the post reform period:

$$\phi = 100 \times \frac{\lambda M_{N_{1996:R}}}{\rho_B N_{1996:R} \bar{w}_B} \tag{5}$$

This estimation entails computing expected yearly benefits stemming from post-reform contributions under the *fully DB* regime and the *mixed DB-NDC* regime and then taking the difference between the two. This in turn requires a set of assumptions about: *i)* the contribution history of the worker from 1996 onward; *ii)* the age at retirement; *iii)* workers' expectations about the evolution of parameters ρ, ϕ, τ, λ and g; *iv)* the path of inflation and nominal GDP growth past 2017, as they enter in the definition of parameters ρ and λ, respectively. Appendix A.1 provides details about these assumptions and the estimation procedure.

Figure 2 shows the probability density function of ϕ for *treated* workers. For around 97% of individuals the simulated change is negative, thus entailing a drop in expected pension

[9] In the period 1990-1997, for example, 33% of hiring took place in January.

entitlements. The median ratio is 78%.[10] Table 2 shows how the median ratio varies across the main socio-demographics groups. First, the ratio is lower for individuals in the bottom and middle terciles of the labour earnings distribution at the reform year, as compared to workers in the top tercile. As explained in Section 2, this mostly stems from the fact that the accrual rate in the DB system declines for high earners, while the parameters of the NDC system (i.e. the social security tax rate, the capitalization coefficient and the transformation coefficient) are invariant across levels of labour income. The ratio is also lower for women, who typically have lower earnings. Although the relationship is non monotonic, the ratio somewhat increases with age. Because the social security tax rate is lower for self-employed than for employees, the ratio if much lower for the former category. Finally, by proxying the education level based on the age at which an individual has her first year-round job spell, the ratio is higher for high-educated workers, as they tend both to have higher earnings and be older than less educated workers.

4 Empirical strategy

The paper compares labour supply trajectories of *treated* workers who were barely assigned to the *mixed DB-NDC* regime and *control* workers who were barely assigned to the *fully DB* regime, in the pre- and post-reform period: as described in Section 3, the former are those who had accrued 17 to 18 (excluded) years of contributions by 1995, while the latter are those who had accumulated 18 (included) to 19 years of contributions by 1995. As a first step, a generalized difference-in-differences model is estimated. The baseline specification is the following:

$$Y_{it} = \lambda_i + \gamma_t + \beta T_i \times Post + \varepsilon_{i,t} \tag{6}$$

i indexes the worker; t indexes the year; y_{it} is the outcome of interest; T_i is a dummy taking value 1 if the individual is treated and $Post$ is a dummy taking value 1 in the post-reform period. β is the coefficient of interest. λ_i and γ_t are individual and year fixed effects, respectively; the former control for time-invariant heterogeneity across workers, while the latter account for common year-specific shocks. $\varepsilon_{i,t}$ is the error term.[11]

[10] Alternative assumptions underlying the simulation of ϕ, detailed in Appendix A.1, leads to a percentage of individuals who benefit from the switch to the NDC regime no larger than 15% and a median ratio no larger than 85%.

[11] Standard errors are clustered at the individual level.

The existence of multiple pre- and post-reform period allows also to estimate a dynamic difference-in-differences model that reads:

$$Y_{it} = \lambda_i + \sum_{k=1990}^{2011} \beta_k \gamma_k + \sum_{k=1990}^{2011} \beta_k^T \gamma_k \times T_i + \varepsilon_{i,t} \tag{7}$$

The coefficients of interest are $\{\beta_k^T\}_{k=1990}^{k=2011}$, as they display the difference between *treated* and *control* workers in year k relative to the reform year (1995).[12] Identification in a difference-in-differences setting requires that *treated* and *control* workers were on parallel labour supply trends before the reform. The plausibility of this assumption can be investigated by looking at the pattern of leads coefficients$\{\beta_k^T\}_{k=1990}^{k=1995}$, which should be non significantly different from 0. On the other hand, the pattern of lagged coefficients $\{\beta_k^T\}_{k=1996}^{k=2011}$ shows whether the labour supply of *treated* and *control* workers differ in the post-reform period and how it evolves over time.

5 Findings

5.1 Main results

Table 3 reports difference-in-differences estimates based on equation (6) relative to the main outcomes: *a)* probability of working; *b)* days worked; *c)* days not covered by contributions, which proxy days of inactivity; *d)* yearly labour earnings. With regards to the extensive margin of labour supply, the probability of working at least one day in a given year slightly increases for *treated* workers relative to *control* ones in the post-reform period: the coefficient is 0.01 and is statistically significant at the 1% level. Benchmarked against the average probability of working for *treated* individuals in the pre-reform period, it would amount to a modest 0.97% increase. With regards to the intensive margin of labour supply, the number of days worked increases in the post-reform period by 5.12, while the number of days not covered by contributions decreases by 4.44 (both coefficients are statistically significant at the 1% level). Re-scaled against their average value among *treated* workers in the pre-reform period, these coefficients would translate into a 1.6% increase in the number of days worked and a 11% decrease in the number of days not covered by contribution. Finally, labour earnings of *treated* workers increase as well. The coefficient - statistically significant as the other at the 1% level - is 354.29 and amounts to

[12]For identification, β_{1995}^T is set equal to 0.

an increase equal to 1.7% of pre-reform earnings of *treated* workers. On the other hand, no significant effect emerges when looking at the number of days during which a worker receives a non-work subsidies or is absent from work due to illness or leave.[13]

Figure 3 plots coefficients from the dynamic specification outlined in (7). Leading coefficients are mostly not significantly different from 0, suggesting that the assumption of parallel trends in labour supply had the reform not passed seems plausible. Table 3 reports the p-values from the F-test of joint statistical significance on the leading coefficients: in all four cases, the test leads to fail to reject the null hypothesis. The post-reform coefficients, on the other hand, are informative about how labour supply responses documented in Table 3 unfold over time. They show that significant effects emerge already in the first post-reform year and then gradually increase in size over time.

Overall, according to evidence provided in Table 3 and Figure 3, the switch from the DB to the NDC system, which tightened the link between benefits and contributions on top of reducing pension entitlements for most workers, mildly affects prime-age labour supply both on the extensive and the intensive margin.

5.2 Robustness checks

5.2.1 Excluding workers very close to the threshold

To alleviate concerns about possible manipulation, due to workers' strategic behaviour, or mis-classification, due to measurement errors, of contribution weeks - the variable that determines the assignment to either the *fully DB* or the *mixed DB-NDC* regime - I re-run the analysis by excluding workers who are in a 4-week window on either side of the threshold. Figure A.1 in Appendix A.2 shows that estimates from this "donut" difference-in-differences exercise are very similar to the baseline ones.

5.2.2 Placebo threshold

As the selection into the treatment or the control group depends on years of contributions by 1995 - and, hence, from pre-reform labour supply - a natural concern is that the documented differences do not reflect the effect of the switch from the DB to the NDC system, but rather differential underlying trends among workers who were supplying a

[13]These last two outcomes present, however, some issues. The take-up and coverage of non-work subsidies was relatively low in the period under consideration. Moreover, very short periods of illness are not recorded in the contribution history. Estimates relative to these outcomes are not reported for brevity, but are available upon request.

different amount of labour before 1995. To assuage this concern I run a placebo exercise whereby I pretend that the threshold assigning workers to either the *fully DB* or the *mixed DB-NDC* regime is at 19 years of contributions rather than at 18. The placebo *treated* group then consists of workers with 18 to 19 (excluded) years of contributions by 1995, whereas the placebo *control* group is made of individuals with 19 (included) to 20 years of contributions by 1995.[14] Both groups are actually subject to the same regime (the *fully DB* one), so no significant difference should emerge around the reform year if responses documented in sub-section 5.1 are really due to the switch from the DB to the NDC system.

Table 4 shows that difference-in-differences estimates from the placebo exercise are smaller than those stemming from the real exercise. Moreover, coefficients are not statistically significant. The p-values associated to the F-test on the joint significance of leading coefficients are however low. To shed more light on the dynamic of placebo effects, Figure A.2 in Appendix A.2 plots coefficients from the dynamic specification. Placebo pre-reform coefficients are indeed less concentrated around 0 than true pre-reform coefficients (this is especially the case when looking at the probability of working and at days not covered by contributions). However, also placebo lagged coefficients are smaller, especially in the first years after the reform. Therefore, although the placebo exercise features worse pre-trends than the real exercise, it appears to suggest that the increased labour supply of real *treated* workers in the post-reform period at least partly reflects responses to the switch from the DB to the NDC scheme. Further analysis, when the universe of contribution histories becomes available, will be carried out to identify placebo *treated* and *control* groups who fare better in terms of pre-reform trends.

