THE EFFECTS OF REFORMS ON RETIREMENT BEHAVIOR

INTRODUCTION AND SUMMARY

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ABSTRACT

The *International Social Security (ISS) project* compares the experiences of a dozen developed countries to study *Social Security Programs and Retirement Around the World.* The project was launched in the mid 1990s and was motivated by decades of decline in the labor force participation rate of older men. The first phases of the project documented that social security program provisions can create powerful incentives for retirement that are strongly correlated with the labor force behavior of older workers. Since then, the dramatic decline in men's labor force participation has been replaced by sharply rising participation rates. Older women's participation has increased dramatically as well.

This tenth phase of the *International Social Security (ISS) Project* is the third step in explaining rising participation at older ages. The first step investigated changes in health and education as potential causes and showed that they could not account for the extent of changes in labor force participation. As a second step, we documented that countries have undertaken numerous reforms of their social security programs, disability programs, and other public benefit programs available to older workers. We found that these reforms substantially reduced the implicit tax on work at older ages and that stronger financial incentives to work were positively correlated with labor force participation at older ages. In this volume, the third step of our analysis, we exploit the time-series and cross-national variation in the timing and extent of reforms of retirement incentives and employ micro-econometric methods in order to study whether the correlation between financial incentives and work at older ages is causal.

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1. Project Overview

Over its twenty-five year history, the International Social Security (ISS) project has used the vast differences in social security programs across countries as a natural laboratory to study the effects of retirement program provisions on the labor force participation of older persons and other questions related to the older workforce. Motivated by the decline in older men's labor force participation during the 20th century and the possibility that the spread of public pensions contributed to this development, the project's early analyses (Gruber and Wise, 1999, 2004, and 2007) documented the strong relationship across countries between social security incentives and older men's labor force participation that existed in the late 1990s, confirmed this relationship in microeconomic analysis, and estimated the labor market and fiscal implications of social security reforms. Later volumes have examined the relationship between disability insurance program provisions, health, and retirement (Wise, 2012 and 2016) and explored whether older employment affects youth unemployment (Gruber and Wise, 2010) and whether older workers are healthy enough to work longer (Wise, 2017).

Since the project's inception, there has been a remarkable reversal of employment trends, with dramatic increases in employment at older ages for both men and women in all of the ISS countries. More recent phases of the ISS project have examined potential explanations for these changes in behavior. The volume edited by Coile, Milligan, and Wise (2019) examined cohort changes in health and education, and the most recent volume (Börsch-Supan and Coile, 2020) explored the evolution of financial incentives to work at older ages from 1980 to the present. The main finding was a surprisingly weak correlation between the development of old-age labor force participation and factors such as cohort changes of health and education, but a strong correlation between changes in financial incentives and changes in old-age labor force participation. The current volume provides a series of country-specific econometric analyses which exploit the time-series and cross-national variation in the timing and extent of reforms of retirement incentives. The key aim of these studies is to study whether the observed correlation between retirement incentives and labor force participation is causal. The richness of our analysis comes from both the cross-country differences in social security policy across the twelve countries and from the inter-temporal changes in policy that have been adopted within these countries over almost four decades.

The results of the ongoing project are the product of analyses conducted for each country by analysts in that country. Researchers who have participated in this phase of the project are listed first below; those who have participated in prior phases are listed second in italics.

Belgium	Anne-Lore Fraikin, Alain Jousten, Mathieu Lefèbvre, *Arnaud Dellis, Raphaël Desmet, Sergio Perelman, Pierre Pestieau*, and *Jean-Philippe Stijns*

Canada	Kevin Milligan, Tammy Schirle, *Michael Baker and Jonathan Gruber*
Denmark	Paul Bingley, Nabanita Datta Gupta, Malene Kallestrup-Lamb, Peder J. Pedersen, *and Michael Jørgensen*
France	Antoine Bozio, Simon Rabaté, Maxime Tô, Julie Tréguier, *Luc Behaghel, Melika Ben Salem, Didier Blanchet, Eve Caroli, Thierry Debrand, Ronan Mahieu, Louis-Paul Pelé, Corinne Prost, Muriel Roger, and Emmanuelle Walraet*
Germany	Axel Börsch-Supan, Irene Ferrari, Nicolas Goll, Johannes Rausch, *Tabea Bucher-Koenen, Hendrik Jürges*, *Simone Kohnz, Giovanni Mastrobuoni, Reinhold Schnabel*, *Morten Schuth, and Lars Thiel*
Italy	Agar Brugiavini, Raluca Elena Buia, Giacomo Pasini, Guglielmo Weber, *and Franco Peracchi*
Japan	Akiko Sato Oishi, Takashi Oshio, Satoshi Shimizutani, *Mayu Fujii, Emiko Usui, and Naohiro Yashiro*
Netherlands	*Klaas de Vos*, Adriaan Kalwij, and Arie Kapteyn
Spain	Pilar García-Gómez, Silvia Garcia-Mandico, Sergi Jiménez-Martín, Judit Vall-Castelló, *Michele Boldrín, and Franco Peracchi*
Sweden	Lisa Laun, Mårten Palme, *Per Johansson, and Ingemar Svensson*
United Kingdom	James Banks, Carl Emmerson, David Sturrock, *Richard Blundell, Antonio Bozio, Paul Johnson, Costas Meghir*, *Sarah Smith, and Gemma Tetlow*
United States	Courtney Coile, *Peter Diamond, Jonathan Gruber, Kevin Milligan, and David Wise*

The selection of these countries at the start of the project was guided by four main criteria. On the one hand, they should represent different pension systems that have emerged from diverse cultural-historical backgrounds. On the other hand, the countries should be comparable with regard to stages of the demographic transition and of economic development with its associated job composition and quality of work. Third, the countries were selected by the quality of the data that is required to precisely describe the incentives exerted by their pension systems and measure them over a relatively long time horizon, spanning the period during and after significant pension reforms. Fourth and maybe most importantly, the twelve countries have excellent research teams well experienced in this type of analyses.

An important goal of the project has been to present results that are as comparable as possible across countries. Thus the papers for each phase are prepared according to a detailed template that we developed in close consultation with country participants. In this introduction, we summarize the collective results of the country analyses and deliver a combined analysis of data that has been pooled across each of the countries. The country papers themselves present much more detail for each country and, in addition to the common analyses performed by all countries, often present country-specific analysis relevant to each particular country.

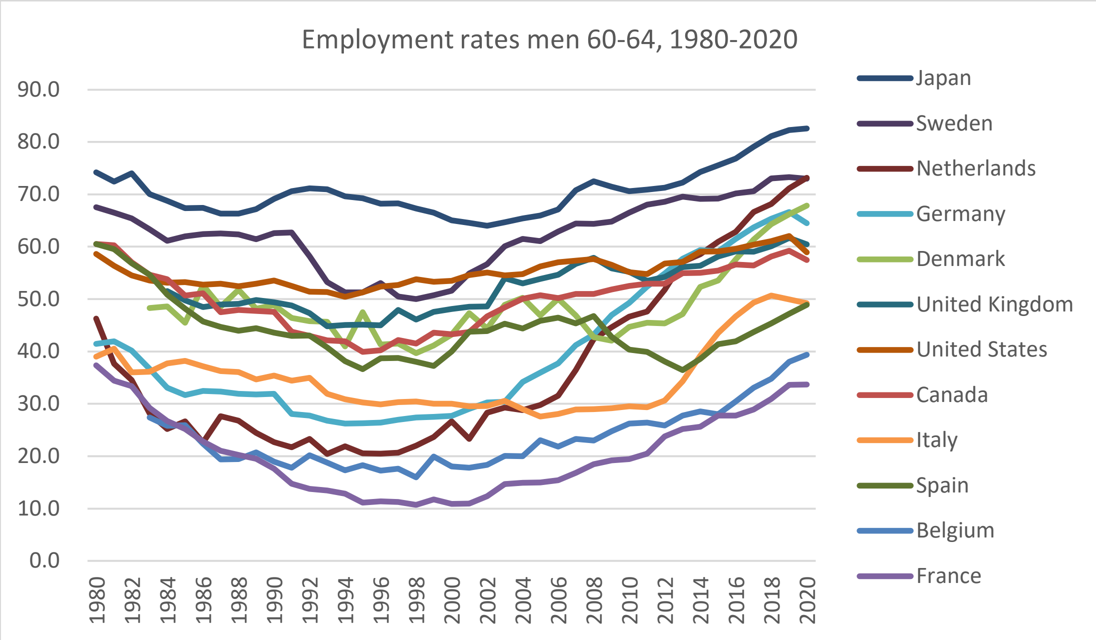
This introductory chapter starts with a brief description of the old-age employment trends from 1980 to 2020 (Section 2), followed by a summary of the main policy changes that happened during this time period (Section 3). We then introduce our key concept, the implicit tax on working longer (Section 4). Section 5 summarizes the main regression results from the country chapters. They are used for counterfactual analyses that show how retirement behavior would have changed if the reforms had not happened (Section 6). Finally, Section 7 presents our pooled time-series cross-national analysis. Section 8 summarizes and concludes.

2. Trends in old-age employment

While life expectancy has risen dramatically almost everywhere in the world, the average retirement age in industrialized countries declined during much of the 20th century, putting enormous pressures on public pension systems. More recently, however, working in later life has been making a comeback. In a striking reversal of the earlier trend, almost all developed countries have seen substantial increases in the employment of older workers since the mid-to-late 1990s.

This is illustrated in Figure 1 for men between ages 60 and 64. We observe a distinct “U-shape” in the employment rate of older workers over time that is markedly similar across countries. An unweighted average of employment rates for men ages 60 to 64 across the twelve countries rose by 21.8 percentage points from 37.3 to 59.1 percent between 1995 and 2020.

