Public-sector compensation over the life cycle*

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Abstract

The size of the public sector in terms of employment and compensation has a strong life-cycle dimension. We establish a quantitative partial-equilibrium life-cycle model with incomplete markets, private and public sectors, and risk-averse workers, and use it to (i) calculate three dimensions of public-sector compensation: wage, pension, and job-security premia, and (ii) quantify the effects of harmonizing the compensation in the two sectors. We find that the job-security and pension's premia are important forms of compensation to public-sector workers. Harmonizing the characteristics of public employment with those of the private sector would lower the unemployment rate and reduce government costs.

JEL Classification: J45, E24, H30, H55.

Keywords: public-sector employment, public-sector wages, life cycle, unemployment, retirement, pensions, job security.

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1 Introduction

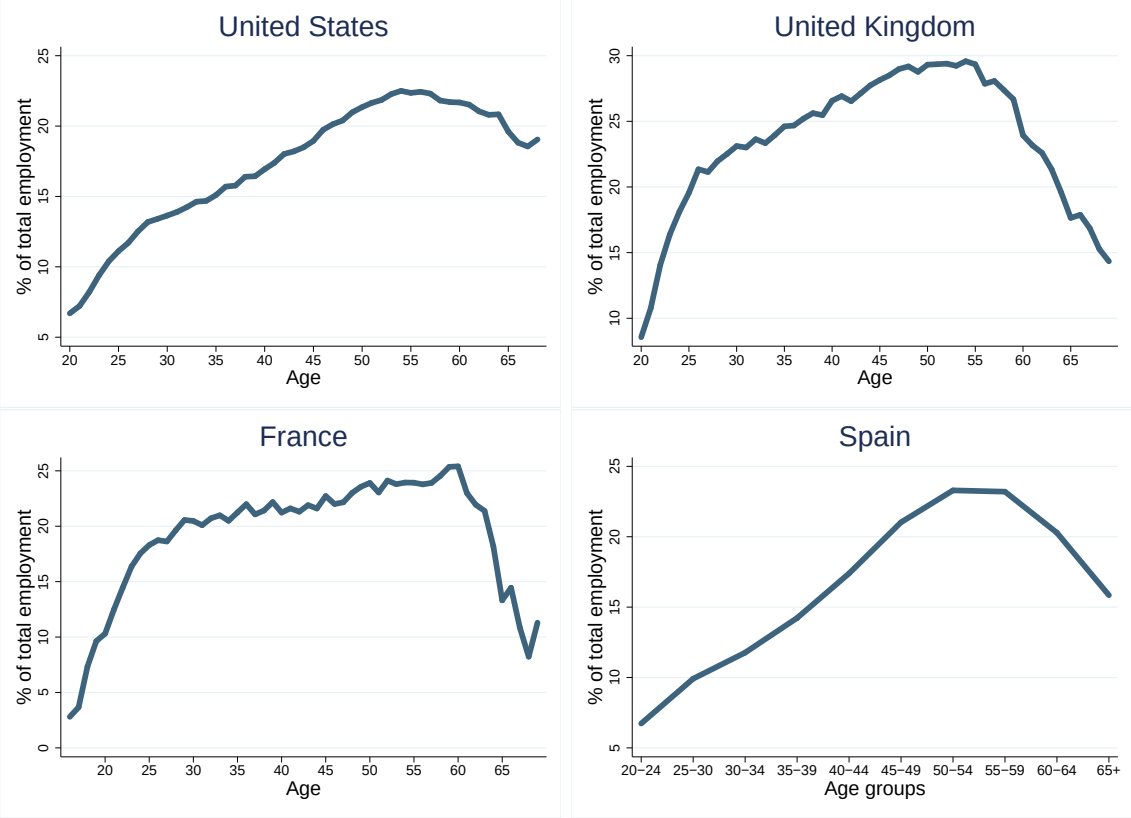
In most developed economies, the public sector accounts for 10 to 30 percent of total employment. Perhaps less know is the strong life-cycle pattern of public(-sector) employment. Figure 1 shows its percentage out of total employment by age for the United States, United Kingdom, France and Spain. Public employment represents a small fraction of total employment for young workers, but progressively grows, peeking at ages 50 to 60, a feature shared by the four countries. Along with age-varying employment, even less is known about age-variation in public-sector compensation. Besides their labour market implications, both employment and compensation have considerable budgetary implications as first pointed by Buchanan and Tullock (1977).

When examining differences in compensation across sectors, most studies focus on average wage differences. These have been widely documented by the empirical literature using micro-level data that usually finds that most public sectors pay relatively higher wages, particularly to low-educated workers, but that these differentials are not homogeneous by age.[1] However, wages are not the only form of compensation difference between the public and private sectors. Perhaps more relevant for older workers, is the fact that retirement benefits are often higher in the public sector. Traditionally, in many countries, public-sector workers have enjoyed separate pensions schemes with larger benefits (see OECD (2017)). The third component of compensation is the job security - a distinctive feature of public-sector jobs in many but not all countries. These different forms of compensation interact with each other in a meaningful way. For example, high public-sector retirement benefits will be particularly valuable for a 50-year-old worker, if her job security is high until she retires.

This paper quantifies the total public-sector compensation premium over workers' life-cycles. To this end, we set up a partial equilibrium, incomplete markets, life-cycle model, with a public and private sector. The two sectors are different in their wage profiles, job-separation rates, and pension benefits. The resulting income risk stemming from

[1] Some recent examples include are Christofides and Michael (2013), Castro et al. (2013) for several European countries, and some older examples include Katz and Krueger (1991) for the United States or Disney and Gosling (1998) for the United Kingdom.

Figure 1: Public Employment Over The Life Cycle,



Note: The figure show public employment out of total employment by age. For the United States the data is take from CPS (1996-2017), for the United Kingdom from the UK Labour Force Survey (2003-2016), for France for the French Labour Force Survey (2003-2016) and from Spain from the Spanish Labour Force Survey (2005-2071). See for details on the methodology in Fontaine et al. (2020). See Appendix for the profile for different cohorts.

unemployment leads to precautionary savings by risk-averse workers. Given their current savings, unemployed workers decide whether to look for work in the private or public sector. Search markets are separated by age; thereby, age-variations in compensation schemes create age-varying labor market outcomes. Additionally, markets are separated by education (college, no college degree), another important dimension of heterogeneity between the two sectors, both in terms of employment and wages (Gomes (2018)). This framework allows us to calculate the total compensation premium over the life-cycle and express is as a single number: the wage compensation that makes a public-sector worker indifferent to her private sector counterpart at each age and education.

We calibrate the model to the four economies shown in Figure 1. We chose these four countries for two reasons. First, these countries are very heterogeneous in several dimensions. Their public sectors have different sizes, with UK and France having larger

public sectors with 23 and 21 percent of total employment, and the US and Spain having smaller public sectors (16 percent of total employment). They also have different labour market institutions. The fact that we find a common pattern regarding the age profile of employment means it is a general characteristic of the public sector. Second, these countries represent the variety of different institutional arrangements regarding pensions, as highlighted in the report Pensions at a Glance by OECD (2017). France has an entirely separate system for civil servants. The United States and the United Kingdom have a fully integrated system with top-up components for civil servants beyond the mandatory schemes for private-sector workers. Finally, Spain had different schemes as France, but in 2011 implemented a series of reforms and now has a fully integrated system between the two sectors. We encapsulate in the model the differences in replacement rates between sectors documented by the aforementioned report.

We find that, across the four countries, the age-averaged total public-sector compensation is substantially larger than suggested by the age-averaged wage premium (henceforth, "naive" wage premium). Premia are particularly large for non-college workers. They are as high as 38.8 and 47.0 percent in Spain and the UK, respectively. The corresponding "naive" wage premia are 15.0 and 10.0 percent. For college workers, it ranges from 4.9 percent in France to 8.3 percent in the US. The corresponding "naive" wage premia are -3.0 percent and 2.0 percent, respectively. Looking at workers of different ages, these premia are heavily tilted towards older workers. The reason is that pension premia are large and particularly valued by older workers.

Next, we study the effects on unemployment of harmonizing the public-sector compensation scheme to that of the private sector. Resulting from the proximity of the public sector with the private sector, these are smallest in France where the average unemployment rate of non-college workers drops by 0.26 percentage points and that of college workers rises by 0.9 percentage points. In the UK, the rate drops by 1.42 and 1.25 percentage points, in the US by 2.68 and 1.11 points, and in Spain by 2.55 and 2.33 percentage points, respectively. Finally, we compute the overall budgetary effects when equalizing all compensations. The government's budget improves by €19 per per-

son/quarter in France, €92 in Spain, $96 in the US, and £229 in the UK.

We contribute to the growing literature examining the particular characteristics of public employment and how they shape aggregate labour market outcomes. Our work is related to the labor market search literature that analyzes the role and effects of public employment and wages. Key alternative modeling strategies are proposed by Bradley et al. (2017), Albrecht et al. (2018) and Gomes (2015). Bradley et al. (2017) includes the public sector in a job-ladder framework where firms post wages, with on-the-job search and transitions between the two sectors, to study the effects of policies on the distribution of private-sector wages. Albrecht et al. (2018) consider heterogeneous human capital and match-specific productivity in a Diamond-Mortensen-Pissarides model. These papers assume that the unemployed randomly search across sectors, and, hence, public-sector policies affect the equilibrium only by affecting the outside option of the unemployed and their reservation wage. Gomes (2015) assumes that the two sectors' labor markets are segmented and that workers choose where to search depending on the values offered by the two sectors. We follow this assumption of segmented markets. We think it portrays a realistic mechanism of selection into the public sector in several countries, documented empirically by Krueger (1988) and Nickell and Quintini (2002) or experimentally by Bó et al. (2013), lying at the heart of current policy discussions. High public-sector wages attract many unemployed to queue for those jobs.