5.3 Heterogeneity

5.3.1 Labour earnings at the reform year

Because the accrual rate in the DB earning-based formula declines as labour earnings increase, the switch to the NDC method entails a lower loss, or even a gain, for high earners. It is therefore interesting to check whether labour supply responses are heterogeneous depending on the position a worker has in the earnings distribution. To this end, workers are divided into terciles based on the distribution of yearly labour earnings at

[14] I restrict the analysis to workers aged 36 to 46.

the reform year.[15] The general picture that emerges from Table 5 and Figure 4 is that labour supply responses of workers in the bottom and middle of the distribution tend to be larger. The probability of working increase by 0.014 and 0.015 for bottom and middle earners, while it increases by only a statistically insignificant 0.005 for top earners. Re-scaling coefficients relative to the average pre-reform labour market participation of each group of *treated* workers leads to increases in the order of 1.73%, 1.58% and 0.48%. The same ranking, both in absolute and percentage terms, holds true when considering as an outcome the number of days worked. They increase by 8.98 (3.54%) for bottom earners, by 5.38 (1.63%) for middle earners and by 2.44 (0.69%) for top earners. The decrease in the absolute number of days not covered by contributions is similarly highest for low-paid individuals and lowest for high-paid ones; coefficients re-scaled by pre-reform averages among *treated* workers provide a different ranking, that puts at the top middle earners and at the bottom low earners. Finally, labour earnings increase more for high-paid individuals when measured in euros, but in percentage terms - which is probably a better metric for this outcome - follow the same ranking as the probability of working and the number of days worked.

5.3.2 Occupation at the reform year

The social security tax rate for self-employed workers is lower than the one levied on employees. Because the NDC contribution-based formula tightly links pension entitlements to contributions, the expected drop of pension benefits is larger for the former category. It is therefore interesting splitting the sample according to the main occupation of the worker (employee or self-employed) in the pre-reform year.[16] According to Table 6, employees tend to respond less than self-employed. The probability of working increases by 0.004 (0.45% of its pre-reform average among *treated* workers) for the former and by 0.017 (1.891%) for the latter. In a similar way the number of days worked increases by 4.087 (1.35%) for employees and by 6.959 (2.19%) for self-employed. The corresponding figures for the number of days covered by contributions are - 3.048 (-6.19%) and - 7.021 (-15.17%), respectively. The p-values associated to the F-test of joint significance of the leading coefficients are however low (below 0.1 in two cases out of three) for employees

[15]In case a worker has no labour earnings in the reform year, labour earnings in the last working year are considered; they are discounted by a penalty factor which is quadratic in the distance between the reform year and the last working year, to take into account that periods of inactivity are typically associated with skill depreciation.

[16]If the worker has no contribution spells in 1995, he is assigned to the main occupation held in the last pre-reform year when he is observed.

and the visual inspection of the dynamic specification of Figure 5 reveals that post-reform coefficients are only slightly different. The outcome for which a large difference emerges (and for which leading coefficients for both groups of workers are very close to 0) is labour earnings. The coefficient is 6 times larger for self-employed (791.116) than for employees (133.116). Relative to average pre-reform earnings among *treated* self-employed and employees, coefficients translate into a 4.78% and 0.60% increase, respectively. While no definitive answer can be given as of why the differential response of earnings seems larger than the differential response of units of labour supply, it could be that the tighter link between benefits and contributions incentive self-employed, who could avoid to declare some income more easily, to report more labour earnings.

5.3.3 Gender

Table 7 shows difference-in-differences estimates when splitting the sample by gender. It emerges that responses of women are larger than responses of men, along both the extensive and the intensive margin, and both in absolute and percentage terms. The probability of working increase by 0.004 (0.41% of its average pre-reform value among *treated* male workers) for males and by 0.020 (2.4%) for females. *Treated* women work 10.61 more days (3.80%), while *treated* men work only 2.41 more days (0.73%). The same figures for the number of days not covered by contributions are -9.41 (-12.8%) and -2.04 (-6.97%), respectively. Yearly labour earnings increase by 487.3 euros for females (3.21%) and by 325.1 euros for males (1.38%).

Uncovering the reason underlying such heterogeneous responses requires further work. In particular, it would be interesting to understand whether they reflect a higher responsiveness of women to a given change in retirement rules - in line with literature documenting that female labour supply is more elastic - or rather stem from the fact that women on average face a higher drop in future pension entitlements than men, or a combination of the two. I therefore plan to perform this exercise also by using a continuous treatment, to check whether a 1% change in expected pension benefits has a differential impact on males and females; alternatively, when the universe of data becomes available, I could rely on the specification with the discrete treatment, but carry out the analysis within terciles of the labour earnings distribution, to confront individuals who experience a similar expected loss.

5.3.4 Age at the reform year

Among prime-age workers in the master sample, older workers have fewer working years left ahead during which they can adjust their labour supply, while younger cohorts can spread the adjustment over a longer period of time. Moreover, older workers are more likely to be self-employed and low earners, which face a larger change in the expected benefits. On the other hand, for older cohorts the fraction of contributions to social security subject to NDC rules is lower. For all these reasons, age is an interesting dimension along which to conduct an heterogeneity analysis. To this end, workers are divided into three age groups: 35-38, 39-42 and 43-45. Table 8 shows that the intensity of labour supply responses, along both the extensive and the intensive margin, appears to be increasing with age. The probability of working increases by virtually 0 for younger cohorts, by 0.008 (0.91% of its average pre-reform value) for individuals aged 39 to 42 and by 0.027 (3.59%) for the cohorts aged 43 to 45. The same figures for the number of days worked are 2.023 (0.60%), 4.55 (1.51%) and 12.84 (5.15%), respectively; as regards the number of days not covered by contributions, they are -1.18 (-6.7%), -4.08 (-7.7%) and -11.94 (-11.6%). The visual inspection of the dynamic specification in Figure 7, however, leads to some caution insofar as, especially looking at the number of days worked or not covered by contributions, leading coefficients for older workers may hint the existence of a trend (although the p-value on the test of joint significance of the leading coefficients is larger than 0.1). With this caveat in mind, these results would suggest that the smaller "horizon" ahead of older workers may be a relevant mechanism. Furthermore, because retirement is an event nearer in time for older workers, the heightened responses could also stem from the fact that they are more informed about the features and the consequences of the pension reform.

5.3.5 (A proxy of) education

Available data do not provide information about education levels. Nevertheless, I build a proxy measure of it by looking at which age a worker has her first year-round job spell. I classify workers as low- or middle-educated if such first spell occurs at age 23 of earlier and as high-educated if it takes place between age 24 and 30.[17] Because the master sample is comprised of individuals with 17 to 19 years of contributions at the reform year, it has to be noted that high-educated workers are on average older than less

[17] I make no guess about the education level of individuals who start working year-round after age 30.

educated ones. Moreover, they are more likely to be female and self-employed. Table 9 and Figure 8 show that high-educated individuals respond more than low educated ones. The probability of working increases by 0.006 (0.67% of the pre-reform average value among *treated* workers) for low-educated individuals, while it increases by 0.024 for high-educated individuals (2.54%). The number of days worked goes up by 4.16 for the former (1.37%) and by 11.81 (3.61%) for the latter. The same figures as regards the number of days not covered by contributions are -3.52 (-6.9%) and -10 (-35%), respectively. Finally, yearly labour earnings increase by 349 (1.75%) among low-educated workers and by 864 (3.83%). To what extent this reflects differences in other underlying observable characteristics is a question that I will explore in the further steps of the research.

6 Conclusions and planned extensions

Pension reforms often comprise grandfathering clauses, meaning that pre-reform rules continue to apply to older cohorts on the cusp of retirement. Workers fully affected by new provisions therefore learn about them years before they come near retirement, sometimes in their prime-age. In this paper I study prime-age labour supply responses to one of the most radical reforms of the public pension system: the transition from a DB scheme to a NDC scheme. Specifically, I leverage novel administrative data on workers' contribution histories to study Italy's transition to the NDC scheme, started in the 1990s following the 1995 Dini pension reform. The switch tightened the link between contributions to social security and retirement benefits; on top of that, for most workers the passage to the NDC system yields less generous pension entitlements.

By exploiting the existence of grandfathering clauses granting different degrees of exoneration to otherwise similar workers, I compare individuals barely assigned to the *mixed DB-NDC* regime to individuals who barely remained under the *fully DB* regime. I document that the transition from the DB to the NDC regime mildly affects prime-age labour supply, along both the extensive and the intensive margin. They emerge already in the first years after the reform and then gradually increase over time. This pattern may stem from a variety of reasons that is not possible to fully disentangle with the available data. It could be due to adjustment costs embedded in labour supply decisions. It could also reflect a process of gradual learning, whereby individuals learn more about their retirement prospects and the features of public pension system as they age.

Heterogeneity analysis reveals stronger effects on groups that on average would face a larger change in pension entitlements: low earners relative to high earners and, particularly so when looking at yearly labour earnings, self-employed as opposed to employees. Women responds more than males and, although less robust as an evidence, responses are increasing in the age at the time of the reform. By proxying education by the age when the first year-round job spell is observed, I also find larger responses among higher educated workers.