Figure 1: Employment rates, Men Ages 60 to 64, 1980-2020 [percentages]

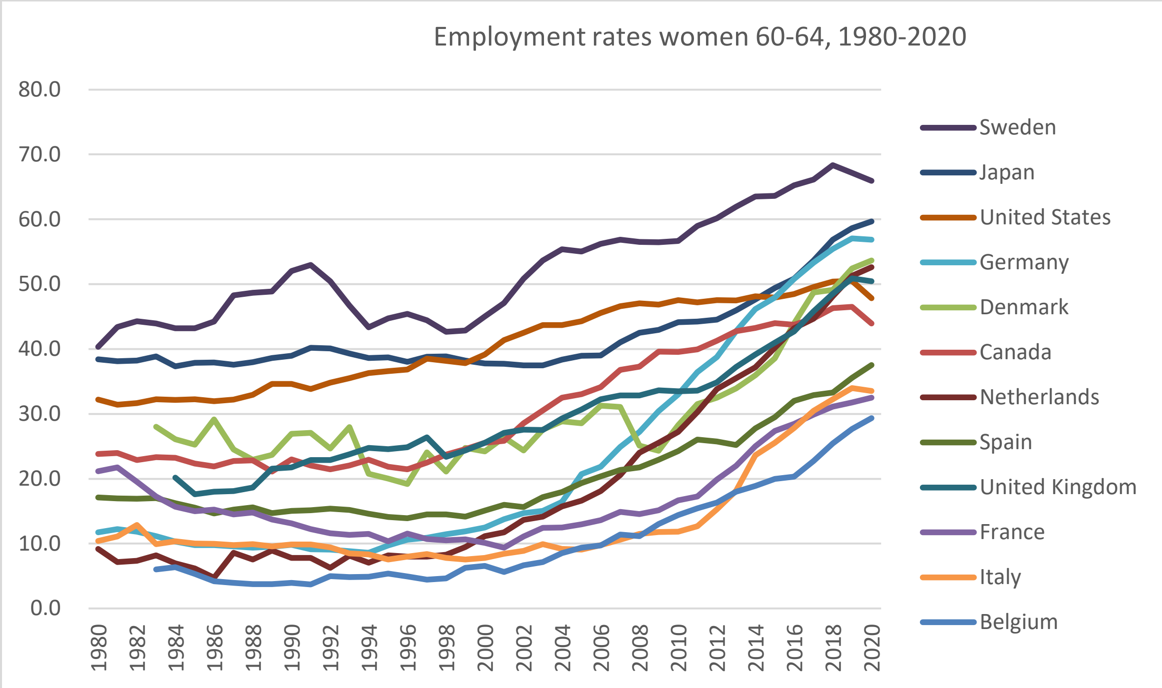


Source: OECD. Data extracted on 08 Jan 2022 11:20 UTC (GMT) from OECD.Stat.

This is a remarkable reversal of the long-standing trend towards ever earlier labor force exit ages, a trend which many viewed as a natural side effect of growing prosperity and which was in contrast to the increases in life expectancy. It is also striking that this trend has affected all countries even though the level of old-age employment is very different across countries. France and Belgium feature relatively low employment rates in this age group while Japan and Sweden have very high employment rates. The trend reversal is most pronounced in Germany and the Netherlands, much less so in the US. Except perhaps in Italy, there are so far no indications that this trend reversal may come to an end, although the influence of the pandemic is evident in 2020.

Figure 2 shows the corresponding employment rate for women between ages 60 and 64. While the “U-shape” is less evident due to women’s initial low levels of participation, the increase since the mid-1990s is similar to if not larger than that for men – the unweighted average of employment rates across twelve countries rose by 26.8 percentage points between 1995 and 2020, from 20.1 to 47.0 percent. Again, the cross-national differences in levels of old-age employment are considerable, with Sweden and the US at the top and Belgium and Italy at the bottom. The increase in old-age employment among women is strongest in Germany.

Figure 2: Employment rates, Women Ages 60 to 64, 1980-2020 [percentages]



Source: OECD. Data extracted on 08 Jan 2022 11:20 UTC (GMT) from OECD.Stat.

What explains these dramatic increases in employment at older ages? A first step has been conducted in the volume edited by Coile et al. (2019). Their research suggests that while better health, more education, and changes in labor supply behavior of married couples may have played some role in this trend reversal, these factors alone are insufficient to explain the magnitude of the employment increase and its large variation across countries. On the demand side, their analysis also concludes that unemployment is not a major driver of labor force participation trends. The analysis does not directly examine other factors that could affect the demand for older workers, such as globalization and automation, and indeed there is as yet little research in this area (National Academies, 2022). By contrast, the literature has been more definitive in dispelling the "lump of labor fallacy" that there is a given amount of paid work to be done in a country at a given time, including analysis by Gruber and Wise (2010) and Munnell and Wu (2012). This suggests that policies that encourage older people to work longer do not reduce the employment of younger people and that trends in participation of prime-age workers are not driving trends in participation at older ages.

3. Policy changes

In a second step, the volume edited by Börsch-Supan and Coile (2020) examined the many social security reforms enacted by ISS countries over the past few decades and their impact on the incentive to work at older ages. The country chapters in that volume described these policy changes verbally in a consistent manner, while the introduction to the volume synthesized the detailed country-level discussions to elucidate key themes.

A first key finding is that the period since 1980 has been one of great pension reform activity. Each of the twelve countries represented in this volume (US, Canada, Japan and nine European countries) has undertaken multiple types of reform – for example, making changes to social security eligibility ages and to benefit formulas. Countries have also made changes to non-social security programs that may affect work at older ages, including disability insurance, unemployment insurance, and special early retirement programs (see also OECD, various issues, and Social Security Administration, various issues, for descriptions of pension programs).

A remarkable exception is the US, which has not passed a major social security reform since 1983 (although some changes mandated in the 1983 reform are still being phased in; such phase-in periods are common, though typically of shorter duration). Some countries have experienced major structural reforms (systemic changes) such as the introduction of a notional defined contribution (DC) system (e.g., Sweden and Italy) or the replacement of parts of the pay-as-you-go (PAYG) system by a fully funded system (e.g., Sweden and Germany). In some countries, changes in the private (personal and occupational) pension sector have interacted with changes in public programs or have otherwise influenced retirement behavior (e.g., UK and Netherlands).

Our other key findings concern the direction of reforms. In most countries, policies moved in one direction over time, either with a single policy change phased in gradually or with multiple similar policy changes. However, some countries experienced an inconsistent back and forth (e.g., first raising, then lowering the statutory eligibility age or first decreasing, then increasing benefit generosity, such as in Germany). Finally, we find that in general, there have been many more reforms that strengthen the incentive to work at older ages than reforms that weaken the incentives to work. This is particularly true when one focuses on more recent reforms.

We summarize a few of the most common reforms here, referring the interested reader to the earlier volume for more details.

- A key parameter for retirement behavior is the social security early eligibility age (EEA). The EEA is the first age at which social security benefits are available, often with an actuarial reduction relative to the benefits available at the statutory eligibility age. Nine countries raised the EEA for all workers, among them four countries which raised the EEA differentially for women, while three countries lowered the EEA.

- A second key parameter for retirement behavior is the social security statutory eligibility age (SEA). This term, sometimes called “normal retirement age” or “pensionable age” refers to the age at which the individual is eligible for full public old-age pension benefits without reduction for early claiming. Nine countries raised the SEA for all workers, among them four countries which raised the SEA differentially for women, while only one country lowered the SEA.

- Social security benefit generosity include changes to the benefit formula, the number of years of earnings used in the benefit calculation, the use of wage vs. price indexation, etc. Nine countries lowered benefit generosity, while three countries raised it.

- Actuarial adjustments define how social security benefits relate to the claiming age. They are usually defined as percentage adjustments and typically lower or raise the monthly benefit amount if the worker claims benefits before or after the SEA. Nine countries strengthened the actuarial adjustment of social security benefits for early or delayed claiming, while four countries lowered it.

- Most countries feature an earnings test at ages before the SEA. This forces individuals to stop working when they want to receive social security benefits, as benefits are taxed, often dollar-for-dollar, against earnings (although a small amount of earnings may be allowed without taxation). The decision to claim benefits and the decision to exit the labor force, which are independent decisions from an individual's point of view, are thus intrinsically combined in these countries; this helps to explain why the word "retirement" means both decisions in some countries. Seven countries weakened the earnings test, while only one country strengthened it.

- Moreover, non-social security programs play an important additional role in decisions to retire very early in many countries. These other programs may include disability insurance (DI), unemployment insurance (UI), and other special early retirement programs that are distinct from the social security system. Six countries weakened retirement incentives in these programs, while four countries strengthened them.

In summary, the past four decades have been a period of intense pension reform activity. While the reform process sometimes includes a back-and-forth element and not all reforms push in the same direction, the general thrust over this period has been in the direction of raising eligibility ages, lowering benefit generosity, strengthening actuarial adjustments for delayed claiming, and reducing access to non-social security programs that offer alternative pathways out of the labor force. All of these changes are expected to encourage workers to retire later. These incentives do not only work on the labor supply side, but also on the demand side since generous early retirement benefits by public pension systems reduce the severance and compensation payments that employers need to pay when they want to reduce their labor force, e.g., to adapt to lower product demand or to technological changes. Hence, understanding the effect of pension incentives on employment at older ages is of great interest to policy makers, as they seek to craft pension programs that are fiscally sustainable and provide adequate financial security in retirement and to understand how population aging may affect the size, age composition, and productivity of the workforce.

4. The implicit tax on working longer

Most of the pension reforms observed in the twelve countries are rather complex and not easy to quantify. This is why the ISS project requires individual country chapters written by teams of specialists who know the reform details in each country. An important piece of their work has been to condense the program parameters discussed in the previous section into a comprehensive, one-dimensional indicator that measures how the reforms have altered the financial incentives to work longer. This indicator is the implicit tax on working longer and claiming later that has been used in previous project phases and is also the key explanatory variable in this volume.

To construct this indicator, the twelve country teams have set up social security benefit calculators that compute the benefits from each salient social security program ("pathway to retirement") for all individuals in their country-specific samples, described in the next section. These benefit calculators were based on our work in Börsch-Supan and Coile (2020) but needed to be adapted to the much greater heterogeneity of individual life circumstances in the micro data, in particular the great variation of earnings histories in the country samples. The country chapters precisely define how earnings histories were constructed as this construction depends on the data situation in each country.