We add to the literature by explicitly introducing a life-cycle dimension and by analysing how wealth interacts differently with the private and public sectors in the presence of risk-averse agents and incomplete markets. The interaction of the life-cycle structure with the public sector has been studied in models without search frictions. Cavalcanti and Santos (2017) set up an occupational choice model and argue that higher wages and better pensions in the public sector in Brazil lead to misallocation of resources with a lower entrepreneurship rate. Also focusing on Brazil, Glomm et al. (2009) set up an overlapping generations model where workers are initially randomly assigned to each sector. They use it to study the effects of early retirement in the public sector.

Hörner et al. (2007) had already introduced risk-averse workers in a search model to

study the effect of wage uncertainty on unemployment when wages in the public sector are insulated from this volatility. We add to them by explicitly considering savings as a self-insurance mechanism, in the spirit of Krusell et al. (2010). There are rich interactions between public employment and wealth accumulation. On the one hand, the accumulated wealth of an unemployed affects the choice of where to search. Because turnover is lower in the public sector and the conditions offered are better, it takes longer to find a job there, so only richer unemployed can afford to queue. On the other hand, as jobs are safer, wage profiles differ, and pension schemes are more generous, public-sector workers have different savings behaviours than their private sector counterparts (both for precautionary, life-cycle and retirement motives). Our approach is different from Reis and Zilberman (2014) who set up an incomplete market Aiyagari model without search frictions to measure the degree of insurance provided by public-sector jobs. In their model, job security is modeled in reduced form by less volatile wages.

The idea that we should focus on measures of lifetime values rather naive estimations of public-sector wage premium was already proposed in Postel-Vinay and Turon (2007) and reinforced by Bradley et al. (2017) and Dickson et al. (2014). Although we use a different modeling strategy, we subscribe entirely to this view. Our contribution relative to their work is twofold. First, we consider risk-averse workers and the ability of self-insurance through savings. Given that one of the commonly argued dimensions of the benefit of the public sector - job-security - evaluating it in the light of risk neutrality only provides a lower bound for the value of insurance provided by the public sector. A second dimension is to also consider retirement pensions in the overall calculation of total compensation. In this sense, we relate to two notable empirical studies that try to calculate the value of public-sector pensions for the UK: Danzer and Dolton (2012) and Disney et al. (2009).

2 Model

2.1 General setup

We consider a model with firms and a public sector. There is a unit mass of risk-averse workers equally distributed over age $h \in (1, H)$ that discount the future at rate β. Workers differ in their education type, e (college vs non-college). During their working life, workers are either unemployed (u) or employed in the public (e^g) or private (e^p) sector.

Workers accumulate assets, a, to insure against the risk of unemployment, for life-cycle reasons, and for retirement. Assets pay a risk free return $R = 1 + r$. Workers decide how much to save and consume and, if they are unemployed, in which sector to search. When employed in the private (public) sector, workers earn $w^P_{h,e}$ ($w^G_{h,e}$) and become unemployed with probability $\delta^P_{h,e}$ ($\delta^G_{h,e}$). When unemployed, they receive unemployment benefits $b_{h,e}$.

All workers retire at age $H_w + 1$. Their retirement benefits depend on their average life-time earnings in the private and public sector ($\bar{E}^P_h$, $\bar{E}^G_h$). These evolve according to:

$$\bar{E}^P_{h+1} = \begin{cases} \frac{w^P_h + \bar{E}^P_h h}{h+1} & \text{if employed in private} \\ \frac{\bar{E}^P_h h}{h+1} & \text{if unemployed or employed in public} \\ \bar{E}^P_h & \text{if retired.} \end{cases} \tag{1}$$

$$\bar{E}^G_{h+1} = \begin{cases} \frac{w^G_h + \bar{E}^G_h h}{h+1} & \text{if employed in public} \\ \frac{\bar{E}^G_h h}{h+1} & \text{if unemployed or employed in private} \\ \bar{E}^G_h & \text{if retired.} \end{cases} \tag{2}$$

Benefits replace a fraction of these average life-time earnings. There are two different replacement rates (rr^P and rr^G), each one applying to the respective careers in each sector: $\bar{E}^P_h$ and $\bar{E}^G_h$. For the amount of retirement benefits, we abstract from institutional details such as minimum contribution lengths. Hence, benefits during retirement are given by $ss = rr^P \bar{E}^P + rr^G \bar{E}^G$.

2.2 Search

An unemployed decide to search for a job in either the public or private sector in a given sub-market Z, as depicted in Figure 2. Each sub-market in the two sectors is segmented by age and education $Z = [h, e]$. Let u_Z^P and u_Z^G denote the number of unemployed searching in each of the sectors. Within each sub-market, the unemployed select into either sector based on the remaining state variables $[a, \bar{E}_h^P, \bar{E}_h^G]$. There are no other sources of heterogeneity.

Denote by v_Z^P and v_Z^G the number of vacancies in the two sectors in a given sub-market. The number of new matches that become productive in the following period is given by

$$m_Z^P = \frac{v_Z^P u_Z^P}{(v_Z^{P\iota} + u_Z^{P\iota})^{1/\iota}} \tag{3}$$

$$m_Z^G = min\{v_Z^G, u_Z^G\}. \tag{4}$$

In the private sector, we assume a matching function as in den Haan et al. (2000), so the job-finding and vacancy-filling rates are bounded between 0 and 1. In the public sector, we assume the min function to simplify the computation of the model. This functional form does not imply that there are no matching frictions, simply that they only matter for the unemployed. The existence or absence of frictions for the government is immaterial because we take the job-creation condition in the public sector as exogenous.[2] Also, this assumption has been used previously by Quadrini and Trigari (2007) or Chassamboulli and Gomes (2020), and there is evidence that the elasticity of matches with respect to the number of unemployed is much lower in the public than in the private sector (Gomes (2015)).

Denote by $\theta_Z^X = \frac{v_Z^X}{u_Z^X}$ the labor market tightness in a specific sub-market. The job finding probabilities and the vacancy-filling rate in the private sector are given by

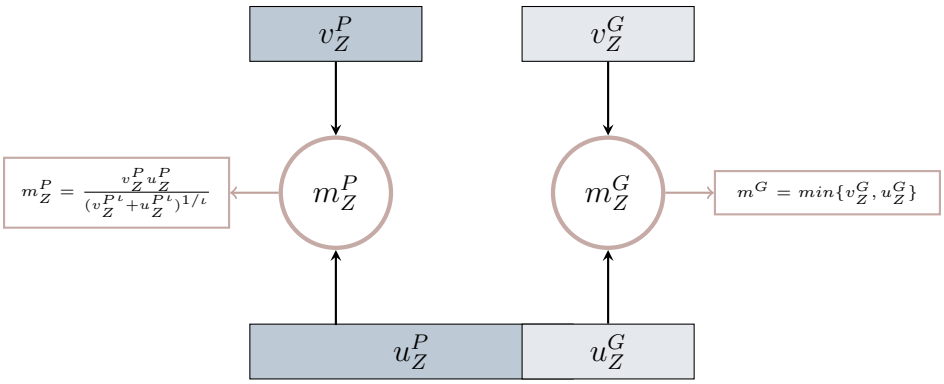
[2]Nothing substantial would change in the model if the matching function in the public sector was equal to that of the private sector. In such case, the vacancy-filling probability of the government would no longer be 1, and it would need to set endogenously the vacancies such that the total number of matches would equate exactly the number of workers that it wanted to hire, but the job-finding rate of the unemployed would be the same. This function implies there is a minimum wage in each submarket below which the government cannot recruit its target number of workers.

$$p^G(\theta_Z^G) = \frac{m_Z^G}{u_Z^G} = \theta_Z^G \tag{5}$$

$$p^P(\theta_Z^P) = \frac{m_Z^P}{u_Z^P} = \frac{1}{(1+\theta_Z^{P-\iota})^{1/\iota}} \tag{6}$$

$$q^P(\theta_Z^P) = \frac{m_Z^P}{v_Z^P} = \frac{1}{(1+\theta_Z^{P\iota})^{1/\iota}} \tag{7}$$

Figure 2: Unemployed's Choice,



2.3 Value functions

Workers make their savings and search decisions to maximize utility from consumption, c, given by

$$U = \frac{c^{1-\gamma}}{1-\gamma}.$$

In the value functions, we denote the pre-determined or deterministic state variables that define a sub-market - education and age - as a subscript. The remaining state variables that reflect choices - assets and average lifetime earnings in the two sectors - are expressed in brackets. The values of working in the private and public sectors are different. The value of employment in the public sector reads

$$V_{h,e}^{EG}(a, \bar{E}^P, \bar{E}^G) = \max_{a'} \left\{ \frac{c^{1-\gamma}}{1-\gamma} + \beta[(1-\delta_{h,e}^G) V_{h+1,e}^{EG}(a', \bar{E}^{P'}, \bar{E}^{G'}) + \delta_{h,e}^G V_{h+1,e}^{U}(a', \bar{E}^{P'}, \bar{E}^{G'})] \right\} \tag{8}$$

$$c = (1+r)a + w_{h,e}^G(1-\tau(w_{h,e}^G)) - a', \tag{9}$$

where $V^U_{h+1,e}(a', \bar{E}^{P'}, \bar{E}^{G'})$ is the value of unemployment in the following period, defined below. With a probability $\delta^G_{h,e}$, workers lose their jobs in the public sector and become unemployed. Workers face a tax schedule $\tau(.)$ that depend on their level of income. They choose how much to consume c and to save a' to maximize their per-period utility plus the continuation value. Similarly, the value of employment in the private sector reads

$$V^{EP}_{h,e}(a, \bar{E}^P, \bar{E}^G) = \max_{a'}\Big\{\frac{c^{1-\gamma}}{1-\gamma} + \beta[(1-\delta^P_{h,e})V^{EP}_{h+1,e}(a', \bar{E}^{P'}, \bar{E}^{G'}) + \delta^P_{h,e}V^U_{h+1,e}(a', \bar{E}^{P'}, \bar{E}^{G'})]\Big\} \tag{10}$$