The work will be extended along several dimensions. First, the analysis will be replicated drawing on the universe of contribution histories of workers who are in a close window around the threshold of 18 years of contributions. The increase in sample size will help improving the precision of estimates, especially in the heterogeneity analysis.[18] Second, it will be enriched by a theoretical model to highlight the mechanisms underlying labour supply responses. Third, conditional on data availability, further measures of labour supply (including, for example, job-to-job transitions) will be built and the analysis will be extended to study household-level labour supply decisions.

[18]The project has been awarded a type B scholarship within the second VisitINPS Program Initiative.

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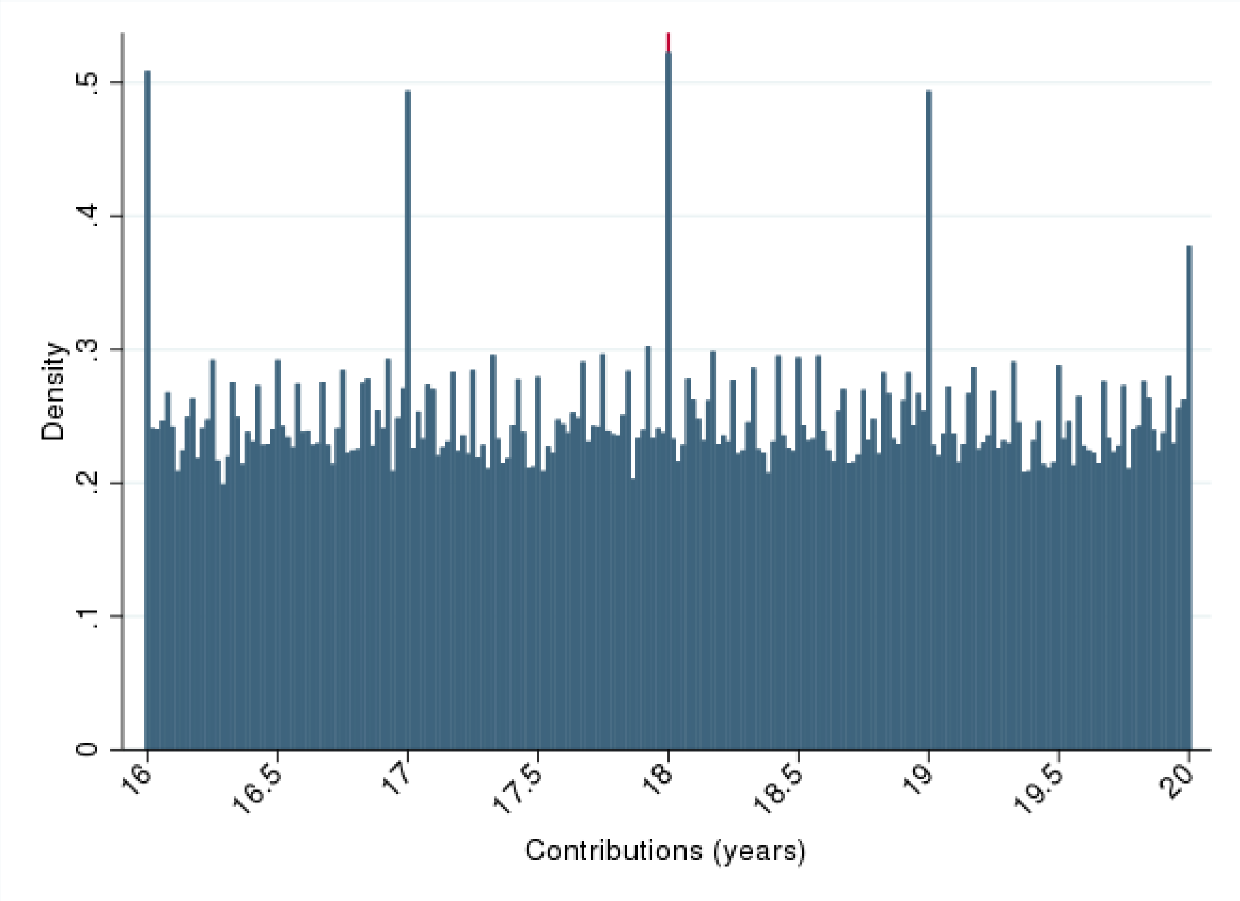
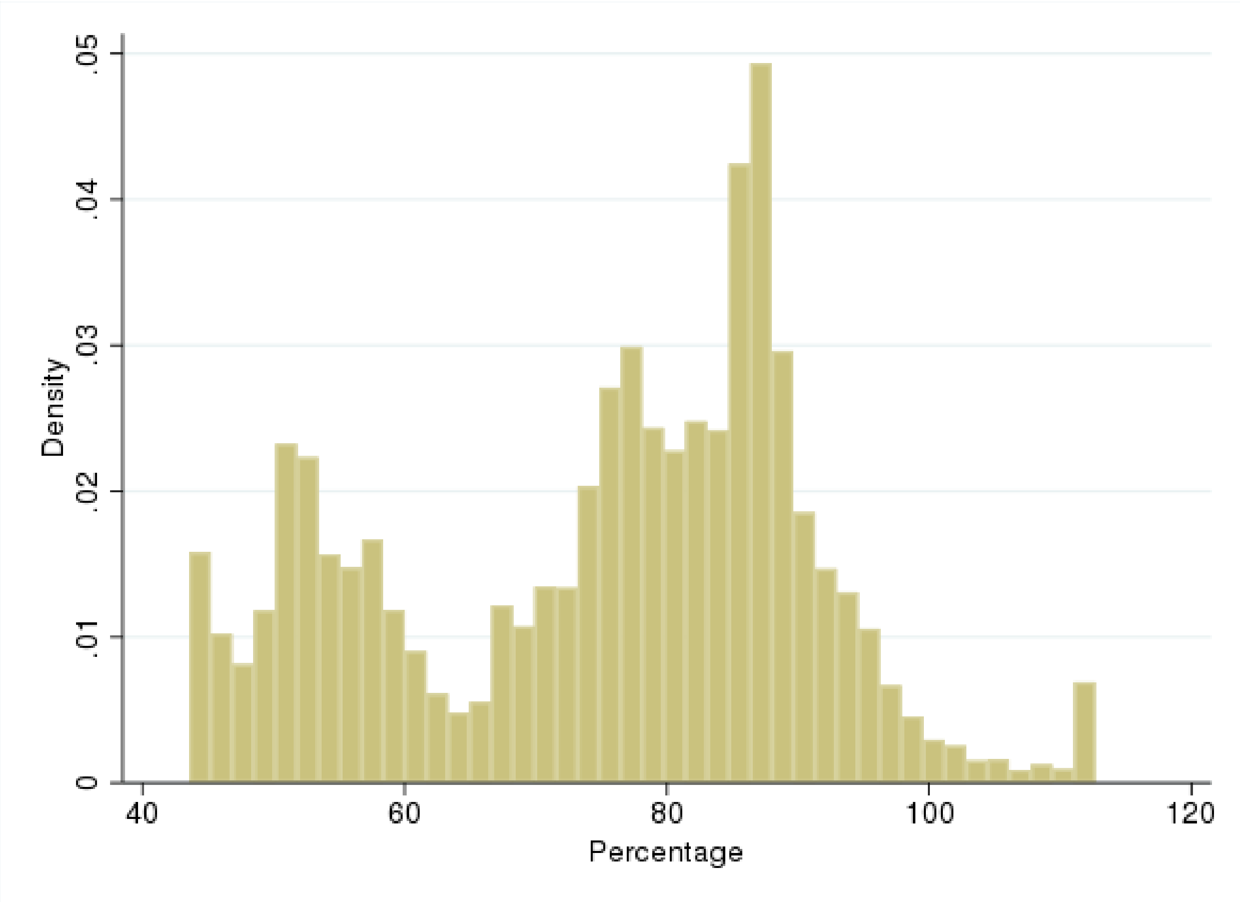
Figures

Figure 1: Distribution of years of contributions by the end of 1995 in the [16,20] interval



The Figure displays the density of years of contributions accrued by the end of 1995 in the [16,20] interval.