For each individual, the social security benefit calculation is done for every year of available data, for every possible retirement age, and for every pathway to retirement (such as old-age public pension, early retirement pension, disability pensions, etc.) that is available for the individuals in the sample. The variation by year captures the many changes in social security laws and regulations that occurred during this time span. The variation of social security benefits by retirement age captures whether it was advantageous for a given type of individual in a given country and year to retire earlier or later, something which differs greatly across the 12 countries. Likewise, there are large differences across countries in which pathways are available for retirement, with some pathways accessible substantially earlier than the statutory eligibility age in the old-age pension. The country chapters show for those individuals in their samples who already retired how well the benefit calculator fitted the observed benefits received. This is summarized in Table 3 further below.

A first product of this benefit calculation is the social security wealth, denoted by *SSW.* It sums up the properly discounted social security benefits from the beginning of retirement over the expected remaining life span. In most European countries, the beginning of retirement is well-defined: individuals stop working and begin to claim social security benefits at the same time, see Table 1. In many European languages, claiming social security benefits is even literally synonymous with stopping to work. Partly, this is due to earnings tests, which severely limit the amount of work allowed when receiving a public pension, partly it is a convention even in the absence of an earnings test. However, there are exceptions, as documented in the rightmost columns of Table 1. Individuals may stop working before receiving social security benefits because they have other means to support themselves. Moreover, individuals may combine receiving social security benefits with continuing to work part or even full time, such as it is frequent in the US. Japan is another prominent example with the institution of a "post-retirement job", usually in a smaller but related company with a lower wage. In these cases, we compute SSW from the beginning of claiming.

Table 1: Claiming social security benefits and stopping to work

Country	Working, No benefits	Not working, benefits	Not working, no benefits	Working and benefits
Belgium	29.1%	44.9%	16.4%	9.6%
Canada	63.9%	12.3%	15.7%	8.2%
France	37.0%	48.8%	11%	3.2%
Germany	56.6%	37.5%	5.4%	0.6%
Japan	33.5%	29.3%	11.3%	25.9%
Netherlands	46.9%	46.5%	5.1%	1.5%
Sweden	53.1%	25.3%	10.5%	11.0%
United States	17.5%	58.3%	3.1%	21.2%

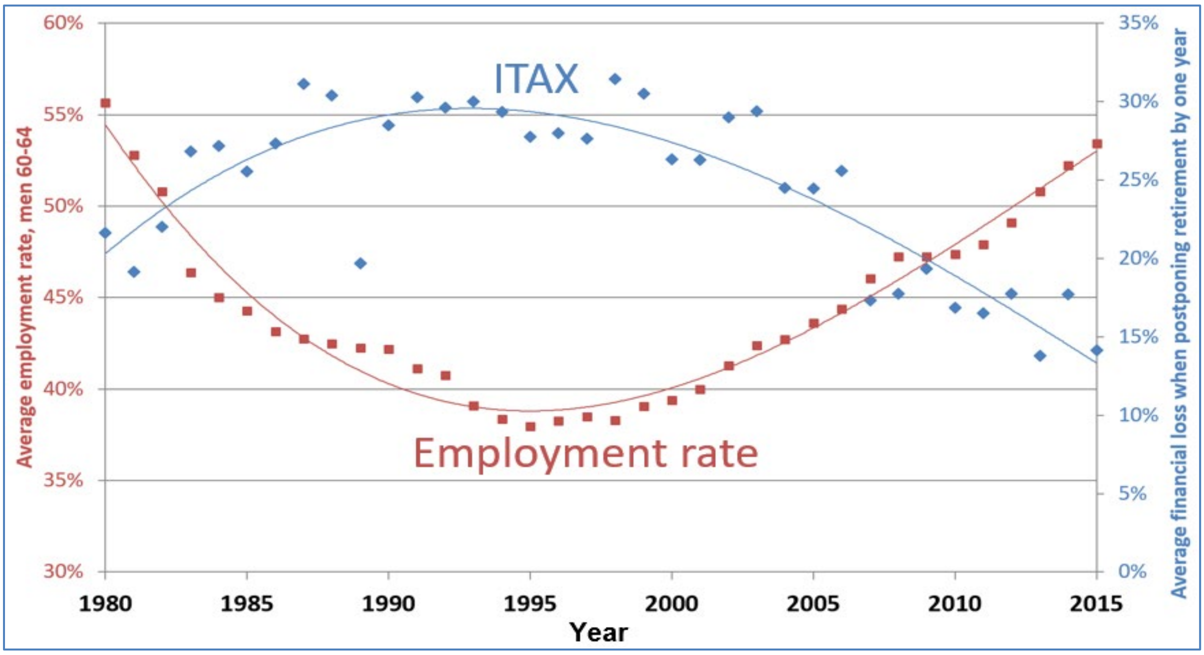
Note: Based on the five most recent years of the data displayed in Table 2. All ages between 55 and 69.

Postponing claiming social security benefits by one year has several effects on social security wealth. On the one hand, the individual receives one year less of benefits, which decreases social security wealth. On the other hand, annual benefits increase with later claiming in most countries due to actuarial adjustments. There may be additional effects depending on the specific rules in each country. E.g., in some but not all countries, the earnings after having claimed social security benefits are subject to social security contributions. These additional contributions will then result in a higher benefit amount. Finally, again depending on national jurisdiction, the individual may make one more year of social security contributions. The balance between these mechanisms determines whether social security wealth increases or decreases with earlier or later retirement. We call the numerical increase or decrease of social security wealth the "accrual" of social security wealth.

If the accrual is negative, the social security system imposes an implicit tax on working longer and claiming later. This is the key concept in this volume, as it has been in previous volumes, abbreviated as *ITAX*. The implicit tax on working longer is defined as the accrual of social security wealth relative to the earnings of the individual. More precisely, we relate the accrual of social security wealth when postponing retirement at a given age to the earnings net of income taxes and social contributions that the individual will receive in this additional year of work. A positive value of *ITAX* means that there is a tax on working longer, a negative value represents a subsidy for working longer. *ITAX* collapses all financial dimensions of social security policy into a single dimension. This is as much an advantage as it is a disadvantage. The advantage is that the single dimension of *ITAX* can conveniently be used as a regressor in micro-econometric analysis linking policy changes with potential outcomes such as old-age employment or labor force participation. The obvious disadvantage is that social security policies may be more complex and may even have inconsistencies that are masked by a one-dimensional measure. For example, if a country increases the eligibility age for early retirement and at the same time increases the generosity of disability benefits, the two opposing effects on ITAX may cancel such that ITAX remains constant; however, individuals may react to such changes by substituting early retirement by disability benefits if health checks are lenient. Moreover, ITAX may not fully capture the importance of raising the eligibility age for individuals who are liquidity constrained. We address these issues by adding covariates such as health and wealth.

In Börsch-Supan and Coile (2020), the country teams computed the development of *ITAX* for a few typical benefit recipients who differ by basic socio-economic characteristics (sex, marital status, and education). They showed that the U-shaped development of employment that is visible in Figures 1 and 2 matches an inverse U-shape of the incentives to work longer for these synthetic cases (Figure 3). This corresponds to past studies such as the seminal work by Gruber and Wise (1999), which found a very strong association between ITAX and the share of older men out of the labor force in a cross-section of the ISS countries, suggesting that social security program provisions that affect the financial incentive to work at older ages can exert a powerful influence on late-career employment decisions.

Figure 3: ITAX and employment rates, men ages 60 to 64, 1980-2015



Source: Börsch-Supan and Coile (2020).

This evidence is suggestive but not causal. The key question for this volume is therefore whether the large variation in levels and temporal changes that we see in old-age labor force participation among men and women in Figures 1 and 2 has been caused by pension reforms that have increased the incentive to work at different times and to a different extent in the twelve countries. Establishing this causal link follows a formal econometric approach for each country similar to the micro-estimates in Gruber and Wise (2004) but exploits the time-series variation between 1980 and 2019 in addition to the cross-sectional variation that was driving the earlier estimates for a more powerful identification of the reform effects. Cross-sectional variation may be generated by earnings differences, which in turn may be correlated with the incentives to stay in the labor force, leading to false inference. The essential instrument in time-series, however, are the many pension reforms that are clearly exogenous to individual retirement decisions in micro data. In addition to using that variation in the individual country studies, we will pool the underlying data here in the introduction to additionally exploit the international variation in the institutional settings across the countries in our study.

5. Country-specific analyses

The major initial work in this volume is to compute a time series of the implicit tax rate on working longer for each individual in the sample. This requires panel data that spans as much of the years visible in Figures 1 and 2 as possible in order to have sufficient observations before, during, and after the reforms. Moreover, the data need to carry sufficient information to construct earnings histories and to establish the eligibility for social security benefits including public pensions and alternative pathways such as disability and unemployment insurance. Ideally, the data also contain information on personal characteristics that influence retirement decisions, e.g., health and education. Finally, the data should be similar across countries in that they permit the construction of identical dependent and independent variables for our analyses.

Finding and constructing such data was a major challenge, and in some cases, not all of these demands could be satisfied simultaneously. Table 2 lists the data sets used by country with the time span covered and the total number of observations.