$$c = (1+r)a + w^P_{h,e}(1-\tau(w^P_{h,e})) - a'. \tag{11}$$

Private-sector workers face different wage and job-separation profile. When unemployed, individuals decide to search in one of the two sectors, with the values given by:

$$V^{UG}_{h,e}(a, \bar{E}^P, \bar{E}^G) = \max_{a'}\Big\{\frac{c^{1-\gamma}}{1-\gamma} + \beta[\theta^G_{h,e} max\{V^{PG}_{h+1,e}(a', \bar{E}^{P'}, \bar{E}^{G'}), V^U_{h+1,e}(a', \bar{E}^{P'}, \bar{E}^{G'})\} \tag{12}$$

$$+ (1-\theta^G_{h,e})V^U_{h+1,e}(a', \bar{E}^{P'}, \bar{E}^{G'})]\Big\}$$

$$V^{UP}_{h,e}(a, \bar{E}^P, \bar{E}^G) = \max_{a'}\Big\{\frac{c^{1-\gamma}}{1-\gamma} + \beta[p^P(\theta^P_{h,e}) max\{V^{EP}_{h+1,e}(a', \bar{E}^{P'}, \bar{E}^{G'}), V^U_{h+1,e}(a', \bar{E}^{P'}, \bar{E}^{G'})\} \tag{13}$$

$$+ (1-p^P(\theta^P_{h,e}))V^U_{h+1,e}(a', \bar{E}^{P'}, \bar{E}^{G'})]\Big\} \tag{14}$$

$$c = (1+r)a + b_{h,e} - a'.$$

Unemployed individuals earn $b_{h,e}$ net of taxes. They face different job-finding rates in the two sector. Furthermore, the values will be different depending on their assets and average lifetime earning. If they found a job in a particular sector, they might decide not to take it, if the value of a job is lower than remaining unemployed. The unemployed choose to search in the sector with the highest value so that the value of unemployment

solves

$$V^U_{h,e}(a, \bar{E}^P, \bar{E}^G) = max\{V^{UP}_{h,e}(a, \bar{E}^P, \bar{E}^G), V^{UG}_{h,e}(a, \bar{E}^P, \bar{E}^G)\} \tag{15}$$

Finally, the value of retirement, $V^R_{h,e}(a, \bar{E}^P, \bar{E}^G)$, is given by

$$V^R_{h,e}(a, \bar{E}^P, \bar{E}^G) = \underset{a'}{max}\left\{\frac{c^{1-\gamma}}{1-\gamma} + \beta V^R_{h+1,e}(a', \bar{E}^{P'}, \bar{E}^{G'})\right\} \tag{16}$$

$$c = (1+r)a + ss(1-\tau(ss)) - a'. \tag{17}$$

with $\bar{E}^{X'} = \bar{E}^X$, and gross social security benefit are given by $ss = rr^P \bar{E}^P + rr^G \bar{E}^G$. Retired individuals face the same tax schedule $\tau(.)$ that depend on their level of income. Once retired, the agents only decide how fast they deplete their savings.

2.4 Equilibrium tightness

As typically in the recent literature on public employment, we do not model why governments follow certain employment policies. These could be due to preferences for the production of goods and services, for redistribution, union pressure, or political economy considerations. We take them as exogenous from data. That is, we exogenously set government vacancies, $v^G_{h,e}$, in each sub-market to target public employment as a fraction of total employment by age and education. We also take the wage profile and separation rates as given. The value of a public-sector job will determine the number of unemployed queueing.

Turning to firms, we model them in a simplified way. When matched with a firm, workers produce output $y(h,e)$ and receive wages that are a constant share of output $w^P_{h,e} = \lambda y_{h,e}$. Thus, profits are given by $\pi_{h,e} = (1-\lambda)y_{h,e}$. The value of a matched worker depends on her education and age, because productivity and the job destruction rate vary with the education and on the age of the worker, and because retirement terminates the match. We assume firms are risk neutral; thus, the resulting firm value is

$$V^F_{h,e} = \pi_{h,e} + (1-\delta^P_{h,e})\beta V^F_{h+1,e}. \tag{18}$$

When posting a vacancy, the entrepreneur pays flow costs κ. There is free entry into each vacancy sub-market:

$$0 = -\kappa + \beta q^P(\theta^P_{h,e}) \int\int\int \mathbf{I}^U_{h+1,e}(a', \bar{E}^{P\prime}, \bar{E}^{G\prime}) V^F_{h+1,e} d\Lambda^{UP}_{h,e}(a', \bar{E}^{P\prime}, \bar{E}^{G\prime}). \tag{19}$$

where $\mathbf{I}^U_{h+1,e}(a', \bar{E}^{P\prime}, \bar{E}^{G\prime})$ is an index whether an unemployed meeting a firm would accept the job, and $\Lambda^U_{h,e}(a, \bar{E}^{P\prime}, \bar{E}^{G\prime})$ is the pdf of the end of period stationary distribution of the unemployed of a given age and education, searching in the private sector.

Hence, equation (19) pins down the vacancy-filling probability in each private-sector sub-market, $q^P(\theta^P_{h,e})$, and, conversely, the job-finding probability in each sub-market. Arising from their heterogeneity in assets and life-time earnings, $[a, \bar{E}^P_h, \bar{E}^G_h]$, each worker has a unique job-finding probability in the public sector that would make her indifferent between searching in the two sectors, $\theta^{G*}_Z(a, \bar{E}^P, \bar{E}^G)$. Moreover, there exists a marginal worker who, at the realized $\theta^G_{h,e}$, is indifferent between searching in the two sectors and all unemployed with a higher (lower) $\theta^{G*}_Z(a, \bar{E}^P, \bar{E}^G)$ search in the private (public) sector. This marginal worker pins down the equilibrium job-finding probability in the public sector.[3]

2.5 Definition of equilibrium

Definition 1 *A steady-state equilibrium in our economy is defined by a set of tightness in the two sectors by age and education* $\{\theta^P_{h,e}, \theta^G_{h,e}\}$*, stocks of public- and private-sector employment and unemployed searching in the two sectors* $\{e^P_{h,e}, e^G_{h,e}, u^P_{h,e}, u^G_{h,e}\}$*, private-sector wages* $\{w^P_{h,e}\}$ *and the distribution of assets and lifetime earnings* $\{\Lambda^P_{h,e}, \Lambda^G_{h,e}, \Lambda^{UP}_{h,e}, \Lambda^{UG}_{h,e}, \Lambda^R_{h,e}\}$ *such that, given some exogenous government policy* $\{v^G_{h,e}, \delta^G_{h,e}, w^G_{h,e}\}$*:*

1. *Workers choose assets according to conditions (9), (11), (13), (14) and (17).*

[3]To compare the values of searching in the private and public sector, workers do not only need to know today's job-finding probabilities, but also the probabilities they will face in the future. To make the model computationally tractable, we assume workers are bounded rational in predicting labor market tightness in the government sector. Instead of having rational expectations over θ^G_Z at each quarter, they have only rational expectations about tightness in the first quarter of each year and use cubic splines to approximate the labor market tightness within a calendar year. Using as measure R^2, the approximation explains 99% of the realized variation.

2. *Unemployed decide optimally the sector to search (15).*

3. *The average lifetime earnings evolve according to (1) and (2).*

4. *Private-sector firms satisfy the free-entry condition (19).*

5. *Job-finding rates in the two sectors and vacancy-filling rates are given by (5), (6) and (7).*