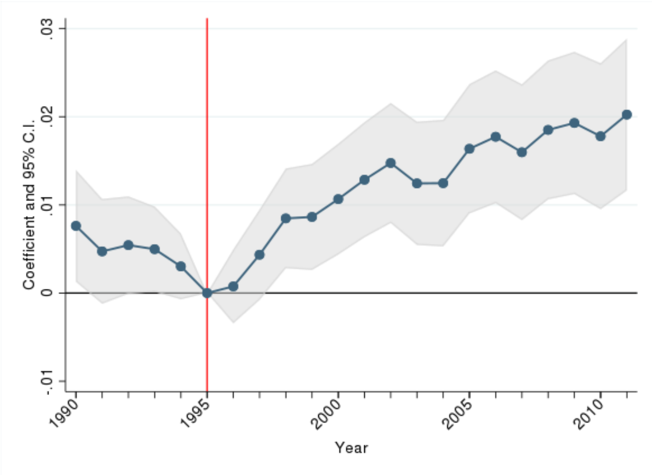
Figure 2: Ratio between post- and pre-reform pension benefits stemming from post-reform contributions



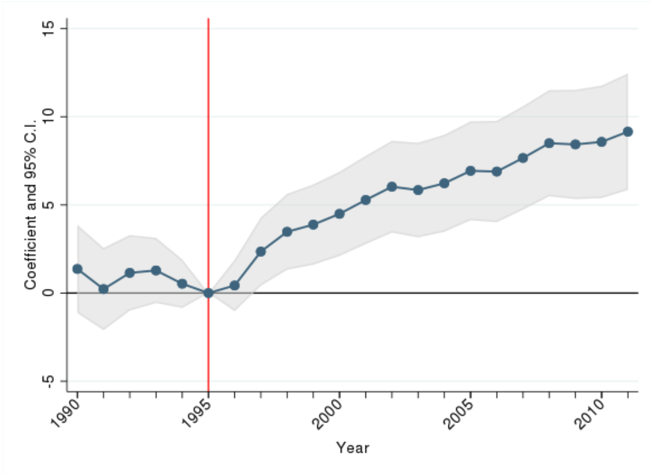
The figure displays the distribution of the drop in yearly earnings that stems from social security wealth accumulated from 1996 onward for workers subject to the *mixed DB-NDC* regime rather than to the *fully DB* regime. For representation purposes, the distribution is windsorized at the 1st and 99th percentile.

Figure 3: Dynamic difference-in-differences: main outcomes

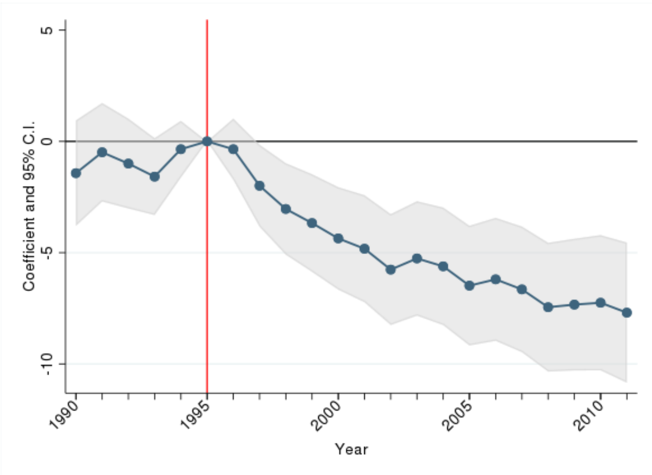
(a) Probability of working



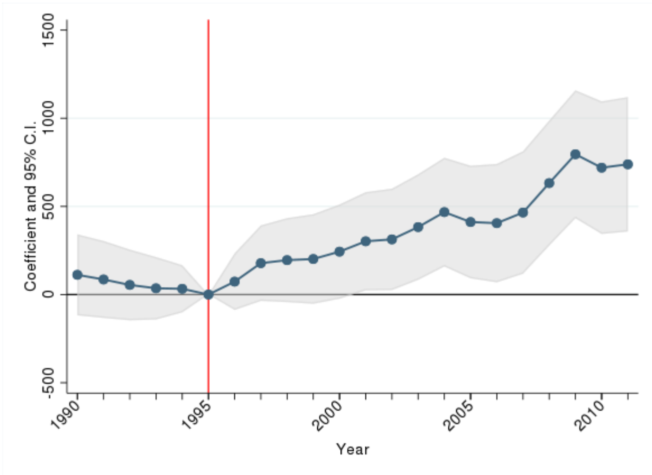
(b) Days worked



(c) Days not covered by contributions



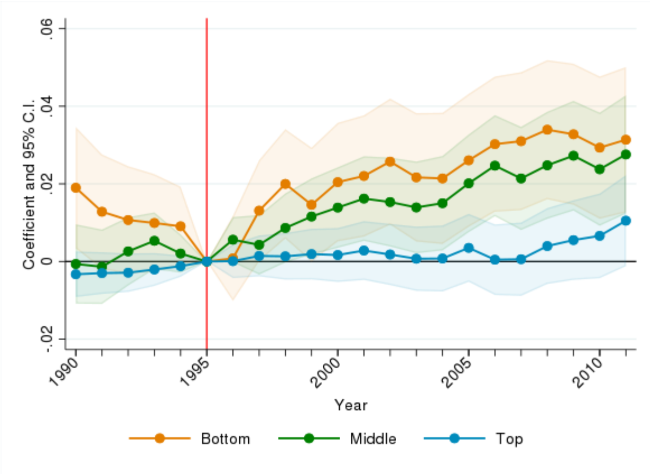
(d) Yearly labour earnings



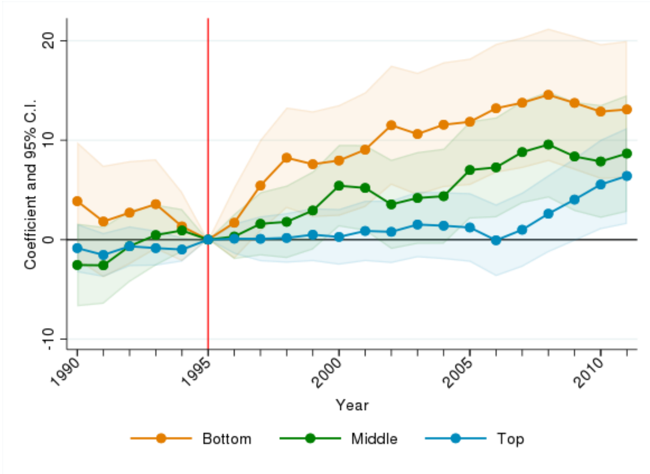
Figures (a) to (d) show the difference between *treated* and *control* workers in year k relative to the reform year (1995), alongside 95% confidence intervals, with respect to: *a)* probability of working; *b)* days worked; *c)* days not covered by contributions; *d)* yearly labour earnings. All specifications include individual and year fixed effects. Standard errors are clustered at the individual level.

Figure 4: Dynamic difference-in-differences:Heterogeneity by pre-reform labour earnings terciles

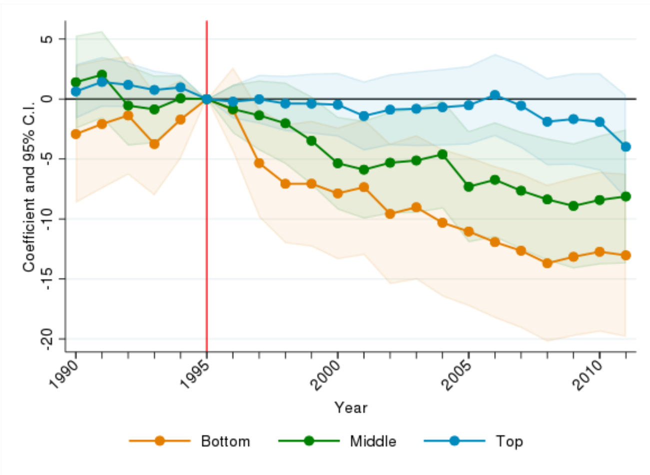
(a) Probability of working



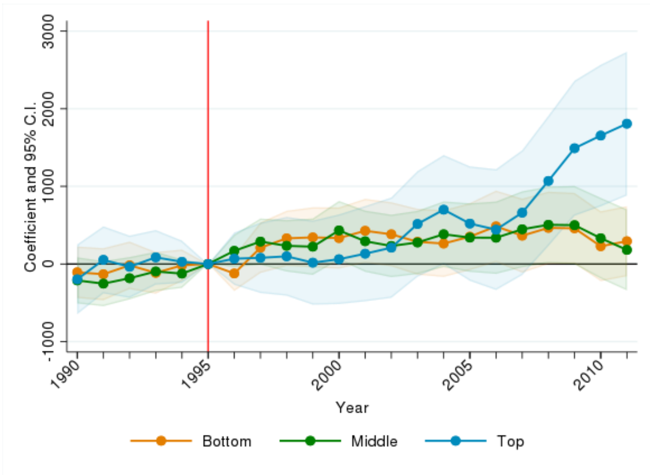
(b) Days worked



(c) Days not covered by contributions



(d) Yearly labour earnings



Figures (a) to (d) show the difference between *treated* and *control* workers in year k relative to the reform year (1995), alongside 95% confidence intervals, with respect to: *a)* probability of working; *b)* days worked; *c)* days not covered by contributions; *d)* yearly labour earnings. All specifications include individual and year fixed effects. Standard errors are clustered at the individual level.