Table 2: Panel data sets

Country	Name	Years	Observations
Belgium	Data Warehouse Labor Market and Social Protection	2004-2010	86,666
Canada	Longitudinal Administrative Databank	1995-2019	1,673,000
Denmark	Danish population register	1980-2016	3,206,300
France	Échantillon Interrégimes de Cotisants and Échantillon Interrégimes de Retraités	1989-2015	71,601
Germany	Socio-Economic Panel	1985-2019	24,300
Italy	Survey of Health, Ageing and Retirement in Europe	2004-2015	24,112
Japan	Longitudinal Survey of Middle-Aged and Older Adults	2005-2016	30,199
Netherlands	Income Panel Study of the Netherlands	1989-2014	~780,260
Spain	Muestra Continua de Vidas Laborales, combined with European Community Household Panel (1994-2001) and EU-Statistics on Income and Living Conditions (2003-2016)	1994-2001 and 2003-2016	11,007,860, 19,350 for combined data
Sweden	Linked Swedish population registers, 10% sample	1991-2012	3,570,269
UK	English Longitudinal Survey of Ageing	2001-2017	20,642
US	Health and Retirement Study	1992-2016	60,000

Some countries used administrative records or register data (Belgium, Canada, Denmark, France, Spain, and Sweden). Some of these process-generated data sets have very large numbers of observations (Canada, Denmark, Spain, and Sweden). Other countries used survey data (Germany, Italy, Japan, the Netherlands, UK, and US). Their sample sizes are substantially smaller, but they tend to have a broader range of covered covariates, especially health and education. Some countries needed to combine data sources to cover the different domains of variables (Spain and Sweden) or to cover different periods in the individuals' life cycle (career and retirement, France). Coverage of the whole range of pre- and post-reform years was another challenge; only two countries had sufficient data in this respect (Denmark, Germany). This was also the reason why most countries – an exception is Italy – decided not to use the internationally harmonized Survey of Health, Ageing and Retirement in Europe (SHARE). While SHARE has a broad range of variables with identical definitions across its member countries, well-defined earnings histories (SHARELIFE) and an excellent coverage of health, the first wave was done in 2004, missing the pre-reform years for many prominent pension reforms. The advantage of survey data is its relatively open access for scientists. Some of the administrative data sets are accessible only under restrictions, e.g., in an enclave. This holds for the Belgian and Canadian data sets, as well as for the US HRS after linking with administrative data. These data sets could therefore not be included in the pooled cross-sectional analysis described in Section 7.

The country teams used these data to compute social security benefits for every observation (individuals or couples in all years of available data), for every possible retirement age between 55 and 69, and for every pathway to retirement that is available for the individuals or couples in the sample. In order to compute SSW, benefits have to be predicted for the entire remaining life span. We used cohort life tables by country but adjusted them for socio-economic status. Mortality probabilities at every age were adjusted by a common multiplicative factor sufficient to generate an average life expectancy at age 60 that is 3 years lower than average for the lowest educational group and 3 years higher than average for the highest educational group, as compared to the medium education group (differences that roughly conform with those observed by education group in the ISS countries). The education groups were defined by terciles of ISCED, the international standard code of education (except for France, where the data has no information on individuals' education). SSW by available pathway was aggregated to a general SSW by weighting each pathway according to the observed frequency of the pathway by country and year.

An important interim step was to validate these complex calculations. This was possible by using those cases in the data sets for which the actual pension benefit and earlier earnings were observed. The team validated their benefit calculators by comparing these observations with their predicted benefits. Table 3 shows the accuracy of the benefit calculations using four measures: the mean deviation, the percentage of observations in which the difference between actual and predicted benefits was smaller than 5% (and smaller than 20%), and the percentage of observations with very large differences (relative deviation larger than 80%).

Table 3: Validation results

Country	Mean difference between actual and predicted benefits	Share of observations with less than 5 percent deviation from actual benefits	Share of observations with less than 20 percent deviation from actual benefits	Share of observations with more than 80 percent deviation from actual benefits
Belgium	2.1%	35.4%	85.1%	0.7%
Canada §	3%; 20%; 7%			
Denmark	9.0%	73.4%	81.8%	2.2%
France	-7.16%	18.9%	99.9%	0%
Germany	-13.5%	11%	75%	0%
Italy	< 1%	100%	100%	0%
Japan +	10.7%	≈ 9%	≈ 30%	≈ 25%
Spain	1.9%	100%	100%	0%
Sweden	6.0%	55.3%	95.8%	1.4%
UK	11%	≤ 17%	32.5%	23%

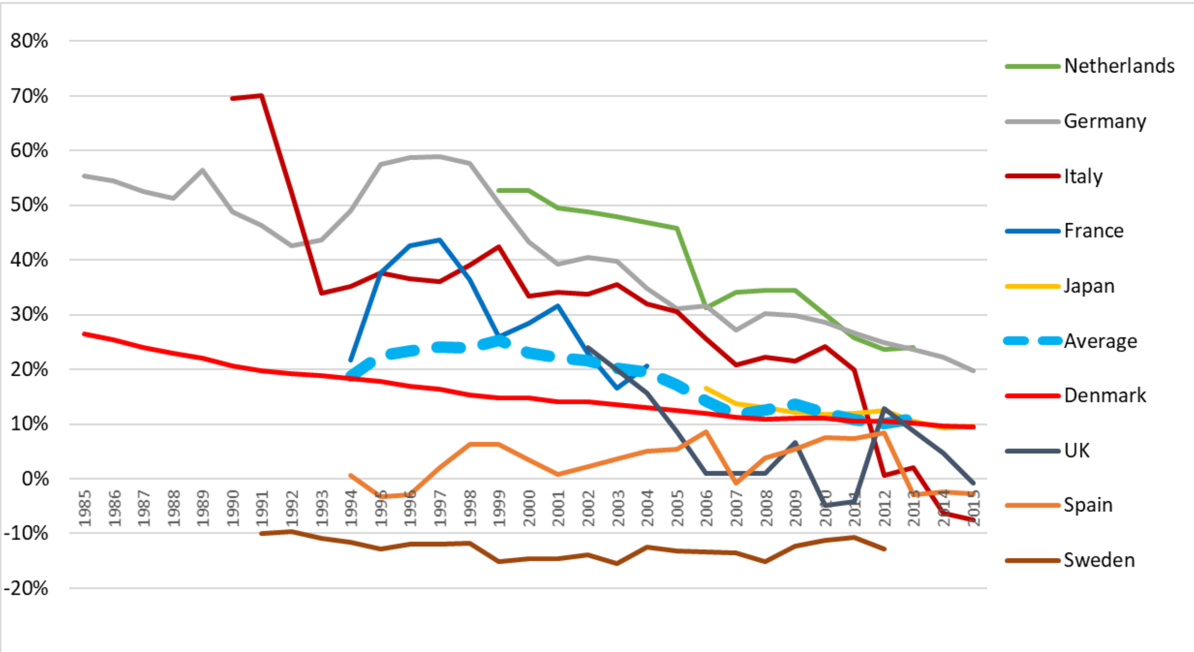
Note: + only observations of men. § the three values in Canada refer to the three branches of the Canadian system (OAS, GIS and CQPP). US did not provide estimates.

Some countries have very precise benefit calculators (e.g. Italy and Spain). Some countries systematically underestimate benefits (e.g. France and Germany). In France, the problem is mainly due to missing data for older cohorts, while in Germany respondents may also include occupational pensions (and severance payments) in their response to the question about public pension benefits. Other countries systematically overestimated benefits (e.g., UK and Japan). In the UK, we had a group of individuals for which the benefit calculators predict benefits but the individuals reported not to receive any, leading a large share of large deviations (right column in Table 3).

The stream of social security benefits by year/age was then used to compute *ITAX* for each retirement age that each individual/couple in the sample could choose. For countries with good earnings histories (e.g., Italy using the SHARELIFE data), this calculation could be done retrospectively, extending the coverage to earlier years than the actual retirement. For countries with earnings tests in effect at least at ages before the SEA (all countries except Canada, the Netherlands, and UK), we assume that retirement means both claiming social security benefits and stopping work.

Figure 4 depicts the predicted *ITAX* for men aged 60-64 by year, averaged across all sample members. It is based on the grouped data of nine countries described in Section 7 as opposed to the synthetic data depicted in Figure 3.

Figure 4: *ITAX* by country, men ages 60 to 64, 1985-2015 [percentages]



Note: Averages across ages 60-64 using the grouped data set described in Section 7.

Figure 4 shows that the countries described in this volume have both very different initial starting values of the implicit tax on working longer at ages 60-64 and very different rates of change over time. Despite this large heterogeneity, there was a common trend, indicated by the average across the countries (broken thick line). This trend has reduced the implicit tax in all countries that started with a disincentive to working longer. Between 1994 and 2004, *ITAX* averaged about 22%, while it was about 12% between 2006 and 2013. In the UK, Italy and Spain this even led to a small negative value, indicating that there is now on average a subsidy to work at older ages. Italy exhibits the largest decline: the implicit tax was about 70% in 1990, and was reduced to about a negative 8% in 2015. In Spain, we observe two distinctive phases: *ITAX* increased between 1994 and 2012 from a negative value to almost 10%, which was then lowered slightly below zero until 2015. Sweden provided a positive incentive to working longer throughout the time depicted in Figure 4. The reader is referred to the country chapters in Börsch-Supan and Coile (2020) for a detailed explanation of these trends.

The country chapters show that incentives correlate with other socio-economic characteristics. Table 4 shows regression results for the grouped data of nine countries. The implicit tax on working longer rises with age, which is consistent with declining employment at older ages. It is higher for male than female, but does not vary significantly with marital status and education.

Table 4: Variation of *ITAX* with socio-economic characteristics

Variable	Coefficient	Std.Error	t-Statistic
Age	0.3853	0.0123	31.4
Age_squared	-0.0030	0.0001	-30.1
Married	-0.0183	0.0119	-1.5
Male	0.0295	0.0039	7.6
Educ_low	0.0114	0.0086	1.3
Educ_hig	-0.0167	0.0098	-1.7

Note: Linear regression of ITAX on socio-economic characteristics based on grouped data set described in Section 7. Eicker-Huber-White-robust standard errors. Year and country dummies included.

The main aim for Phase 10 is to use panel data to estimate a regression equation of the form

(1) $EMP_{it} = f(ITAX_{it} ; CHAR_{it})$

where the binary dependent variable *EMP* is the employment status of individual *i* at time *t* which is 1 if employed and 0 if retired. Most countries used the employment status as reported in the data. Some countries used an income-based definition. Here, retirement is assumed to occur in the last year with positive earnings before a year of zero earnings (e.g., if earnings during four years are 20, 20, 5, and then 0, then we assume that retirement occurs during the third year).

ITAX is our main explanatory variable measuring the implicit tax on continuing work as defined in Section 4. Some country teams also employ alternative incentives variables, such as the peak value or the option value of continuing work as described in Gruber and Wise (2004); see the individual country chapters.