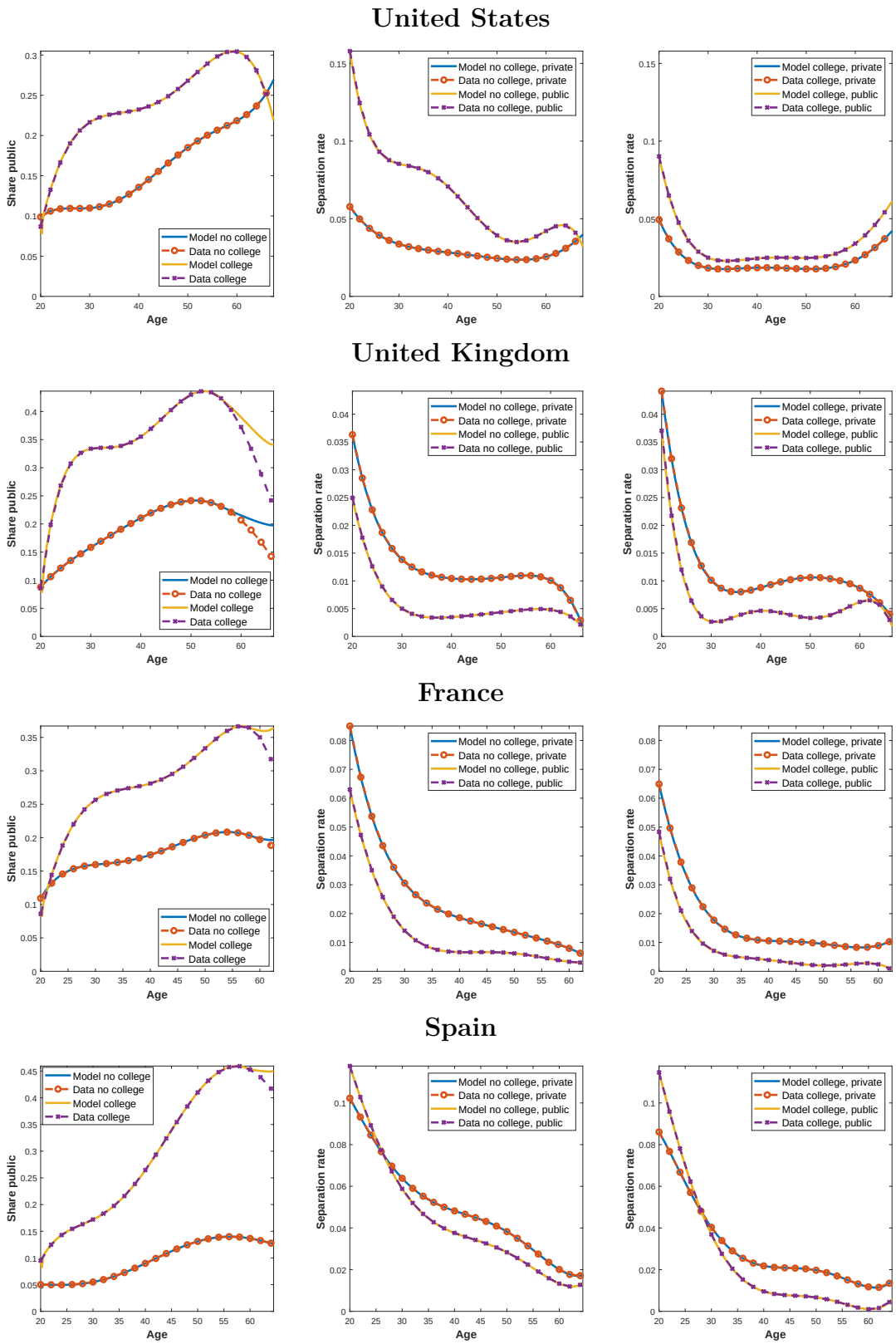
3 Calibration

We calibrate the model to data from the four countries: US, UK, France, and Spain. For the US, we use data from the Survey of Income and Program Participation (SIPP) for the period 2005-2017. We prefer the SIPP to the CPS as it has more comprehensive data on wages and wealth, but we show in Appendix the comparison of the key variables of the two surveys. For the European countries, we use data from the Labour Force Surveys: the UK LFS (2003-2016), the French LFS (2003-2016) and the Spanish LFS (2005-2017), that were extracted by Fontaine et al. (2020). We complement it with wage data from the Structure of Earning Survey (SES) for the years 2002, 2006, 2010 and 2014, and wealth data from the Household Finance and Consumption Survey (HFCS) for 2010 and the UK Household Assets Survey for 2006. Finally, for government programs, we rely on data from the OECD.

3.1 Public-sector policies

Figure 3 shows the size of the public sector relative to the private sector over worker's age, by education. In all four countries, the public sector is a more dominant employer for workers with a college degree. Moreover, in all four countries, the share of workers in the public sector is increasing until age 55 and decreases slightly thereafter. In all countries but Spain, the share of non-college workers working in the public sector rises from around 10% at age 20 to around 20% at age 55. In Spain, it rises from around 5% to 15%. The increase is yet more pronounced for college-educated workers. It is around

Figure 3: Labour Market Stocks And Flows By Education And Age



Note: The figure show public employment out of total employment and the job-separation rates in the two sectors, by age and education. The data is taken from SIPP (1996-2017), UK Labour Force Survey (2003-2016), French Labour Force Survey (2003-2016) and Spanish Labour Force Survey (2005-2017).

10% in all countries at age 20 and rises to 30 to 45 percent at age 55 depending on the country. In the model, we replicate these increases by setting the profile of public-sector vacancies, $v^G_{h,e}$. The figure shows that the model traces the data almost perfectly but falls somewhat short in replicating the decline in the public share after age 55. We think this fact, visible mainly in the European countries, is due to the possibility of early retirement that is more prevalent in the public sector - something that we do not take into account in the model.

Next, consider the differences in the job-security between the two sectors shown in the remaining graphs of Figure 3. We target these rates with the exogenous job-separation rates, $\delta^P_{h,e}$, $\delta^G_{h,e}$. In the three European countries, the public sector has lower separation rates than the private sector, except for the youngest workers in Spain. The differences are particularly pronounced in France with the separation rate in the public sector being lower by about 1 percentage point. At the same time, only in the US, the job-separation rates are higher in the public sector. Fontaine et al. (2020) found that, for the US, the unconditional job-separation rate in the private sector was double the one in the public sector. However, when controlling for observable characteristics like age, education, and gender it is much lower - only 36 percent higher. The fact that we do not control for other characteristics (namely gender) might explain why we find marginally lower job-separation rates in the US.

Turning to wage differences in the two sectors, we regress the log of hourly wages on age bracket dummies, and age bracket dummies interacted with a public-sector dummy, separately for workers with and without a college degree, controlling for regions (NUTS I), occupation (2-digit), gender, manager, part-time and year dummies. The education premium is estimated for private-sector workers aged 20-29. Table 1 shows the resulting wage profiles. In the model, we match gross wages in the public sector, $w^G_{h,e}$, directly to this profile. We match the private-sector wages, $w^P_{h,e}$, by adjusting worker's output in the model. To make countries more easily comparable, the table also displays the wage premium of the average public employee. To that end, we compute the wage premium at each age and weight each age by the density of public employment. As we have discussed

Table 1: Estimated Wage Profiles

	United States		United Kingdom		France		Spain	
Age	Private	Public	Private	Public	Private	Public	Private	Public
No college								
20-29	1.00	1.10	1.00	1.14	1.00	1.01	1.00	1.15
30-39	1.15	1.26	1.15	1.27	1.14	1.14	1.09	1.29
40-49	1.23	1.40	1.19	1.28	1.21	1.22	1.16	1.36
50-59	1.29	1.42	1.16	1.27	1.27	1.29	1.23	1.41
60+	1.26	1.30	1.11	1.22	1.35	1.32	1.27	1.41
Average	–	1.09	–	1.10	–	1.01	–	1.15
College								
20-29	1.30	1.37	1.31	1.41	1.38	1.34	1.31	1.42
30-39	1.57	1.58	1.53	1.58	1.61	1.55	1.51	1.62
40-49	1.62	1.65	1.59	1.64	1.80	1.72	1.68	1.75
50-59	1.63	1.66	1.55	1.65	1.90	1.86	1.81	1.84
60+	1.58	1.62	1.45	1.59	2.02	1.93	1.87	1.87
Average	–	1.02	–	1.06	–	0.97	–	1.06

SIPP (2005-2017), SES (pooled 2002, 2006, 2010, 2014). Estimation by regressing the log of hourly wage on age bracket dummies, and age bracket dummies interacted with public sector, separately for college graduates (skilled) and bellow college graduates (unskilled), controlling for regions, occupation, gender, manager, part-time and year dummies. Education premium is estimated for private sector 20-29 years old. Wages of the unskilled, 20-29 old private-sector worker normalized to 1 (US: $5208, UK: £3961, France: €4980, Spain: €3369).

above, this wage premium is different from the average wage difference between public- and private-sector employees because it puts higher weights on older workers that, on average, have higher wages. Comparing the wage premia across countries, some common features stand out. In all countries but France, the public sector pays higher wages than the private sector. Also, as commonly found in the literature, there is a higher premium for workers without a college degree. In this dimension, Spain stands out with an average premium of 15 percent. For college-educated workers, Spain and the UK pay the highest premia of about 6 percent. Finally, the public-sector wage premium is higher for younger workers, that is, wages grow more steeply in the private sector. Non-college workers in the US are the exception to this pattern.

For retired workers, the compensation difference between the two sectors also results from their retirement replacement rates. The top panel of Table 2 compares the estimates of replacement rates in the two sectors, from the report Pensions at a Glance by OECD (2017). The original graphs from the report are shown in Figures A3-A6 in the Appendix. The differences in the retirement replacement rates are the highest in the UK, with private-sector pensions replacing 50 percent of wages, while public-sector pensions replace

Table 2: Unemployment And Retirement Benefits

	United States	United Kingdom	France	Spain
Retirement replacement rate				
Private	67.8	51.4	55.4	81.2
Public	86.8	106.0	63.4	100
Unemployment replacement rate				
No college	42.5	41.8	59.8	49.8
College	29.0	24.8	47.4	33.1

Note: OECD Pensions Outlook 2016. Unemployment benefits calculated from OECD as the simple average of the net Replacement Rates for six family types, on the initial phase of unemployment and long term unemployment, for a family that does not qualify for cash housing assistance or social assistance "top ups", earning 67 percent of the average wage (no college) or 150 percent of the average wage (college) in 2006.

more than 100 percent. This is a large number that we take at face value. In the US and Spain, the replacement rates are 20 percentage points higher in the public sector. Despite having entirely separated pension schemes, France has the lowest asymmetry between sectors, with a difference of only 8 percentage points.

Finally, the government runs insurance schemes that are independent of the sector of work. First, the government runs an unemployment insurance scheme. The bottom panel of Table 2 shows that, on average, the replacement rates are higher in France and Spain compared to the UK and US, and they are also higher for non-college educated workers. Second, the government runs a progressive income tax system, $\tau(.)$, that follows the statutory tax schedule (comprising both income tax and social security contributions) detailed in the Appendix. The progressivity of the system reduces the difference between the net income of workers.

3.2 Remaining parameters

Following Attanasio and Weber (1995), we use a risk aversion coefficient of 1.5. We set $r = 0.01$ and calibrate β to match the median net wealth holdings over age groups. Workers start with zero wealth at age 20. Regarding the private sector, we set the share of wages in output, λ, to the labor share of the four economies. Following Hagedorn and Manovskii (2008), we set the vacancy posting costs, $\kappa(e)$ to 4.5% of quarterly output and 3.67% of quarterly wages in the private sector. We use the matching efficiency in the private sector, $\iota(e)$, to calibrate the average unemployment rate of low- and high-educated

workers. Moreover, we match the unemployment rate and the share of employed workers in the private and public sector by education at age 20, assigning the status randomly across individuals.