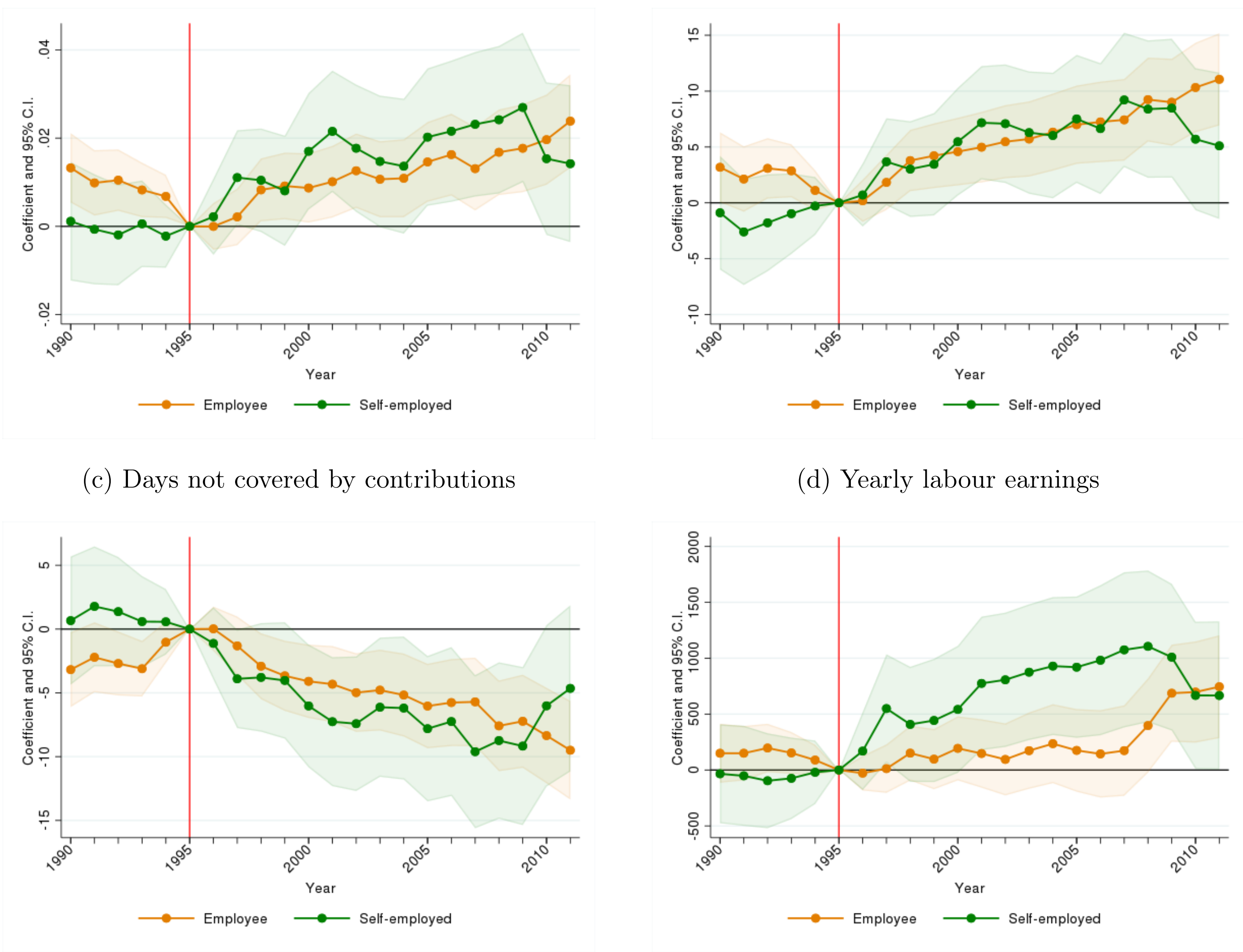
Figure 5: Dynamic difference-in-differences: heterogeneity by pre-reform working status

(a) Probability of working

(b) Days worked

(c) Days not covered by contributions

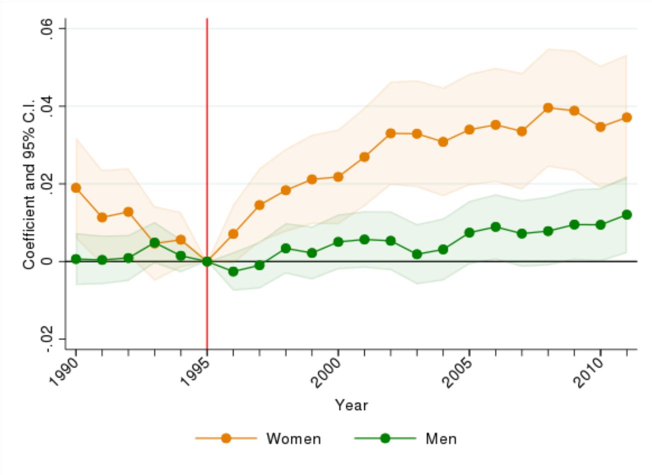
(d) Yearly labour earnings



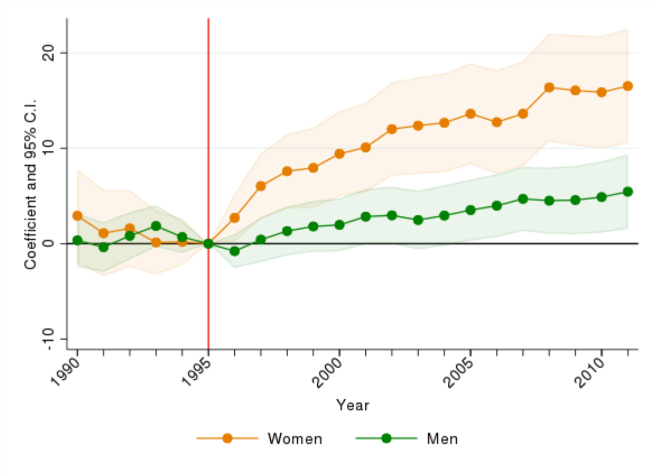
Figures (a) to (d) show the difference between *treated* and *control* workers in year k relative to the reform year (1995), alongside 95% confidence intervals, with respect to: *a)* probability of working; *b)* days worked; *c)* days not covered by contributions; *d)* yearly labour earnings. All specifications include individual and year fixed effects. Standard errors are clustered at the individual level.

Figure 6: Dynamic difference-in-differences: heterogeneity by gender

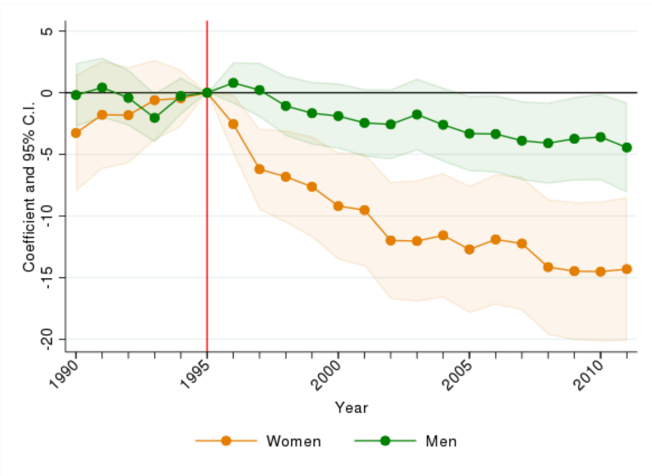
(a) Probability of working



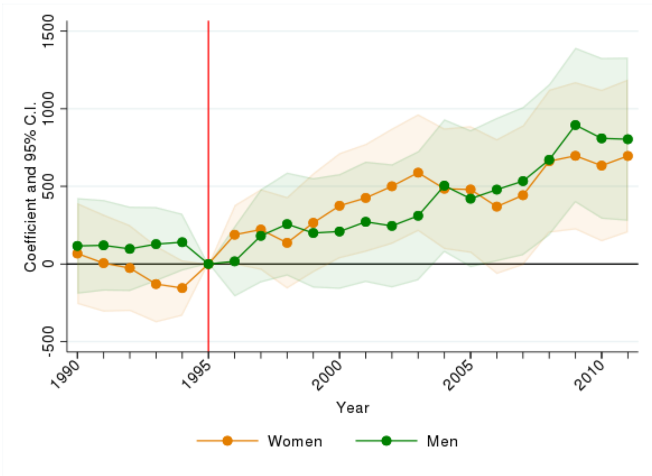
(b) Days worked



(c) Days not covered by contributions



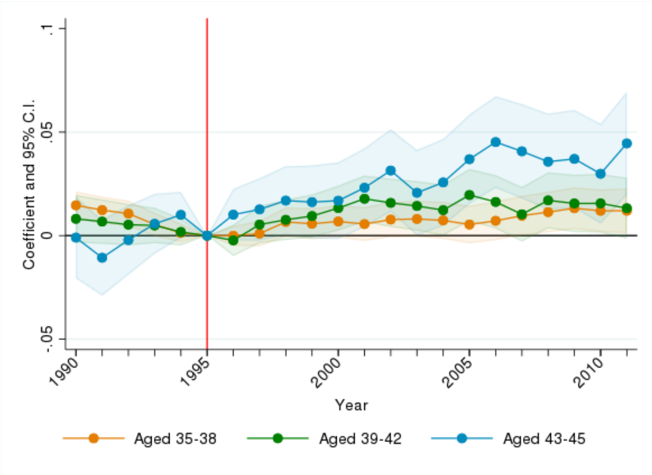
(d) Yearly labour earnings



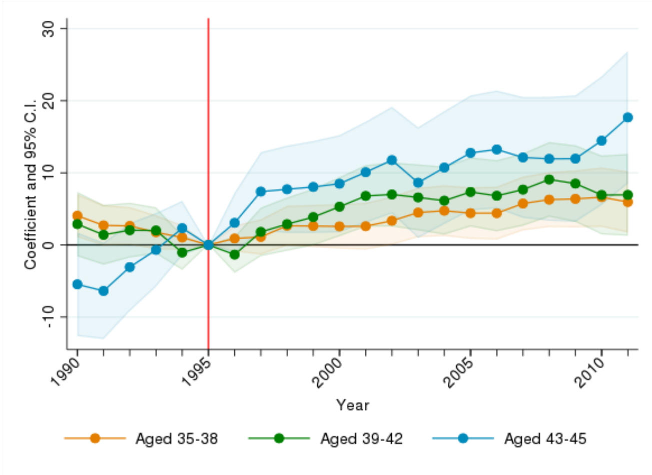
Figures (a) to (d) show the difference between *treated* and *control* workers in year k relative to the reform year (1995), alongside 95% confidence intervals, with respect to: *a)* probability of working; *b)* days worked; *c)* days not covered by contributions; *d)* yearly labour earnings. All specifications include individual and year fixed effects. Standard errors are clustered at the individual level.