CHAR is a set of personal characteristics including socio-demographics. Age dummies are included in all models and specifications. Besides standard demographics, they include social security wealth (*SSW*) and average life time earnings (*ALTE*) in order to isolate the effect of *ITAX* from socio-economic status at the time of the retirement decision. *ALTE* is the sum of price-indexed annual earnings from whenever the person entered labor force to present, divided by the number of years, using 2020 as base year for the price index). Depending on data availability, regressions also included other personal characteristics such as health, education, one-digit occupation code (ISCO, the international standard code of occupations), and measures of other financial and real wealth. The health measures differ across datasets; education is measured as a set of two dummy variables for more or less than medium education as defined by ISCED, the international standard code of education.

Since *EMP* is binary, *f* represents a linear or probit specification such that the model has an interpretation as a discrete time hazard model of retiring where retiring may mean quitting work and/or receiving a pension.

The country teams included fixed or random effects to take care of those error components that describe unobserved individual or household characteristics that do not change over time. Table 5 reports the results from the country chapters for five regression specifications (linear probability model, linear probability model with fixed effects, linear probability model with random effects, probit model, and probit model with random effects). Table 5 shows the marginal effects of *ITAX* on remaining in employment. Significance is derived from standard errors that are cluster robust.

Table 5: Marginal effects of *ITAX* on the probability to keep working

Country	Linear probability model	Linear probability model with fixed effects	Linear probability model with random effects	Probit model	Probit model with random effects
Belgium	-0.079***	-0.148***	-0.093***	-0.063***	-0.075***
Canada	-0.036***	-0.039***	-0.060***	-0.059***	-0.065***
Denmark$	-0.060***	-0.069***	-0.076***	-0.045***	
France	-0.080***	-0.108***	-0.080***	-0.089***	-0.084***
Germany §	-0.096***	-0.121***	-0.096**	-0.107***	-0.107***
Italy	-0.008	-0.044***	-0.030***	-0.029	-0.029
Japan +	-0.161***	-0.172***	-0.168***	-0.142***	-0.146***
Netherlands +	-0.204***	-0.120***	-0.211***	-0.101***	-0.089***
Spain	-0.067***	-0.090***	-0.033***	-0.066***	-0.060***
Sweden	-0.016***	-0.129***	-0.028***	-0.077***	-0.122***
UK §§	-0.017*	-0.027***	-0.042***	-0.018**	-0.021**
US	-0.093***	-0.153 ***		-0.063***	

Note: *** = p-value < 0.01; ** = p-value < 0.05; * = p-value < 0.10. §= males in couple households only, §§=all observations, + only men. Sweden and US did not provide estimates for the probit model with random effects; US also for logit model.

Table 5 carries a clear message: In almost all of the countries and models, the financial incentives to retire early as captured by the implicit tax on working longer have an economically strong and statistically significant negative effect on the probability to keep working. The average marginal effect of ITAX on remaining in employment across all countries and models is about -0.1, lowest in the UK (about -0.03) and highest in Japan (about -0.17) for the linear specification with fixed effects.

This is our preferred specification since the fixed effects correct for unobserved heterogeneity in our data. The magnitude of the marginal effects closely follows the institutional set-up of the social security systems. Large marginal effects indicate that individuals react strongly to the financial incentives provided by ITAX in their retirement decisions. This is the case in countries with strong earnings-related social security systems, e.g., Japan, the US, Sweden and Germany. In turn, countries with social security systems that are dominated by flat-rate pensions have relatively small marginal effects, e.g., the UK, Canada and Denmark. In Italy, all estimated marginal effects are negative but only in the linear probability models with fixed or random effects are they statistically significant. Similar to Spain, one reason is the very heterogeneous labor market history of women that is not well described by ITAX. It is notable that the fixed effects specification yields substantially larger marginal effects in these two countries than the specifications that do not account for heterogeneity.

It is important to point out that these marginal effects have a causal interpretation since they rest on econometric estimates identified by exogenous policy reforms. Together with the findings of small effects of changes in health and education in Phase 8 of this project (Coile et al. 2019), this implies that the policy reforms that have reduced the financial incentives to retire early were the main drivers of the increase in old-age employment shown in Figures 1 and 2. Moreover, it means that the suggestive findings in Phase 9 of the project in which synthetic effects were calculated based on a few household types (Börsch-Supan and Coile 2020) can be backed up by these causal estimates.

6. Counterfactual simulations

In order to show the impact of the incentive variable *ITAX* in the metric of the outcome variable (the probability of still working), we applied the technique of counterfactual simulations. This may be more intuitive than the marginal effects displayed in Table 5. The counterfactual is obtained by predicting the probability of still working using the same model, but substituting the true time- and individual-varying incentives by those values that would have prevailed if the past reform process had not taken place. All other covariates including age are kept at their actual and changing value. In this way, we eradicate all changes due to policy reforms. The underlying probability model is:

$$(2) \qquad EMP_{it} = f(ITAX_{it}, Y_{it}, age_{it}, covariates_{it}) + \mu_{it}$$

where Y_{it} is a measure of life-time income of individual i up to time t and μ_{it} an error term. We use the estimates of Section 5 for this model. Based on them, the counterfactual predicted probability of still working for each individual is defined as:

$$(3) \qquad EMP^{cfac}_{it} = f(ITAX_0, Y_0, age_{it}, covariates_{it}).$$

More precisely, since *ITAX* and *SSW* are themselves functions of age and covariates, equation (3) should be written as:

(4) $EMP^{cfac}_{it} = f(ITAX(law_{i0}, age_{it}, covariates_{it}), Y(law_{i0}, age_{it}, covariates_{it}), age_{it}, covariates_{it})$.

We apply the pension law and rules for individual/couple *i* as they were in effect (not only announced) at time 0, while age and the covariates describe the state at time *t*.

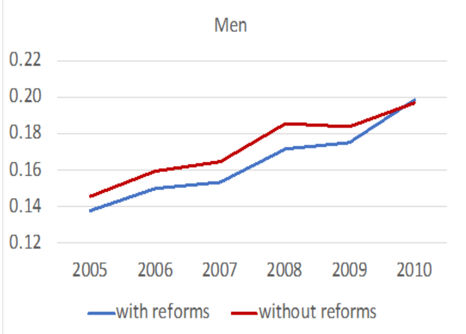
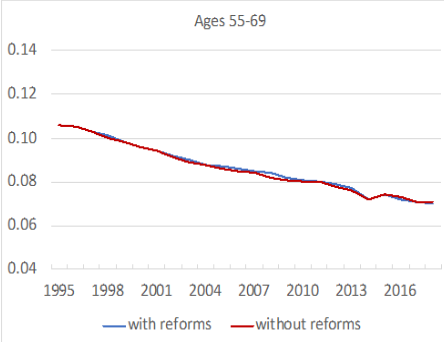
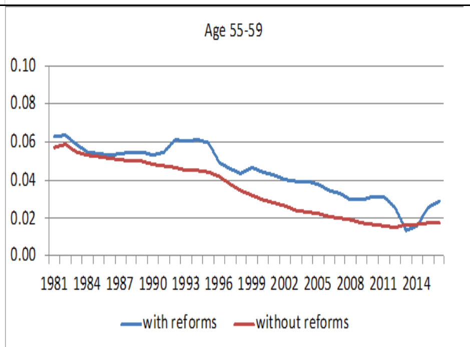
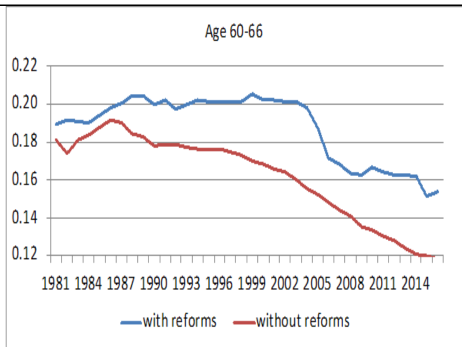
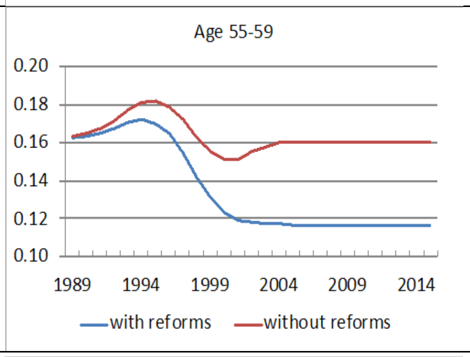
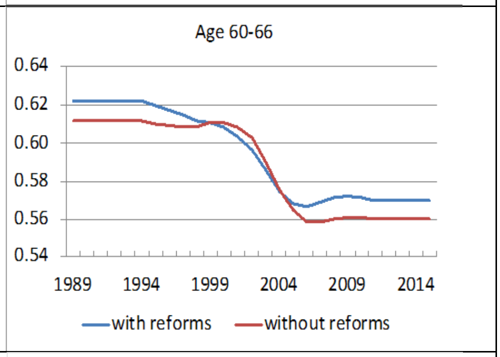
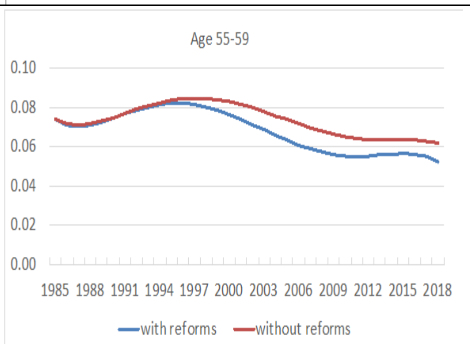
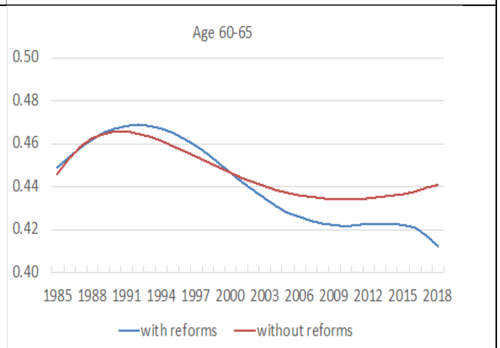
The simulations are cohort-based. This means that we "age" the individuals in our samples until everyone has reached age 69. The time-varying covariates (e.g., age, lifetime earnings) are adjusted accordingly as the sample ages. This also requires us to dynamically adjust the weights for each pathway since their probability distribution changes over time. We use the predicted probabilities for each pathway at age=*t*-1 to weight the probability to retire at age *t.*