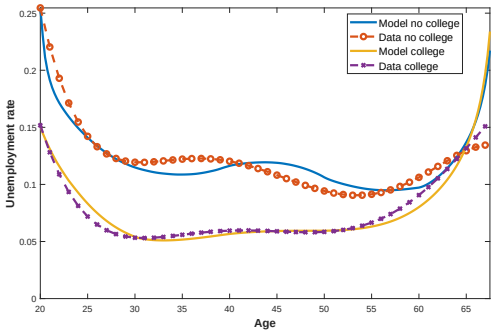
3.3 Analysis of the baseline economies

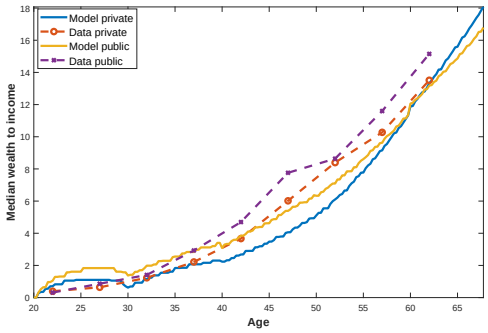
Our calibration targets the initial and average unemployment rate and the median wealth to income ratio, but not their life-cycle behaviors. Still, Figure 4 shows that the model replicates well these variables over the life-cycle. The left panels display the unemployment rate for college and non-college workers. In all countries but the US, unemployment rates are declining in age, and we replicate the relatively quick decline early in life. In the US, the relationship is U-shaped in age, though, the model somewhat overstates the increase late in life.

The right panels display median wealth to income ratios over the life-cycle. We display these ratios for public and private-sector workers in all countries, except for the UK for which these data are not available. In general, resulting from life-cycle motives, workers' wealth is increasing relative to their income with age. The model overstates this increase for France and Spain, but it matches the increase closely in the UK and the US. The model helps us understand the differences in wealth patterns across sectors and countries over the life-cycle. First, public-sector workers tend to hold, relative to their private-sector counterparts, little wealth late in their life-cycle. The model rationalizes this difference by their higher retirement replacement rates. Second, young Spanish public-sector workers hold relatively much wealth. As we will explain below, workers with high wealth tend to search in the public sector because their wealth permits them to wait longer for a relatively attractive job offer. By this mechanism, high wealth workers tend to sort themselves into the public sector. Third, US prime-aged public-sector workers hold relatively much wealth. For one, this results again from high wealth workers sorting into the public sector. Moreover, separation rates are relatively high in the US public sector (see Figure 3), leading to high precautionary savings. Fourth, private-sector workers have more wealth than public-sector workers in France. In France, the only institution

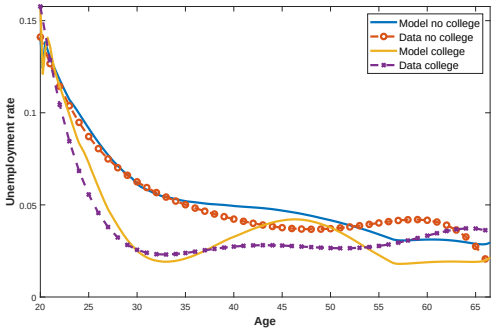
Figure 4: Unemployment Rates, Median Wealth To Income Ratio By Age

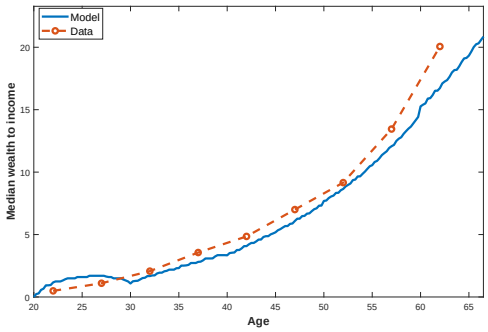
United States



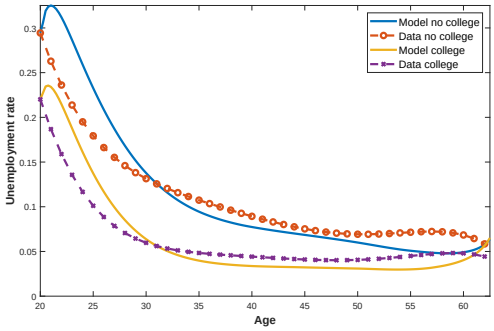


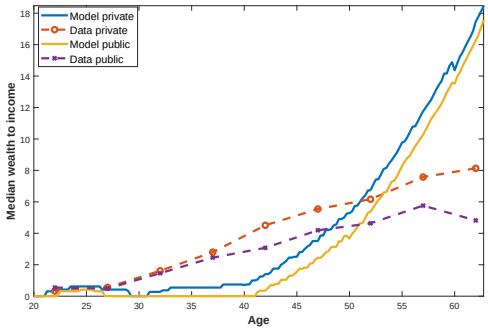
United Kingdom



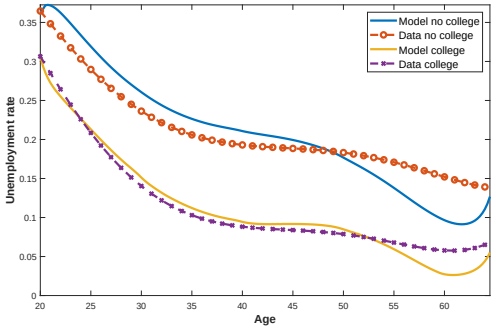


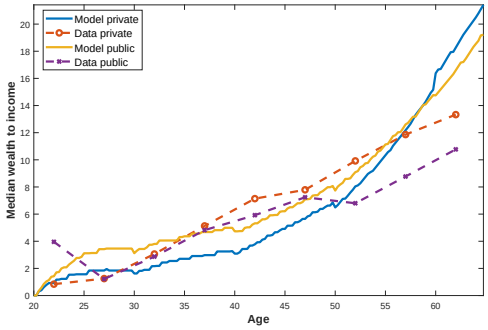
France





Spain





Note: The left graphs show the unemployment rate of college and no-college workers, in the model and in the data by age. Only the initial unemployment rate at age 20 and the average unemployment rate across educations were model targets. The graphs on the right show the mean wealth to income ratios of public- and private-sector workers, with and without college.

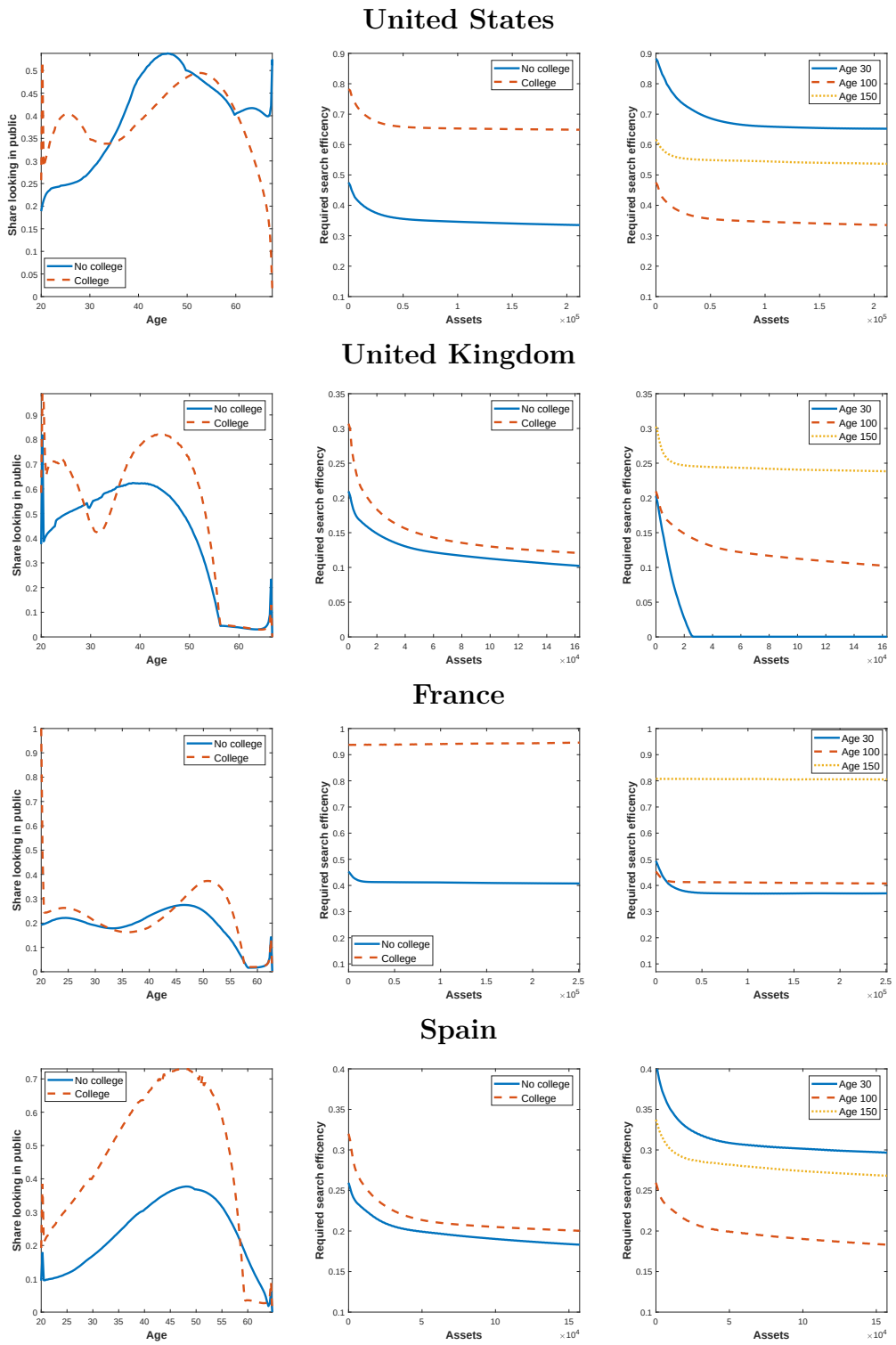
markedly different between the two sectors is the higher retirement replacement rate in the public sector. Thus, the selection of high wealth workers into the public sector is limited and, at the same time, private-sector workers need to accumulate more wealth for their retirement.