Figure 7: Dynamic difference-in-differences: Heterogeneity by age in 1995

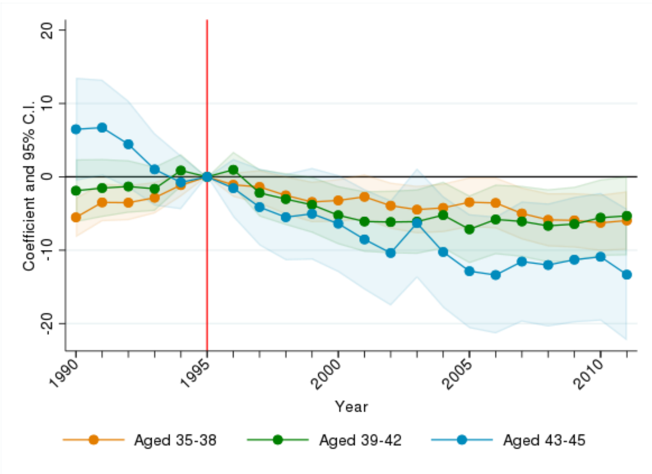
(a) Probability of working



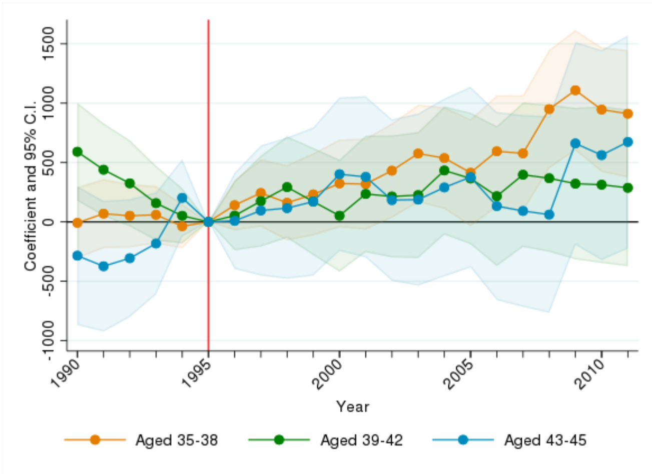
(b) Days worked



(c) Days not covered by contributions



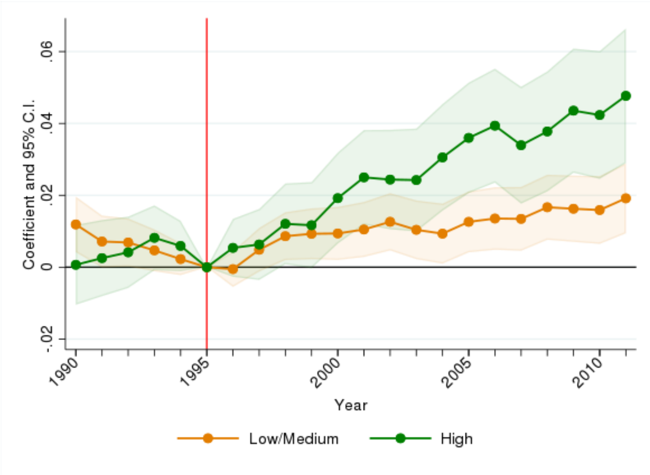
(d) Yearly labour earnings



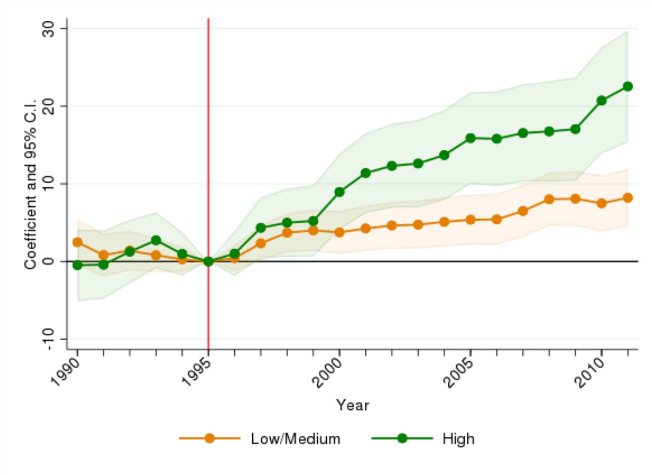
Figures (a) to (d) show the difference between *treated* and *control* workers in year k relative to the reform year (1995), alongside 95% confidence intervals, with respect to: *a)* probability of working; *b)* days worked; *c)* days not covered by contributions; *d)* yearly labour earnings. All specifications include individual and year fixed effects. Standard errors are clustered at the individual level.

Figure 8: Dynamic difference-in-differences: heterogeneity by education

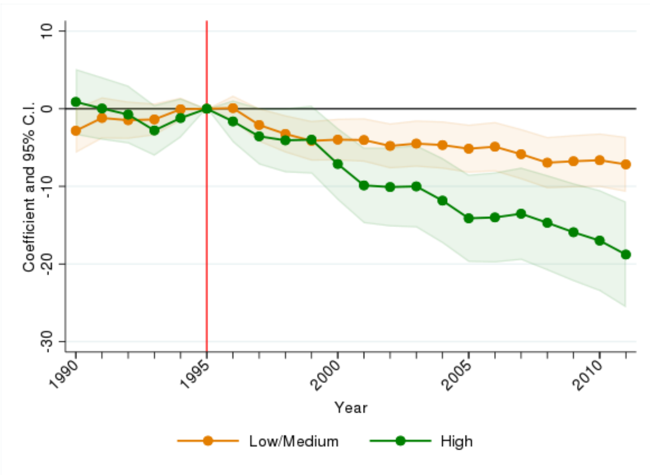
(a) Probability of working



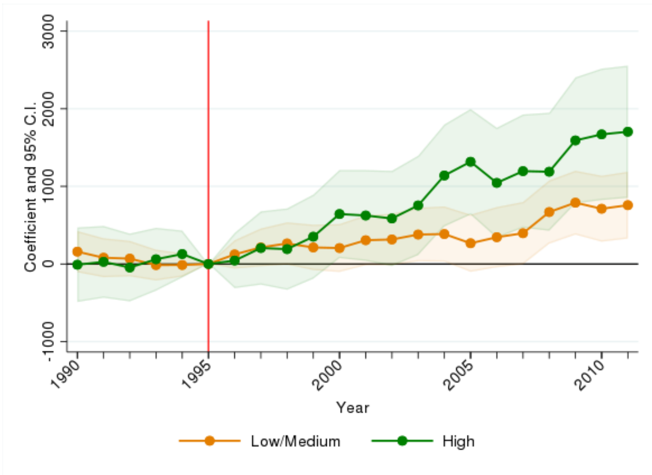
(b) Days worked



(c) Days not covered by contributions



(d) Yearly labour earnings



Figures (a) to (d) show the difference between *treated* and *control* workers in year k relative to the reform year (1995), alongside 95% confidence intervals, with respect to: *a)* probability of working; *b)* days worked; *c)* days not covered by contributions; *d)* yearly labour earnings. All specifications include individual and year fixed effects. Standard errors are clustered at the individual level.

Tables

Table 1: Master sample - Baseline characteristics at the reform year (1995)

	Treated		Control	
	mean	sd	mean	sd
Gender (1=male)	0.64	0.48	0.65	0.48
Age	39.22	2.98	39.39	2.97
Born in Italy	0.98	0.14	0.98	0.14
Labour market experience	17.53	2.18	18.48	2.11
Work at least one day	0.85	0.36	0.88	0.33
Yearly labour earnings	18772.95	16281.04	19707.13	16121.56
Days worked	297.01	135.73	309.48	124.99
Days without contributions	58.31	128.28	46.72	116.41
Employee	0.63	0.48	0.63	0.48
Self-employment	0.37	0.48	0.37	0.48
Employee and tracked in the MEE dataset	0.55	0.50	0.57	0.49
Full-time	0.92	0.27	0.92	0.27
Blue collar	0.52	0.50	0.54	0.50
White collar	0.45	0.50	0.44	0.50
Manager	0.01	0.11	0.01	0.11
Observations	19691		20482	

Notes: The table reports a set of descriptive statistics about baseline characteristics as of the reform year for workers in the master sample.