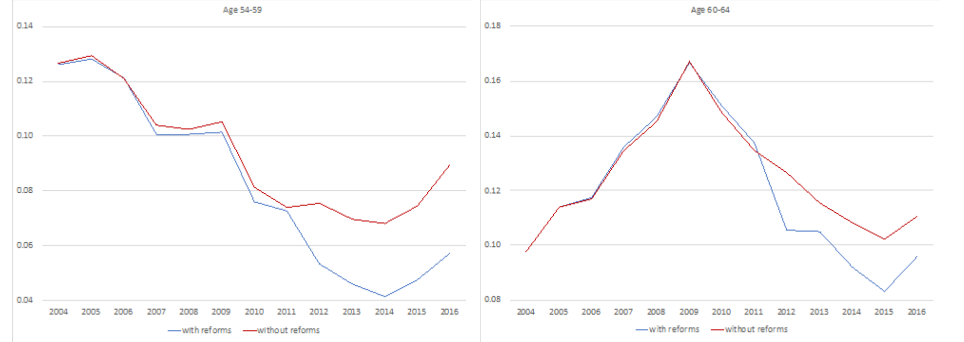
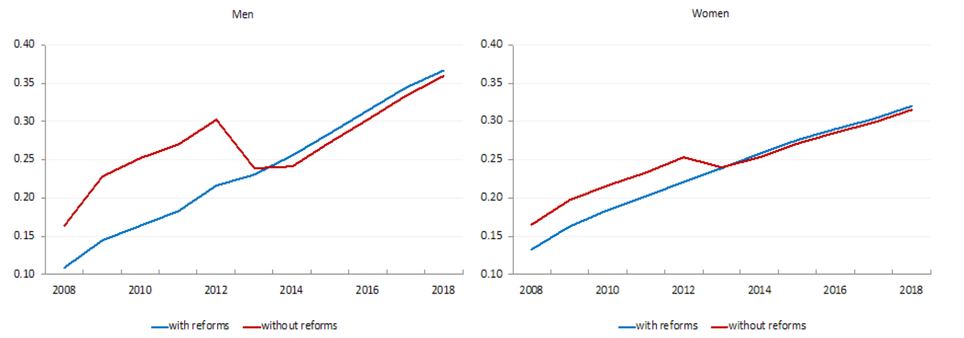
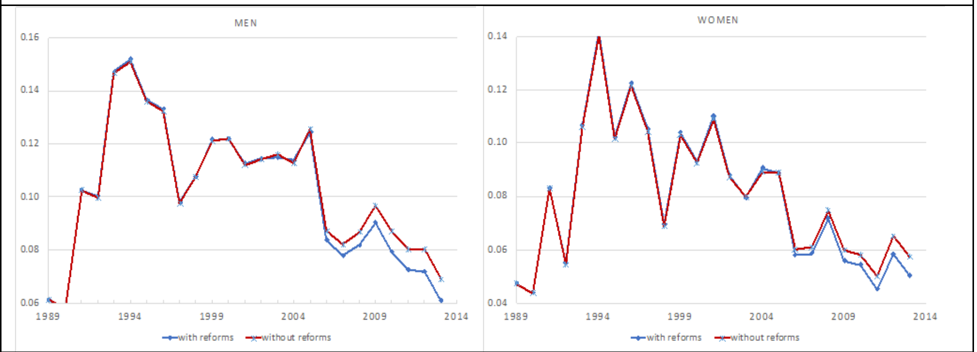
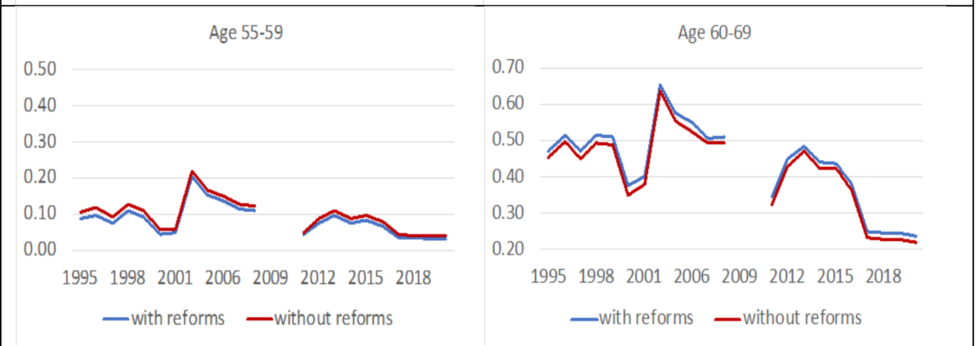
There may be macro feedback from the (non-)reform on the covariates in our counterfactual prediction (e.g., a reform or its absence will imply different earnings which in turn may affect health and this may affect retirement). We did not model these effects since they are unlikely of a magnitude that would raise concerns.

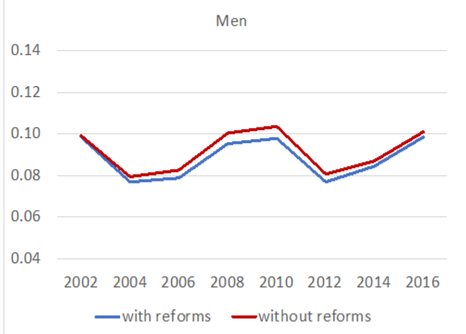
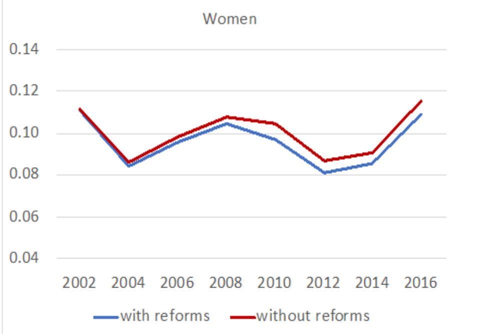
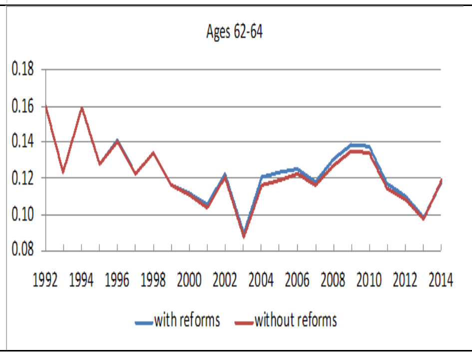
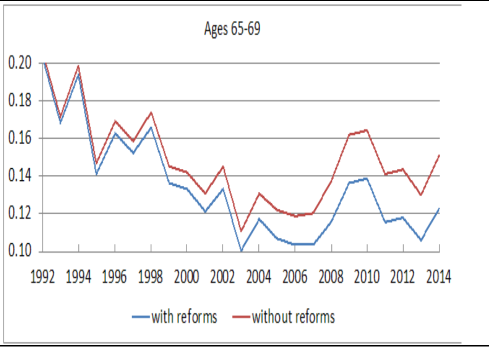
The country chapters plotted the development of several indicators of the counterfactual outcome (employment as if no reform had happened) against predicted outcome (employment under the actual legislation including all reforms). Some countries also compared these model outcomes with the actual development of these indicators over time. Indicators included retirement probabilities at several ages and average retirement age.

Table 6 shows how the probability of exiting the labor market changed over time. These graphs combine the evolution of the retirement incentives shown in Figure 4 with the effect of these incentives on employment as displayed in Table 5. In Canada, the Netherlands, Sweden, and the UK, the incentives changed little. We therefore see relatively small changes between the predicted and the counterfactual outcomes in the graphs of Table 6 for these countries. In Denmark, ITAX declined but the predicted exit rate from employment is actually higher than the counterfactual without reforms. In all other countries, the counterfactual simulations show how the reforms have reduced the probability of exiting the labor market, in line with the reduction in the incentives to retire early. The reform-driven decline in the average probability of exit is generally in the range of 1 to 3 percentage points, though there are differences by age or gender in some countries. In Spain and France, the change in incentives reduced the probability of labor force exit at ages 55 to 59 but not at older ages; by contrast, in the US, reforms reduced the probability of labor force exit only after age 65.

Table 6: Predicted and counterfactual retirement probabilities

Country	Sample	Probability of labor market exit with and without reforms	
Belgium	Ages 56-65; men and women		
Canada	Ages 55-69; men and women pooled		
Denmark	Ages 55-59 and 60-66, men and women pooled		
France	Ages 55-59 and 60-66, men and women pooled		
Germany	Ages 55-59 and 60-65, men and women pooled		

Italy	Ages 54-59 and 60-64, men	
Japan	Cohort born in 1948, men and women	
Netherlands	Ages 55-63, men and women	
Spain	Ages 55-59 and 60-69, men	
Sweden	Age 63 and 64, men and women pooled	

UK	Ages 55-69, men and women	 
US	Ages 62-64 and 65-69, men and women pooled	 

Note: graphs are scaled to show a 10 percentage point range, except in the case of Japan and Spain.

7. Pooled time-series cross-national analysis

Since the results in Tables 5 and 6 are based on country-specific data, they only exploit the within-country changes in social security policies to estimate the effects of financial incentives on labor force participation at old ages. Harmonization across countries was achieved by using an analytic template that rigorously applied the same methodology to country-specific databases. The econometric estimations, however, were done on separate datasets for each country as displayed in Table 2.

In this section, we create a consolidated data set that has been pooled across countries. The pooled data allow us to exploit the international differences in social security policies across countries to pin down the effects of *ITAX* on old-age labor force participation. At the same time, we can account for international differences in other factors that may affect retirement behavior, including observable variation across countries (e.g., due to health, education, macroeconomic conditions) and unobservable variation (e.g., due to cultural factors).

Because many data sets are assembled from government administrative records, country-specific data registries and other sources with strict data use limitations, we could not pool the micro data. We therefore constructed a pooled data set based on cells of size *N* with average data by year, age, sex, and income group. *N* is the minimum cell size defined by the country-specific data protection regulations. Belgium, Canada and the US used administrative datasets (or survey data linked with administrative data) which did not permit this type of data usage, hence the pooled international dataset represents nine countries.