Next, we turn to the search decisions of unemployed workers that lead to these unemployment and wealth outcomes. The left panels of Figure 5 show the share of the unemployed searching in the public sector. At the beginning of their career, few unemployed search in the public sector. This fraction increases over the life-cycle, falling sharply after age 50 when fewer job openings become available. Across countries, the share of workers searching in the public sector is larger than its relative size. That is, public-sector jobs are relatively attractive leading to relatively more unemployed workers queuing for these jobs and, hence, facing a relatively low job-finding rate. On an aged-averaged basis, conditional on searching in the respective sector, the job-finding probability in the public sector relative to the private sector is 25 percent lower in the US, 30 percent in France, 65 percent in Spain, and 75 percent in the UK. These differences are yet larger for low-skilled workers.

The center panels of Figure 5 highlight this latter point. They show the conditional job-finding rate in the public sector relative to the one prevailing in the private sector that makes a worker indifferent about the sector to search. In all countries, this threshold ratio is below one and it is substantially lower for non-college workers. The figures also show that both types of workers are more inclined to search in the public sector when their wealth is higher. A high wealth allows the worker to maintain a higher consumption during unemployment and, thus, more willing to search for a more desirable job.

The right panels of Figure 5 highlight workers' selection based on age, again displaying the threshold ratio of job-finding rates that makes a worker indifferent between searching in the two sectors. In the US and Spain, resulting from high job-separation rates in the public sector, young workers prefer it only slightly, i.e., the threshold for the ratio of job-finding rates is close to one. Differently, in the UK and France, young workers are particularly willing to wait for an attractive public-sector job.

Figure 5: Attractiveness Of The Public Sector, By Age And Education



Note: The left graphs show the fraction of the unemployed searching for public-sector jobs, for college and no-college workers. The middle graphs show the job-finding rate in the public sector relative to the private sector required by an unemployed with particular assets to search there, for college and no-college workers. The graphs on the right show the job-finding rate in the public sector relative to the private sector required by an unemployed with particular assets to search there, workers we different ages: 27.5, 45 and 57.5.

4 Results

4.1 Public-sector premia

Often in policy discussions, there is the argument that public-sector jobs offer extra-compensation besides wages. Two of these compensations are job-security and better pensions. However, there are few attempts to quantify these job-security and pensions premia. Furthermore, the "naive" wage premia reported in Table 1 give only an incomplete view about the economic value of average public- sector wage premia and the variation of this premia over the life-cycle. Assessing the true economic value of the wage premium together with the economic value of higher pensions and job security is extremely important from a policy perspective. According to Gomes (2015), the government should offer wages that equalize the value between the public and the private sector taking the entire economic value of the jobs into account.

Our model offers a laboratory to calculate the retirement and the job-security premia, as well as the wage premium. We express these as the percentage increase in public wages (at all ages) required to compensate a public-sector worker for having the same wage schedule, pension scheme, or job-destruction rates as the private sector. We study these compensations jointly, as well as separately, holding other policies fixed.

The second panel of Table 3 displays the wage premia for different ages for public-sector workers. That is, we ask by what percentage wages at all ages need to rise over the private-sector wage schedule to accept it over their own, i.e., $\tilde{w}^G_{h,e} = (1+\omega)w^P_{h,e}$, where $\tilde{w}^G_{h,e}$ is the resulting public-sector wage and ω is the wage premium. Hence, the measure eliminates any difference in the age-schedule of wage compensation between the two sectors. We calculate this premium for workers who are employed in the public sector at different ages, as well as the average wage premium where we weight the age-specific premia by the density of public employment. Comparing these averages to the "naive" average wage premia in Table 1 shows that these are, in general, quite similar within one percentage point. There are two exceptions. College workers in Spain require a higher average wage premium by 9 percent, instead of 6 percent suggested by the "naive" wage

Table 3: Public-Sector Premia By Age

	United States		United Kingdom		France		Spain	
	No college	College	No college	College	No college	College	No college	College
Total premium								
20	-0.81	0.83	26.57	14.03	5.59	0.21	14.39	6.61
30	2.44	1.86	25.52	13.82	5.28	-1.08	27.09	17.19
40	7.03	4.01	28.33	20.11	5.99	0.09	33.46	19.28
50	10.80	6.48	39.34	32.64	7.77	3.65	35.95	23.37
60	14.59	15.65	77.35	70.53	18.59	16.11	50.01	56.93
Avg	10.03	8.29	46.97	38.03	9.31	4.90	38.83	34.57
Wage premium								
20	9.54	4.90	11.53	5.77	0.59	-3.15	16.26	9.24
30	8.97	1.29	9.31	4.31	0.34	-3.68	16.78	6.43
40	12.34	1.98	8.31	5.01	0.82	-3.60	16.58	4.17
50	9.13	2.15	8.91	7.31	1.15	-2.77	14.15	4.69
60	3.30	2.82	9.31	9.31	-2.20	-4.52	11.32	15.68
Avg	6.89	2.39	9.13	6.83	0.07	-3.61	13.95	9.36
Retirement premium								
20	0.45	0.95	4.11	3.31	0.73	0.75	2.18	2.18
30	1.79	1.83	6.81	5.50	1.38	1.28	3.91	3.73
40	4.00	3.66	11.34	9.84	2.31	2.21	6.97	5.33
50	6.53	7.11	20.73	17.95	4.32	4.28	11.97	8.85
60	16.65	18.47	56.45	54.25	19.81	18.81	30.71	27.59
Avg	9.90	9.40	27.69	25.20	6.74	6.74	16.79	14.78
Security premium								
20	-10.39	-3.85	8.96	4.68	4.25	3.07	-1.67	-2.91
30	-8.72	-0.86	7.44	3.62	5.54	1.84	3.64	6.14
40	-7.92	-1.16	5.85	3.77	2.62	1.60	5.89	8.63
50	-3.65	-1.95	4.47	3.32	1.71	1.81	5.31	8.03
60	-3.45	-3.11	1.99	0.26	0.72	1.92	2.41	4.95
Avg	-5.46	-2.15	4.68	2.53	2.22	1.87	3.79	6.26

Note: The premia are calculated as the permanent increase as percentage of income that public-sector workers would require to accept the same: i) profile of private-sector wage, ii) retirement replacement rate of the private sector, iii) the profile of job-separation of the private sector, iv) or all three together.

premium. The reason is that public-sector wages are frontloaded relative to the private sector for college workers in Spain. For a young public-sector worker, receiving the high wage premium of older workers is uncertain due to the high separation rate as young. Hence, she requires a relatively higher compensation to be willing to give up her high wages when young. The reverse is true for non-college educated workers in the US where the public-sector wage premium is backloaded. For these workers, the "naive" measure is 9 percent, whereas the model suggests 7 percent.

The third panel shows the retirement premium, i.e., the rise in the public-sector wage that makes a worker indifferent when the pension schemes are equalized across sectors. We express the premium relative to the existing public-sector wage: $\tilde{w}^G_{h,e} = (1+\omega)w^G_{h,e}$, so the wage profiles are again different between the two sectors. Looking at the age average,

strikingly, in all countries, the retirement premium is larger than the wage premium. It ranges from 6.7 percent in France, to above 25 percent in the UK. There are no large differences between education groups. Yet, there is large heterogeneity across ages within countries. At age 20, workers only value the better pension regime at between 0.5 to 4.1 percent of their wages. Young workers heavily discount the higher pension benefits because of time discounting and the probability of changing sector during the working life. The premium reaches between 16.7 percent and 56.5 percent for workers at age 60, which suggests how much older public-sector workers would oppose any reform equalizing the pension schemes without large indemnities.

The last panel shows the job-security premium, again measured relative to the public-sector wage: $\tilde{w}^G_{h,e} = (1+\omega)w^G_{h,e}$. In the European countries, the average premium ranges from around 2 percent in France to 6.2 percent for college workers in Spain. Resulting from high job-destruction rates for young Spanish public-sector workers, the security premium is actually negative at these ages. This, however, is compensated by highly stable jobs at older ages. The premia are always higher for low-educated workers, as they face a higher risk of unemployment. In the US, public-sector jobs have higher separation rates leading to a negative premium.

The first panel shows the total premia, i.e., when all three compensation schemes are equalized to the private sector. Considering the age-averaged premia, they are higher for workers without college in all countries. Also, the total public-sector compensation is substantially larger than suggested by the "naive" wage premia. For college workers, the premia range from 4.9 percent in France to 8.3 percent in the US. The corresponding "naive" wage premia are -3.0 percent and 2.0 percent, respectively. For non-college workers, the premia are as high as 38.8 and 47.0 percent in Spain and the UK, respectively. The corresponding "naive" wage premia are 15.0 and 10.0 percent. Resulting from the retirement premium, these premia are heavily tilted towards older workers.