Table 2: Ratio between post-and pre-reform post-1996 pension entitlements for *treated* workers

Total	78.1
Labour earnings tercile pre-reform	
Bottom tercile	66
Middle tercile	78.4
Top tercile	87.2
Gender	
Female	73.4
Male	84.6
Age in 1995	
35	75.5
36	76.1
37	77.9
38	78.3
39	77.1
40	77.6
41	76.9
42	78.7
43	80.3
44	81.4
45	83
Working status pre-reform	
Employee	83.6
Self-employed	54.7
Education	
Low/middle	76.7
High	83

Notes: The table reports the simulated median ratio between post- and pre-reform pension entitlements stemming from contributions accrued in the post-reform period.

Table 3: Difference-in-differences estimates: main outcomes

	Prob. of working	Days worked	Days w/out. contr.	Labour earnings
DiD coeff	0.009 ***	5.126 ***	-4.438 ***	354.285 ***
	(0.003)	(1.010)	(0.979)	(125.229)
F-test leads	0.17	0.29	0.21	0.96
N	883806	883806	883806	846896

Note: The table reports the difference-in-differences estimates from equation (6). The outcomes of interest are: probability of working; *d)* days worked; *c)* days not covered by contributions; *d)* yearly labour earnings. All specifications include individual and year fixed effects. Standard errors are clustered at the individual level. The row "F-test leads" show the p-value of the F-test of joint statistical significance on the lead coefficients of specification (7).

Table 4: Difference-in-differences estimates: placebo

	Prob. of working	Days worked	Days w/out. contr.	Labour earnings
DiD coeff	-0.000	1.453	-0.895	57.792
	(0.003)	(1.043)	(1.009)	(130.075)
F-test leads	0.00	0.03	0.00	0.06
N	850542	850542	850542	812436

Note: See notes to Table 3.

Table 5: Difference-in-differences estimates: by pre-reform earnings

	Prob. of working	Days worked	Days w/out. contr.	Labour earnings
		Bottom		
DiD coeff	0.014**	8.975***	-7.572***	413.4**
	(0.006)	(2.297)	(2.249)	(169.4)
F-test leads	0.25	0.53	0.54	0.85
N	273614	273614	273614	272036
		Middle		
DiD coeff	0.015***	5.383**	-5.940***	424.9**
	(0.004)	(1.746)	(1.665)	(170.8)
F-test leads	0.40	0.46	0.21	0.63
N	273614	273614	273614	269557
		Top		
DiD coeff	0.005	2.437**	-1.794	614.4**
	(0.003)	(1.270)	(1.202)	(285.7)
F-test leads	0.90	0.37	0.37	0.50
N	273636	273636	273636	270359

Note: See notes to Table 3.

Table 6: Difference-in-differences estimates: by occupation pre-reform

	Prob. of working	Days worked	Days w/out. contr.	Labour earnings
		Employee		
DiD coeff	0.004	4.087***	-3.048**	133.116
	(0.003)	(1.261)	(1.217)	(149.100)
F-test leads	0.01	0.12	0.06	0.61
N	566236	566236	566236	563021
		Self-Employed		
DiD coeff	0.017***	6.959***	-7.021***	791.116***
	(0.005)	(2.063)	(2.034)	(236.261)
F-test leads	0.92	0.77	0.94	1.00
N	243628	243628	243628	240882

Note: See notes to Table 3.

Table 7: Difference-in-differences estimates: by gender

	Prob. of working	Days worked	Days w/out. contr.	Labour earnings
		Men		
DiD coeff	0.004	2.416**	-2.048*	325.067*
	(0.003)	(1.118)	(1.070)	(171.728)
F-test leads	0.35	0.27	0.07	0.80
N	571670	571670	571670	543013
		Women		
DiD coeff	0.020 ***	10.611***	-9.417***	487.323***
	(0.005)	(1.980)	(1.933)	(164.058)
F-test leads	0.03	0.60	0.70	0.51
N	312136	312136	312136	303883

Note: See notes to Table 3.

Table 8: Difference-in-differences estimates: by age

	Prob. of working	Days worked	Days w/out. contr.	Labour earnings
		Age 35-38		
DiD coeff	0.000	2.023	-1.188	506.477***
	(0.003)	(1.261)	(1.209)	(175.366)
F-test leads	0.00	0.15	0.00	0.87
N	400114	400114	400114	387380
		Age 39-42		
DiD coeff	0.008*	4.555***	-4.076**	-3.241
	(0.004)	(1.741)	(1.685)	(218.609)
F-test leads	0.82	0.16	0.39	0.14
N	319572	319572	319572	302664
		Age 43-45		
DiD coeff	0.027***	12.843***	-11.942***	431.411
	(0.008)	(2.947)	(2.887)	(297.304)
F-test leads	0.09	0.13	0.31	0.21
N	164120	164120	164120	156852

Note: See notes to Table 3.

Table 9: Difference-in-differences estimates: by (a proxy of) education

	Prob. of working	Days worked	Days w/out. contr.	Labour earnings
		Low		
DiD coeff	0.006*	4.165***	-3.516***	349.300**
	(0.003)	(1.166)	(1.136)	(145.342)
F-test leads	0.06	0.30	0.14	0.77
N	658460	658460	658460	639288
		High		
DiD coeff	0.024***	11.814***	-9.997***	864.210***
	(0.005)	(2.101)	(2.023)	(260.633)
F-test leads	0.38	0.96	0.30	0.93
N	203654	203654	203654	188189

Note: See notes to Table 3.

A Appendix

A.1 Simulating yearly pension benefits under the *fully DB* and the *mixed DB-NDC* regimes

To compute the expected change, as of 1995, in yearly pension benefits stemming from post-reform contributions to social security because of the switch to the *mixed DB-NDC* regime, I proceed according to the following steps:

1. For every worker, I retrieve all the information about the pre-1995 contribution history and I use it: *i)* in the computation of pension benefits that a worker would have received if she remained subject to the *fully DB* system, as some pre-reform earnings enter in the formula of quota B; *ii)* to choose a starting value for the daily wage and the number of days worked in the post-reform period.

2. For every worker, I simulate the post-reform contribution history by assuming that the daily wage and the number of days worked evolve according to the following formula:

$$w_t^d = w_0^d \prod_{j=1996}^{j=R} (1 + i_j + \mu) \text{ and } N_t = k$$

   w_0^d is the daily wage in the last pre-reform year z when the worker works at least x days, after expressing it in 1995 euros and applying a penalty that is quadratic in the distance between year z and the reform year, to account for the fact that periods of non-work often leads to skill depreciation. In the baseline simulation $x = 180$; in alternative simulations, I set x to either 90 or 0. The daily wage than grows every year at a rate that equals the sum of the realized inflation and a parameter μ that in the baseline simulation is set equal to 2%, which would correspond to a medium-speed career progression according when simulating expected pension benefits; in alternative simulations, μ can take values of 0% or 1%). In the baseline simulation I assume that $k = 365$ (i.e. workers work 365 days a year in the post-reform period), while in alternative ones I set $k = N_z$.

3. I assume that men (women) retire on $12/31/q$, where q is the year when they turn 65 (60). Given that the master sample consists of prime-age workers aged 35 to 45 at the time of the reform, retirement dates span from 2010 to 2025.

4. I assume that every worker will contribute in the post-reform period into the same pension fund (i.e. the fund of employees, the fund of self-employed,...) she was contributing in year

z. This assumption is needed because different funds feature different social security tax rates τ. I am therefore implicitly assuming no switches from salaried employment to quasi-salaried employment or self-employment in the post-reform period.

5. I assume that workers cannot anticipate that the 2012 Fornero pension reform will apply the NDC computation method for contributions accrued from 2012 onward also to workers who were originally entirely grandfathered by the Dini pension reform. As a result, for workers who retire after 2011 counterfactual pension benefits under the *fully DB* regime are computed neglecting this change.