We first describe the ideal set-up, although not all data sets are sufficiently rich to support this procedure. To construct the cells, we started with a person-year sample of observations who are between age 55 and 69 and are employed at the beginning of the year. In a first stage, we have about 25 years x 15 ages x 2 sex groups = 750 cells. We denote the resulting cell sizes with K_i, i=1…750.

In a second stage, we divide each of these 750 cells according to average life-time earnings. Let's suppose that cell K_i has 120 observations and N=12. Then we form 10 equally sized cells, equivalent to splitting up the original cell into deciles by average life-time earnings. More generally, we divide the original cell according to K_i/N percentiles of average life-time earnings. Since K_i differs across the 750 cells in the 1st stage, the number of cells constructed in the 2nd stage will differ by year, age, and sex (and also across countries). If K_i is not evenly divisible by N, we allow the highest income group to be larger (e.g., in this example if K_i=125, the top income group has 15 observations).

This construction works well for very large data sets, e.g. the publicly accessible register data of Denmark. The sample sizes of the survey data (e.g., ELSA, SHARE and SOEP) are much smaller. Here we needed to aggregate cells further to achieve the demanded and/or statistically sensible minimum cell size, or drop one stratification dimension.

This aggregation procedure into cells of a minimum size has its obvious disadvantages vis-à-vis genuine micro data. The estimates will be less precise than the regressions in Section 5 because they are based on cell averages rather than individual data. On the other hand, the estimates will be identified by the combination of time and country variation, especially social security reforms that occurred at different times in different countries, which should yield more precise estimates. It also responds to the concern that *ITAX* could be correlated with other country-specific factors that influence retirement. This was a genuine threat to the validity of the analysis in Phase 2 (Gruber and Wise, 2004) since identification relied on differences in incentives that arise, at least in part, from differences in earnings histories and other characteristics that may affect retirement as opposed to financial incentives.

A central team then pooled these cell-based datasets across countries and estimated variants of the following equation, separately by sex:

(2) $$EMP_{cayt} = \alpha\, ITAX_{cayt} + \beta\, SSW_{cayt} + \gamma\, ALTE_{cayt} + \delta\, CHAR_{cayt} + \lambda_t + \theta_c + \varepsilon_{cayt}$$

where:

c	country
a	age group
y	income group
t	year
EMP	frequency of being employed
$ITAX$	mean implicit tax on working longer
$CHAR$	vector of other covariates (e.g., age, sex, marital status, education)
λ_t	year fixed effect
θ_c	country fixed effect
ε_{cayt}	remaining error term

The main dependent variable is the frequency of being employed among the individuals/couples in each cell who are between age 55 and 69. It has the familiar U-shaped development observed in the previous volume (Börsch-Supan and Coile, 2020): first declining, and then increasing again after the mid1990s.

The main explanatory variable is the mean of *ITAX* across all individuals/couples in each cell as calculated for the work in Section 5 and depicted in Figure 4. Covariates include age and age squared, and the frequency of male, married, low and high education in each cell.

In order to purge the variation in employment by country and time specific unobserved heterogeneity, we include a set of fixed effects for country (shown) and year (not shown).

In order to account for the fact that the variance of the remaining error term ε_{cayt} is different across cells, we correct the significance levels in two different ways. Column 3 reports t-statistics based on Eicker-Huber-White robust standard errors. Column 4 uses clustering by year and country, assuming a block-diagonal covariance matrix which allows higher correlations within year-country cells than between such cells. This very conservative way to estimate significance reduces the statistically relevant number of observations from 23,353 to 202.

Results are presented in Table 7. *ITAX* is highly significant under both methods of constructing robust standard errors. The country fixed effects mirror the average employment shares in each country relative to Germany. The probability of employment decreases with age, is higher for males, and has a U-shaped pattern for education.

Table 7: Pooled regressions of the probability to work on ITAX and covariates

		Without health			Health included	
	Coefficient	**Robust t**	**Clustered t**	**Coefficient**	**Robust t**	**Clustered t**
ITAX	-0.0668	-19.97	-5.84	-0.0670	-20.07	-5.85
Germany	0	0	0	0	0	0
France	-0.4566	-48.97	-19.95	-0.4820	-44.39	-19.07
UK	0.1201	17.24	14.20	0.1502	17.01	11.08
Denmark	0.0909	14.19	13.67	0.1389	17.93	11.08
Japan	0.0586	8.68	5.18	-0.0198	-2.05	-0.92
Spain	-0.0235	-2.51	-1.34	-0.0221	-1.91	-1.04
Netherlands	0.0481	5.49	3.98	0.1014	8.56	5.29
Italy	0.0637	8.30	4.68	0.0649	6.87	3.40
Sweden	0.0689	10.42	7.98	0.1213	8.76	5.51
Age	-0.1459	-20.80	-7.18	-0.1459	-20.84	-7.08
age_squared	0.0010	17.30	5.90	0.0010	17.33	5.81
Married	-0.1769	-14.39	-6.10	-0.1657	-13.30	-6.01
Male	0.0331	15.82	7.43	0.1332	13.24	5.90
educ_low	0.0094	1.45	0.97	0.0116	1.82	1.22

educ_hig	0.1140	11.43	7.53	0.1167	11.71	7.56
health_LE60				0.0265	9.62	4.24
health_yrslost[100]				0.0034	5.46	2.41
health_subj				-0.0020	-6.93	-3.34
Number of obs		23,353	202		23,353	201
F(45, Nobs)		736	215		682	176
Prob > F		0	0		0	0
R-squared		0.5942	0.5942		0.5972	0.5972
Root MSE		0.13877	0.13877		0.13826	0.13826

One may argue that at least part of the increase in old-age employment over time has been due to better health. The right-most columns in Table 7 add three health variables to the regression, mimicking the approach taken in Phase 8 of the International Social Security project (Coile et al., 2019). These country-specific time series are reported in the OECD Health data files. The first variable (life expectancy at age 60) is significant and has a positive sign as hypothesized. However, the other two variables (years lost due to death before age 75 and subjective health) have significant coefficients with unexpected signs. The contribution to overall fit is very small.

Finally, we ask ourselves whether the explanatory power of the complex *ITAX* variable vanishes if we add simple system characteristics such as the eligibility ages SEA and EEA. The leftmost columns of Table 8 show the results: they are essentially unchanged from Table 7. For five of the countries, we also have measures of the actuarial deductions (as percentage averaged over the retirement window), the net replacement rate (average benefit if retire now divided by average life time earnings), and whether an earnings test is applicable. This is now a smaller and different set of countries. Results are shown in the central columns of Table 8. One may expect that the other incentive variables take explanatory power away from *ITAX*. This is not the case as the rightmost columns in Table 8 show: the coefficient for *ITAX* is even more significant when including the measures but restricting the analysis to the subset of countries used in column (2). This is an important indication that our key variable in this volume works as designed.

The country indicators in Tables 7 and 8 show some remarkable differences. If the eligibility ages SEA and EEA are not included, France dramatically deviates from the reference country (here Germany). This effect vanishes in Table 8. This indicates that French workers are not only reacting to the financial incentives in ITAX but that the eligibility ages SEA and EEA send an important additional signal to retire as soon as these ages are reached. The opposite is the case for the Netherlands. Relative to Germany, more Dutch workers continue to work in spite of having reached the relevant eligibility ages.

Table 8: Pooled regressions of *ITAX* and other incentive variables

	(1) Main result, full sample of countries		(2) With measures of actuarial deductions, subset of countries		(3) Without measures of actuarial deductions, subset of countries	
	Coef.	Robust t	Coef.	Robust t	Coef.	Robust t
ITAX	-0.0652	-19.67	-0.0367	-10.44	-0.0108	-3.77
SEA	-0.0119	-9.58	-0.0124	-6.37	-0.0105	-5.38
EEA	0.0141	12.55	0.0103	5.52	0.0086	4.61
adjust			0.0879	6.61		
replace			-0.0038	-2.01		
earn_test			0.0432	6.34		
Germany	0.0000		0.0000		0.0000	
France	-0.0554	-0.38				
UK	0.1066	10.66	0.0975	5.98	0.0679	4.51
Denmark	0.1617	19.56	0.1280	12.49	0.1175	12.17
Japan	0.0266	2.49	0.0604	4.23	0.0678	4.93
Spain	0.0013	0.11				
Netherlands	0.5420	3.79				
Italy	0.1141	10.08				
Sweden	0.1574	10.41	0.1511	7.50	0.1175	6.39
age	-0.1467	-21.1	-0.2370	-34.67	-0.2094	-36.27
age2	0.0010	17.58	0.0018	31.23	0.0015	32.62
married	-0.1627	-13.02	0.0761	3.58	0.0584	2.67
male	0.1211	11.99	0.0545	5.71	0.0561	5.82
educ_low	0.4245	2.95	0.2000	1.44	0.3419	2.71
educ_med	0.4079	2.84	0.2272	1.63	0.3694	2.92
educ_hig	0.5272	3.67	0.2945	2.11	0.4375	3.46
health_LE60	0.0225	8.17	0.0078	2.96	0.0080	2.97
health_yrslost	0.0060	8.69	0.0025	3.04	0.0017	2.08
health_subj	-0.0020	-6.04	0.0007	1.38	0.0008	1.56
Number of obs		23,353		18,914		18,914
F-test	F(51, 23301)	665.59	F(50, 18863)	393.48	F(47, 18866)	376.45
Prob > F		0		0		0
R-squared		0.6019		0.3952		0.386
Root MSE		0.13747		0.11538		0.11624

8. Conclusions

This tenth phase of the *International Social Security (ISS) Project* is the third step in explaining the reversal of the past trend to ever earlier retirement ages around the late 1990s and early 2000s. The first step investigated changes in health and education as potential causes. In the second step, we found that the financial incentives to work at older ages had been strengthened as a result of many social security reforms in recent decades and were positively correlated with labor force participation at older ages.