4.2 Reforms

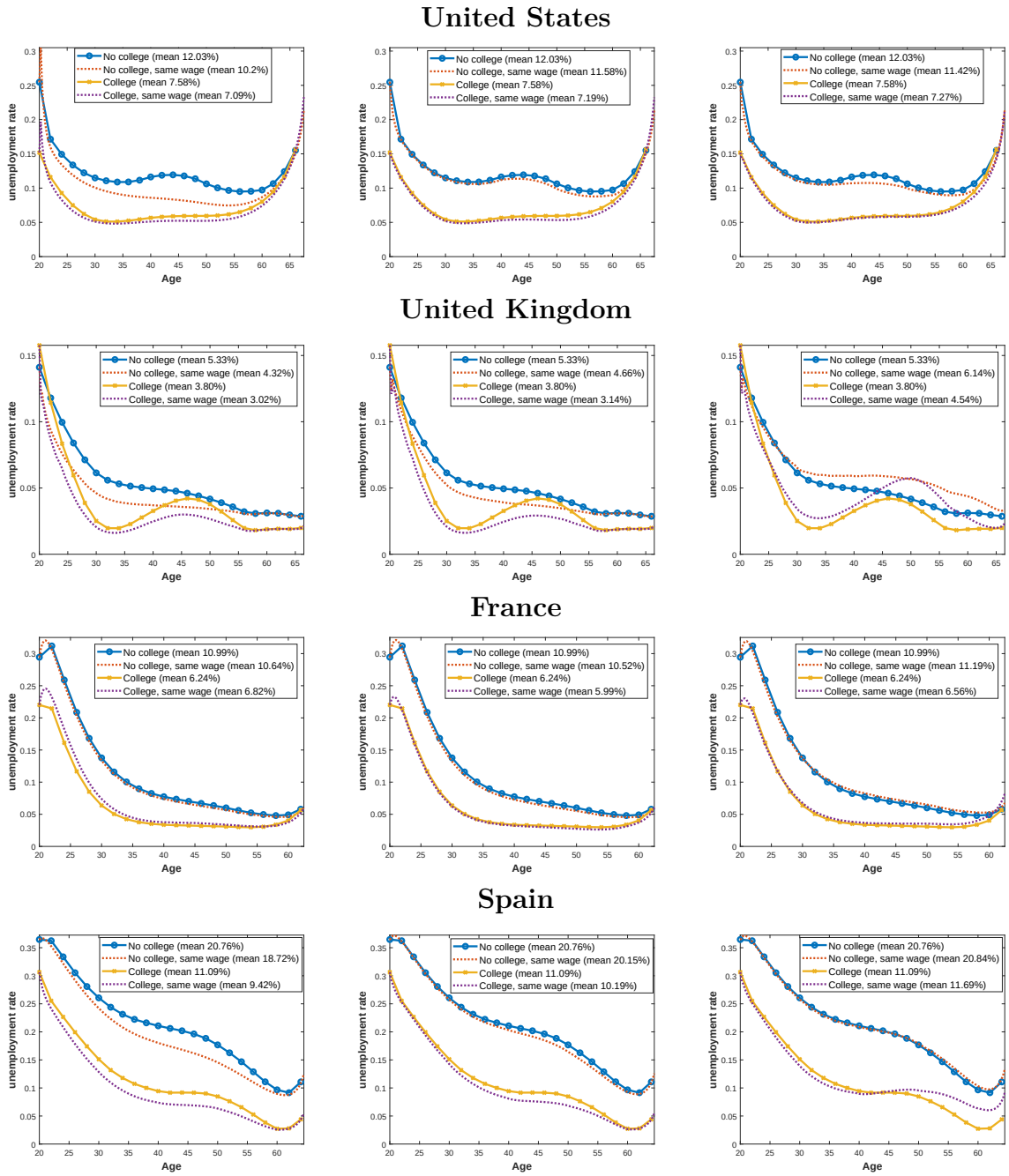
The substantial premium from having a public-sector job implies that many workers queue for these jobs which reduces job creation of firms. As a result, the unemployment rate is higher. Moreover, the age variation in these premia implies that this queuing of unemployed workers also has an age dimension. We now examine the effects that reforms harmonizing the public-sector wages, pension scheme and job-security with those of the private sector have on life-cycle unemployment and government expenditures. Across all experiments, we keep the size of public employment by age constant.

Equalizing the compensation schemes lowers the age-averaged unemployment rate, except in France. Resulting from the proximity of the public sector with the private sector, in France, the average unemployment rate of non-college workers drops by only 0.26 percentage points and that of college workers rises by 0.9 percentage points. In the UK, the rate drops by 1.42 and 1.25 percentage points, in the US by 2.68 and 1.11 points, and in Spain by 2.55 and 2.33 percentage points, respectively.

Figure 6 shows the effects on the unemployment rate when equalizing each compensation scheme one-by-one. In the US, UK, and Spain, equalizing wages alone reduces the unemployment rate by about one percentage point, as shown in the left graphs. The effect is more pronounced around the age of 45 to 50 when the share of workers searching in the public sector is at its peak. Eliminating the pension premium, shown in the middle graphs, leads to a reduction in the unemployment rate by about half a percentage points in most countries and education groups. Finally, eliminating the additional security that European public sectors provide has a theoretically ambiguous effect on the unemployment rate. On the one hand, it reduces the attractiveness of these jobs leading to fewer workers queuing for them. On the other hand, it increases the frictional unemployment rate because the inflow into unemployment becomes larger. We find that the second effect dominates, i.e., increasing public-sector job-separation rates leads to more unemployment.

By changing the unemployment rate and the payments to public-sector workers, the reforms also have large fiscal effects, as shown in Table 4. Take the US as an example.

Figure 6: Effects Of Three Reforms On Unemployment



Note: The left graphs show the effect of equating the wage profile of the public sector to that of the private. The middle graphs show show the effect of equating the replacement rates of the public sector to that of the private. The right graphs show the effect of equating the job-separation rate profile of the public sector to that of the private.

Equating the wages lowers the government's wage bill. Moreover, resulting from the fall in the unemployment rate, the costs with unemployment benefits also fall. The effect on retirement benefits is theoretically ambiguous. On the one hand, lower wages lead to lower public-sector pensions. On the other hand, higher private-sector employment

implies higher private-sector retirement benefits. We find that the latter effect dominates marginally for the US, Spain, and France, but not in the UK. Similarly, the effect on government revenue is ambiguous. On the one hand, higher employment increases tax revenue. On the other hand, lower wages and retirement benefits decrease tax revenue. Here, we find that the former effect dominates slightly, so there is an increase in revenue in all four countries. In total, we find that by equating wages to those of the private sector, the net government budget improves by $46 per person/quarter in the economy. The gains are yet larger in the UK and Spain with £62 and €92, respectively. In France, given the closer alignment of the two sectors, the effects are close to zero.

When equating the replacement rates, the overall cost of pensions decreases, and the unemployment decreases which lowers the costs with unemployment benefits. Again, the effect on tax revenues is ambiguous, and we find that these decrease slightly. The total improvement in the government's budget ranges from €33 per person/quarter in France to £178 in the UK, that has the largest difference in replacement rates. Equalizing the job destruction rates has again heterogeneous effects across countries. The unemployment

Table 4: Program Costs Per Person/Quarter (In Dollars, Pounds, And Euros)

	Baseline	Total	Same wage	Same rr	Same destruction
US					
Unemployment rate %	9.30	7.58	8.29	8.88	8.87
Costs benefits	170	138	151	163	162
Costs wage	843	813	813	843	843
Costs pension	776	737	782	727	779
Revenues	1459	1454	1462	1446	1466
UK					
Unemployment rate %	4.65	1.56	3.75	3.99	5.44
Costs benefits	57	40	46	49	67
Costs wage	887	833	833	887	887
Costs pension	708	507	696	509	701
Revenues	736	693	721	707	730
France					
Unemployment rate %	9.47	9.58	9.42	9.09	9.71
Costs benefits	212	216	211	203	219
Costs wages	708	716	717	708	708
Costs pension	843	813	844	814	840
Revenue	1047	1042	1053	1042	1043
Spain					
Unemployment rate %	17.77	15.32	15.83	17.06	18.00
Costs benefits	224	193	199	215	228
Costs wages	397	368	368	397	397
Costs pension	592	541	595	533	591
Revenue	764	745	764	744	761

rate falls in the US leading to an improvement in the budget, but it increases in the other three countries leading to a worsening in the budget.

Finally, the first column shows the overall budgetary effects when making equating the three compensation schemes. The government's budget improves by €19 per person/quarter in France, €92 in Spain, $96 in the US, and £229 in the UK.

5 Conclusion

Public employment is not driven by the same objectives as private employment. As such, the two labour markets function differently. Amongst several of the differences, this paper is motivated by the substantial asymmetries in the size of the public sector in total employment, as well as the differences in compensation over the life-cycle.

We set up a partial-equilibrium life-cycle model with a public and private sector. The model simplifies an intrinsically complex issue, but it has the key features that we think are essential. The model features search and matching frictions in the labour market, necessary to capture unemployment risk, together with incomplete markets and risk-averse workers. While one can think about many interesting dimensions that are absent from the model: joint decision of the couple of the sectors to join; adding job-to-job transitions; early retirement or the presence of business cycles; we think that including them in the model, while relevant to study other questions on public employment, it would complicate much the analysis without additional insights.

While the purpose of the model is quantitative – to calculate the public-sector job-security and pension's premia and the effects of different reforms – we should interpret the results with caution. Our calibration is based on average policies in the 2000s. However, when we look at the government policies in the different countries, in particular the wage premia, there have been sharp changes in policies, in some cases reducing the asymmetries and in other cases increasing them. We interpret the finding of large quantitative effects of reforms on the unemployment rate and in fiscal variables, as a call for more research on how to improve wage and employment policies in the public sector.