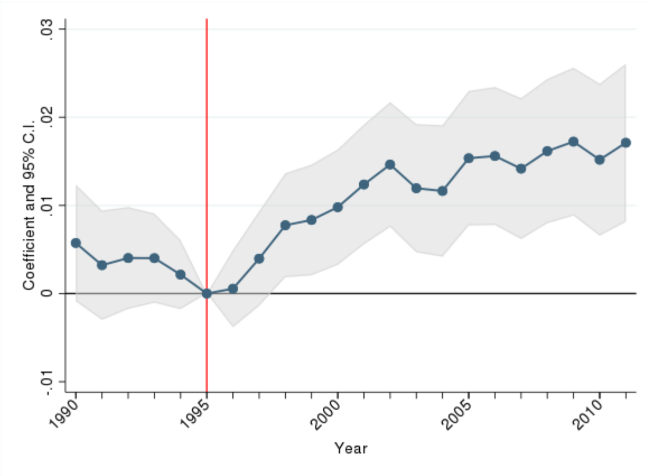
6. I assume that workers have perfect foresight as regarding the evolution over time of the parameters embedded in the DB and NDC formulae of yearly pension benefits. I therefore assume that $\{\eta_B, \rho_B, \lambda, \tau, g\}$ take the realized values. For cohorts of workers who retire past 2018, I predict the values that these parameters will take by relying on the latest available forecasts about the inflation rate and GDP growth rate.

7. I express the change in yearly pension benefits stemming from post-reform contributions to social security as the ratio between the benefits received under the *mixed DB-NDC* regime and the benefits that would have been received under the *fully DB* regime.

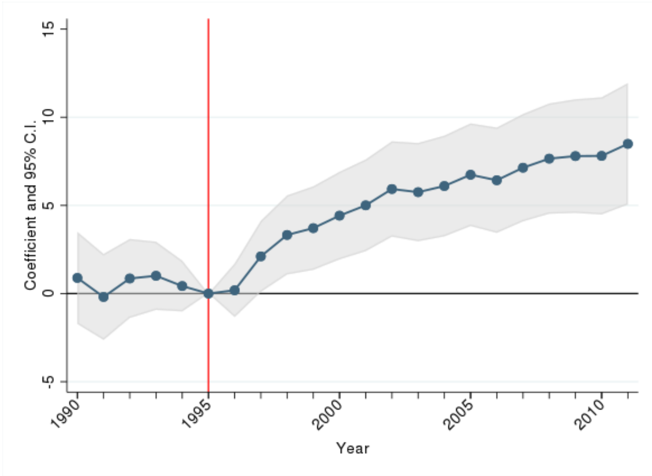
A.2 Additional Figures

Figure A.1: Dynamic difference-in-differences: main outcomes excluding the "donut"

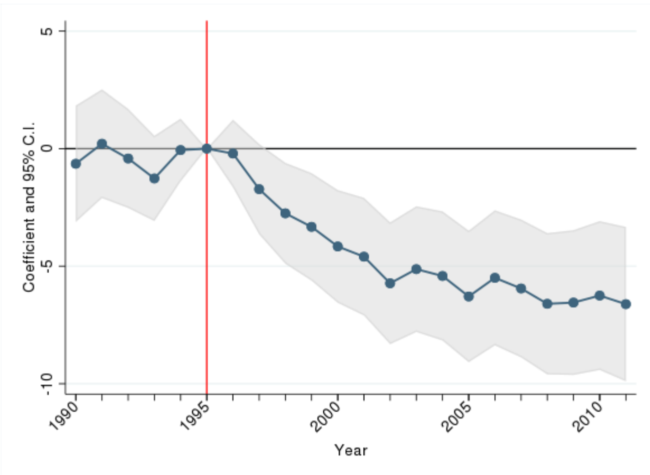
(a) Probability of working



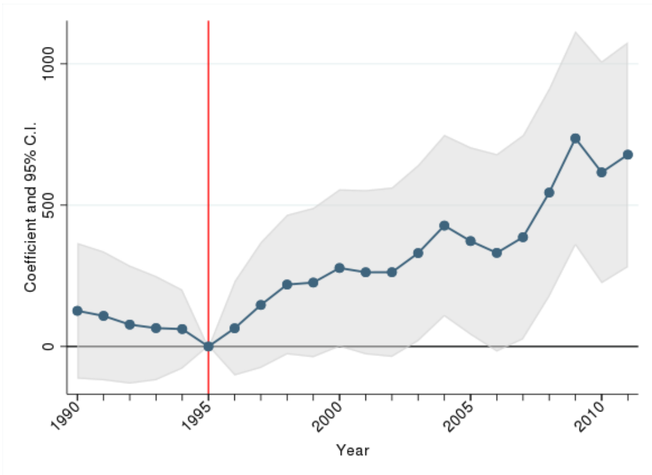
(b) Days worked



(c) Days not covered by contributions



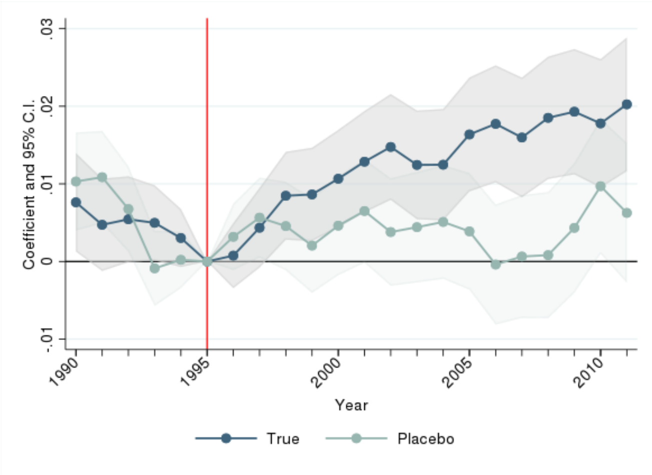
(d) Yearly labour earnings



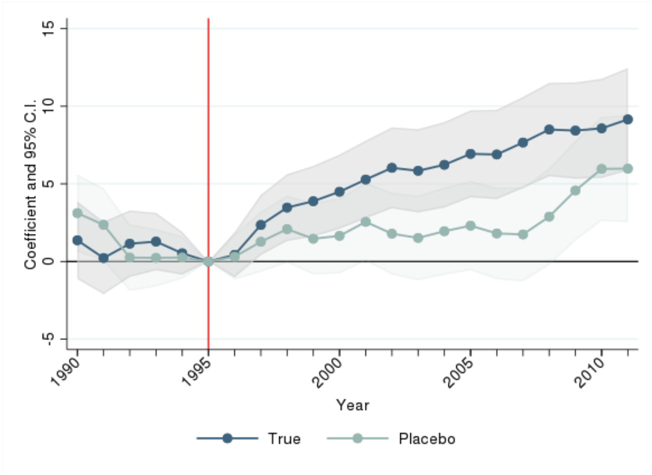
Figures (a) to (d) show the difference between *treated* and *control* workers in year k relative to the reform year (1995), alongside 95% confidence intervals, with respect to: *a)* probability of working; *d)* days worked; *c)* days not covered by contributions; All specifications include individual and year fixed effects. Standard errors are clustered at the individual level.

Figure A.2: Dynamic difference-in-differences estimates: placebo

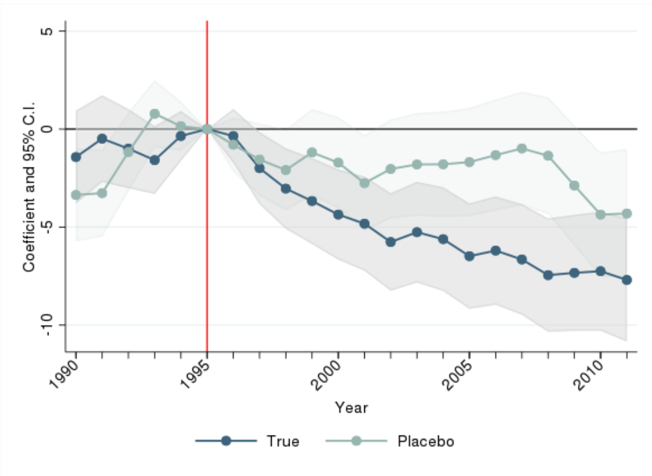
(a) Probability of working



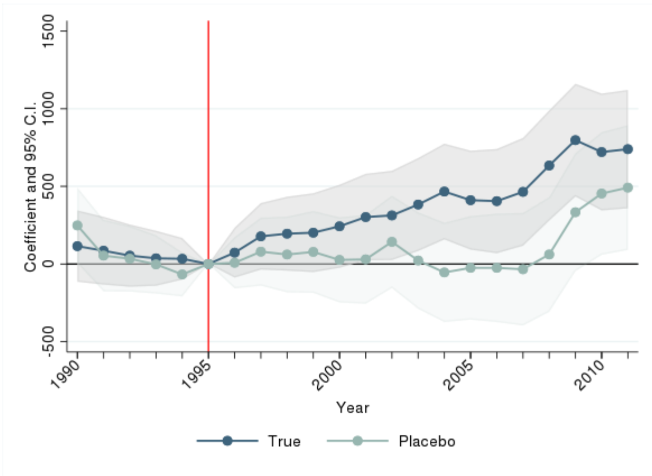
(b) Days worked



(c) Days not covered by contributions



(d) Yearly labour earnings



Figures (a) to (d) show the difference between *treated* and *control* workers in year k relative to the reform year (1995), alongside 95% confidence intervals, with respect to: *a)* probability of working; *b)* yearly labour earnings; *c)* days worked; *d)* days not covered by contributions. All specifications include individual and year fixed effects. Standard errors are clustered at the individual level.