In this volume, twelve country teams exploited the time-series and cross-national variation in the timing and extent of pension reforms to study whether this correlation is causal, using micro-econometric regression methods to relate the probability of exiting the labor market to the financial incentives to retire early. These regressions were based on large administrative data sources and survey data available in the twelve countries. Harmonization across countries was achieved by using an analytic template that rigorously applied the same methodology to country-specific databases.

In almost all of the countries and models, the financial incentives to retire early as captured by the implicit tax on working longer have a statistically significant negative effect on the probability to keep working.

While these results are based on the within-country changes of social security policies only, they are confirmed when we pooled data across all participating countries. Pooled data allow us to exploit the international differences in social security policies across countries to pin down the effects of *ITAX* on old-age labor force participation. At the same time, we can account for international differences in other factors that may affect retirement behavior, including observable variation across countries (e.g., due to health, education, macroeconomic conditions) and unobservable variation (e.g., due to cultural factors). The effect of *ITAX* on employment in the pooled analysis is slightly smaller than the average effect across all countries. It is highly significant. This contrasts with variables such as the secular health improvements which account for very little of the total variation, re-iterating the findings in Phase 8 of this project as reported by Coile et al. (2019).

It is important to point out that these effects have a causal interpretation since they rest on econometric estimates identified by exogenous policy reforms. Together with the findings of very small effects of other secular changes such as better health and better education, we conclude that the policy reforms that have reduced the financial incentives to retire early were the main drivers of the increase in old-age employment.

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Appendix: Methodology

The twelve country teams have set up social security benefit calculators (Section A1) which compute the after tax benefit stream from each salient social security program and pathway as a function of observed and, if necessary, imputed earnings histories (Section A3). This benefit stream starts after "retirement" which may take several "pathways". This is defined more precisely in Section A2. Survival probabilities are adjusted for socio-economic status (Section A4). Where significant, we include occupational pensions in addition to public pensions (Section A5).

A1: Computation of *ITAX*

Section 4 has described the construction of *ITAX*, our key indicator of retirement incentives. More formally, social security benefit calculators convert an earnings history y up to age R-1 into a benefit B from age R onwards:

(1) $B_{k,t,a}(R,i) = f_{k,t,a}(y(R\text{-}1,i))$

where $B_{k,t,a}(R,i)$ is the after tax benefit from social security program and/or pathway k for an individual of type i and at age $a \geq R$, where R is the first year of benefit receipt occurring at calendar time t. Note that potential cohort differences are fully captured in this notation. This benefit has changed over time (index t) due to policy changes, as we know, and it may change as individuals age (index a). The benefit is dependent on the entire earnings history as expressed by $y(R\text{-}1,i)$ which is the vector of earnings from age 15 to R-1 for an individual with a specific set of socio-economic characteristics (index i). In most countries, benefit computations start at a=55 and end at a=69; in some countries, however, it is possible to claim pensions even earlier. Ineligibility for a pathway is modeled by setting $B_{k,t,a}(R,i) = 0$.

Summarizing and properly discounting the expected stream of social security benefits for the remaining life span yields the social security wealth, denoted by *SSW*. For an individual of type i starting to claim benefits from program/pathway k at age R in time t, denoting time at death with T, social security wealth is the present discounted value of all future social security benefits:

(3) $SSW_{k,t}(R,i) = \sum_{a=R,T} B_{k,t,a}(R,i)\ \sigma_{t,a}\ \beta^{a-R}$.

Discounting has two components: $\sigma_{t,a}$ is the survival probability at age a in time t and β is the usual discount factor for a discount rate of 3%.

Postponing claiming by one year has two effects on social security wealth. On the one hand, annual benefits $B_{k,t,a}(R,i)$ increase with later claiming in most countries due to additional contributions and actuarial adjustments. On the other hand, however, benefits are received one year less. The accrual of social security wealth

(4) $ACC_{k,t}(R,i) = SSW_{k,t+1}(R+1,i) - SSW_{k,t}(R,i)$

can thus be positive, zero, or negative. If the accrual is negative, the social security system imposes an implicit tax on claiming later. This implicit tax rate is the (negative) accrual of social security wealth divided by the after tax earnings during the additional year of work:

(5) $ITAX_{k,t}(R,i) = - ACC_{k,t}(R,i)/Y_{t+1,i}$

Since most countries feature earnings tests at least at ages before the statutory retirement age, this implicit tax on claiming later is also an implicit tax on working longer. *ITAX* is the key incentive variable which we model in this volume and associate with the change in labor force participation. A positive value of *ITAX* means that there is a tax on working longer, a negative value represents a subsidy for working longer. It collapses all the various dimensions of social security policy into a single dimension; this is as much an advantage as it is a disadvantage. The advantage is that the single dimension of *ITAX* permits to easily display associations between policy and potential outcomes such as old-age employment or labor force participation. The obvious disadvantage is that social security policies may be more complex and may even have inconsistencies that are masked by a one-dimensional measure.

The main work in this volume is for each country to compute a time series of ITAX for each sample member in their longitudinal dataset:

Figure A1: Time series of incentive variables

	55	56	…	68	69
1980	x(55,1980,i,k)	x(56,1980,i,k)	…	x(68,1980,i,k)	x(69,1980,i,k)
…	…	…	…	…	…
2015	x(55,2015,i,k)	x(56,2015,i,k)	…	x(68,2015,i,k)	x(69,2015,i,k)

In this matrix, the entry *x*(55,1980,*i*,*k*) represents the implicit tax of claiming benefits from program/pathway *k* one year later expressed as a percentage of the earnings in that additional year for a 55-old worker *i* under the pension rules that have been legislated in 1980.

A2. Definition of retirement and pathways

In many languages, there is only one word "retirement" for two distinct economic decisions: exiting the labor force and claiming a pension or social security benefits. For the benefit calculator, *R* is the combination of the age of claiming and leaving the labor force. The matrix in Figure A1 represents the *implicit tax of working longer* only in the case when social security or other rules enforce the equality of the age of retirement from the labor force (R_L) and the age of claiming benefits (R_C). Most often, this equality is enforced by earnings tests which disallow earning more than Y_{test} and/or by clawback rules in the benefit calculation which tax earnings while receiving benefits at a high rate τ in addition to earnings taxation.

In most European countries and Japan, earnings tests are still strict such that claiming benefits forces the individual to give up work for pay. In these countries, the two decisions are equivalent and working a year longer implies postponing claiming benefits by a year. In the US and the UK, however, earnings tests have been abolished. Hence, retiring from work and claiming benefits are separate decisions in principle, although we still observe a strong habitual link between retiring from the labor force and claiming benefits.

For countries in which pathways to retirement via disability or unemployment insurance are important (e.g., Germany and Italy), we construct separate matrices for each pathway. We then compute a weighted mean over these pathways where the weights are the actual proportions in which these pathways have been selected. The country chapters show graphs how the weights have evolved over time.

The case of couples retiring at different ages can become very complex. To keep matters simply, we assume that the spouse's retirement behavior is fixed, i.e., will not react to the other partner's retirement decision. In many countries, the case for couples is therefore identical to the unmarried case. One example for an exception is the US with their spouse benefits; other examples include survivor benefits.

A3. Construction of earnings histories

If the longitudinal data does not cover the full earnings history, we need to impute the missing data. We apply country-specific earnings profiles that are derived from aggregate labor force statistics available in each participating country; to account for cohort effects, theses profiles are based on cohort-specific longitudinal data wherever available. They are aggregated from models of the earnings process which exploits all available information on individuals' earnings histories, based on regressions of the form:

$$\Delta lnY_t = \alpha + X_t\delta + \beta_1 AGE + \beta_2 AGESQ + \beta_3 \Delta lnY_{t-1} + \beta_4 \Delta lnY_{t-2} + \beta_5 \Delta lnY_{t-1}*AGE + \beta_6 \Delta lnY_{t-1}*AGESQ + \beta_7 \Delta lnY_{t-2}*AGE + \beta_8 \Delta lnY_{t-2}*AGESQ + TIME_t\lambda + \varepsilon \quad (8)$$

where Y_t is earnings of individual *i* in period *t*
X is a set of human capital control variables for individual *i*: education, marital status, race, tenure in the labor market, tenure at the firm, region of residence, etc.
AGE is age, *AGESQ* is its square
TIME is a set of dummy variables for each year of the sample

Earnings are deflated by a consumer price index or equivalent. The data is then differenced such that the dependent variable is the percentage change in earnings for the individual. After having run the regression on an individual basis, we aggregate the projected earnings profiles over the lower, middle and upper tercile of the income distribution, separately for men and women.

Some countries condition the eligibility for a certain pathway (e.g. Germany) or pension benefits in general (e.g. France) to the number of years of contribution. These may include drop-out years for parents during child raising, sometimes also unemployment, further education, care for parents etc. In this case, we use a suitable average number of such years derived from national labor statistics.

Social security benefits are computed net of applicable income taxes. The earnings in the denominator of *ITAX* are net of payroll taxes, i.e., income taxes, mandatory social contributions etc. Some country teams used an income tax calculator (stratified by single vs. couple household) which included the preferred tax treatment of pension benefits. Other country teams used simpler alternatives, e.g., applied statutory tax rates stratified by household type and income bracket.

A4. Survival probabilities based on socio-economic status

We use country-specific survival rates that are specific for each cohort, based on country statistics or the Human Mortality Database. In addition, these rates are adjusted to generate a life expectancy which is 3 years higher (lower) to reflect the difference in life expectancy across three income categories: lowest, medium and upper tercile. This adjustment is a mixture of a proportional increase (decrease, resp.) of the survival rates and a shift of the survival curve to the right. These values are used to calculate the conditional probability that a 55-year-old will alive at every future age (56-100) when he/she might receive benefits, and so on for workers of different ages represented in the matrix.

A5. Occupational and private pensions

In some countries, occupational pensions play a minor role and are simply ignored (e.g. in Italy). In other countries they are an essential part of the old-age income provision system (e.g. in the Netherlands). If occupational pensions are included, they are treated as an “add on” to public pensions; hence public and occupational pensions are considered as a package. DC pensions are only included when they affect the eligibility for means-tested benefits (e.g., in Canada). Private pensions (e.g., IRAs in the US and Riester pensions in Germany) are not included.