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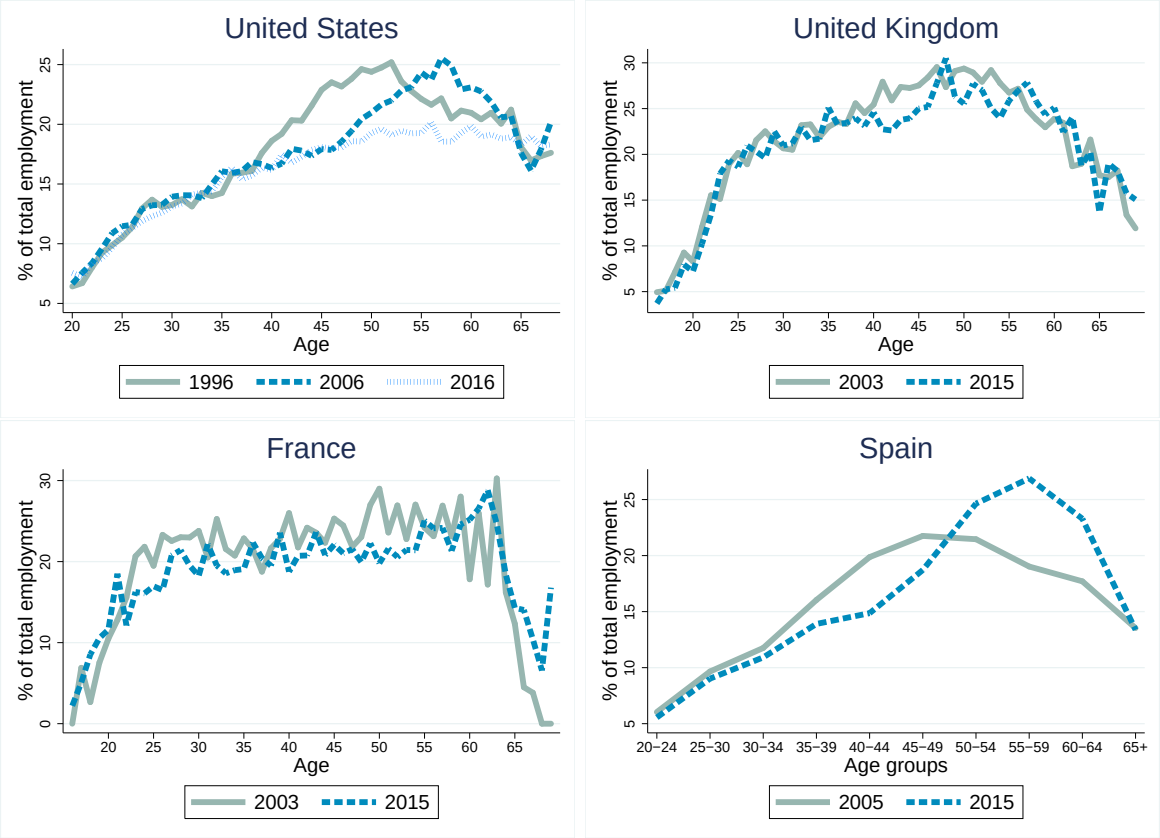
Appendix

Cohort effects

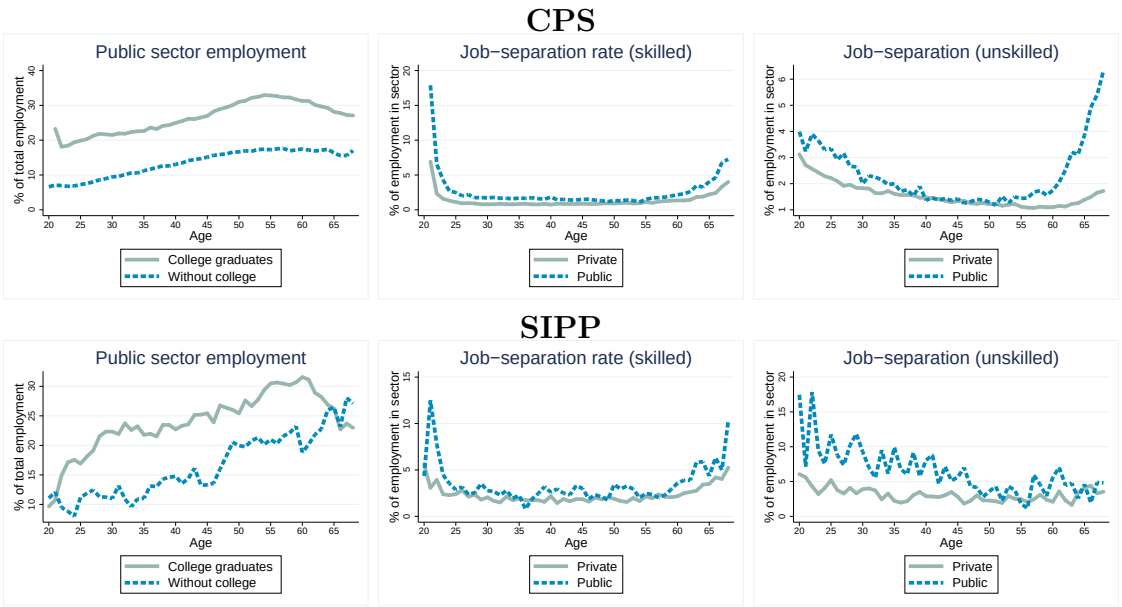
Figure A1: Public Employment Over The Life Cycle, Different Cohorts



Note: The figure show public employment out of total employment by age for different cohorts. For the United States the data is take from CPS (1996-2017), for the United Kingdom from the UK Labour Force Survey (2003-2016), for France for the French Labour Force Survey (2003-2016) and from Spain from the Spanish Labour Force Survey (2005-2017). See for details on the methodology in Fontaine et al. (2020).

CPS and SIPP comparison

Figure A2: CPS and SIPP Comparison: Stocks And Flows By Education And Age



Note: The figure show public-sector employment out of total employment and job-separation rates by sector by age. The data in the top panel is taken from CPS (1996-2017) while from the bottom panel is take from SIPP (2005-2017).

Table A1: CPS and SIPP Comparison: Estimated Wage Profile

	No college		College		No college		College	
Age	Private	Public	Private	Public	Private	Public	Private	Public
CPS					**SIPP**			
20-29	1.00	1.01	1.55	1.57	1.00	1.08	1.33	1.43
30-39	1.29	1.32	1.91	1.91	1.27	1.28	1.48	1.59
40-49	1.38	1.44	2.03	2.01	1.32	1.36	1.56	1.73
50-59	1.41	1.50	2.03	2.08	1.33	1.36	1.62	1.75
60+	1.36	1.42	1.95	2.02	1.28	1.32	1.59	1.63

Note: The data in the left panel is estimated from CPS (1996-2017) while from the right panel is estimated from SIPP (2005-2017). Estimation by regressing the log of hourly wage on age bracket dummies, and age bracket dummies interacted with public sector, separately for college graduates (skill) and bellow college graduates (unskill), controlling for regions (nuts), occupation, manager, year dummies. Education premium is estimated for private sector 20-29 years old. Wages of the unskilled, 20-29 old private-sector worker normalized to 1.

Tax schedule and calibration

All numbers are yearly.

$$\tau(E) = \tau^{i}(E) + \tau^{ss}(E)$$

$$\tau^{ss}(E) = \begin{cases} \tau_1^{ss} E & \text{if } E \leq d_1^{ss} \\ \tau_1^{ss} d_1^{ss} + \tau_2^{ss}(E - d_1^{ss}) & \text{if } d_1^{ss} < E \leq d_2^{ss} \\ \tau_1^{ss} d_1^{ss} + \tau_2^{ss}(d_2^{ss} - d_1^{ss}) + \tau_3^{ss}(E - d_2^{ss}) & \text{if } E > d_2^{ss}, \end{cases}$$

$$\tau^{i}(E) = \begin{cases} \tau_1^{i} \tilde{E} & \text{if } \tilde{E} \leq d_1^{i} \\ \tau_1^{i} d_1^{i} + \tau_2^{i}(\tilde{E} - d_1^{i}) & \text{if } d_1^{i} < \tilde{E} \leq d_2^{i} \\ \tau_1^{i} d_1^{i} + \tau_2^{i}(d_2^{i} - d_1^{i}) + \tau_3^{i}(\tilde{E} - d_2^{i}) & \text{if } d_2^{i} < \tilde{E} \leq d_3^{i} \\ \tau_1^{i} d_1^{i} + \tau_2^{i}(d_2^{i} - d_1^{i}) + \tau_3^{i}(d_3^{i} - d_2^{i}) + \tau_4^{i}(\tilde{E} - d_3^{i}) & \text{if } d_3^{i} < \tilde{E} \leq d_4^{i} \\ \tau_1^{i} d_1^{i} + \tau_2^{i}(d_2^{i} - d_1^{i}) + \tau_3^{i}(d_3^{i} - d_2^{i}) + \tau_4^{i}(d_4^{i} - d_3^{i}) + \tau_5^{i}(\tilde{E} - d_4^{i}) & \text{if } \tilde{E} > d_4^{i} \end{cases}$$

Table A2: Calibration Of Taxes Schedule

	US	UK	Spain	France
τ_1^{ss}	0.153	0	0.0635	0.137
τ_2^{ss}	0	0.12	0	0.137
τ_3^{ss}	0	0.02	0	0.137
d_1^{ss}	94200	8359	34772	∞
d_2^{ss}	94200	46027	34772	∞
$allow$	5150	5035	3400	0
τ_1^{i}	0.1	0.1	0.15	0
τ_2^{i}	0.15	0.22	0.24	0.055
τ_3^{i}	0.25	0.4	0.28	0.14
τ_4^{i}	0.28	0.4	0.37	0.30
τ_5^{i}	0.33	0.4	0.45	0.40
d_1^{i}	7550	2150	4162	5614
d_2^{i}	30650	33300	14358	11198
d_3^{i}	74200	33300	28842	24872
d_4^{i}	154800	33300	46818	66679

Pensions replacement rate in private and public sectors

Figure A3: Heterogeneous Retirement Schemes In OECD Countries, Pensions in a Glance

Table 6.1. **Institutional arrangements for pensions covering civil servants vs. private sector workers**

Fully integrated	Separate but similar benefits	Fully integrated with top-up	Entirely separate
Chile (1981)	Finland (1995)	Australia	Belgium
Czech Republic	Luxembourg (1999)	Austria (2004, 2009)	France
Estonia	Netherlands	Canada	Germany
Greece (2011)	Sweden	Denmark	Korea
Hungary		Iceland	
Israel (2002)		Ireland (1995)	
Italy (1995/2008)		Mexico (2007)	
Japan (2015)		Norway	
Latvia		United Kingdom	
New Zealand (2007)		United States (1984)	
Poland			
Portugal (2006)			
Slovak Republic			
Slovenia			
Spain (2011)			
Switzerland			
Turkey (2006)			

Note: The years in brackets refer to the date from which newly hired civil servants are no longer covered by an entirely separate scheme, but are rather in the fully integrated private sector scheme or have a top-up. For Italy new civil servants were covered by the private sector scheme from 1995 onwards, while in 2008 future contributions for all civil servants were under the private sector rules. For Austria the pension was fully integrated from 2004 but an additional top-up was introduced in 2009. For Finland the unifying process began in 1995, before which there was more of a top-up element to the system. All countries without a date have been in that particular category for at least the last 35 years.

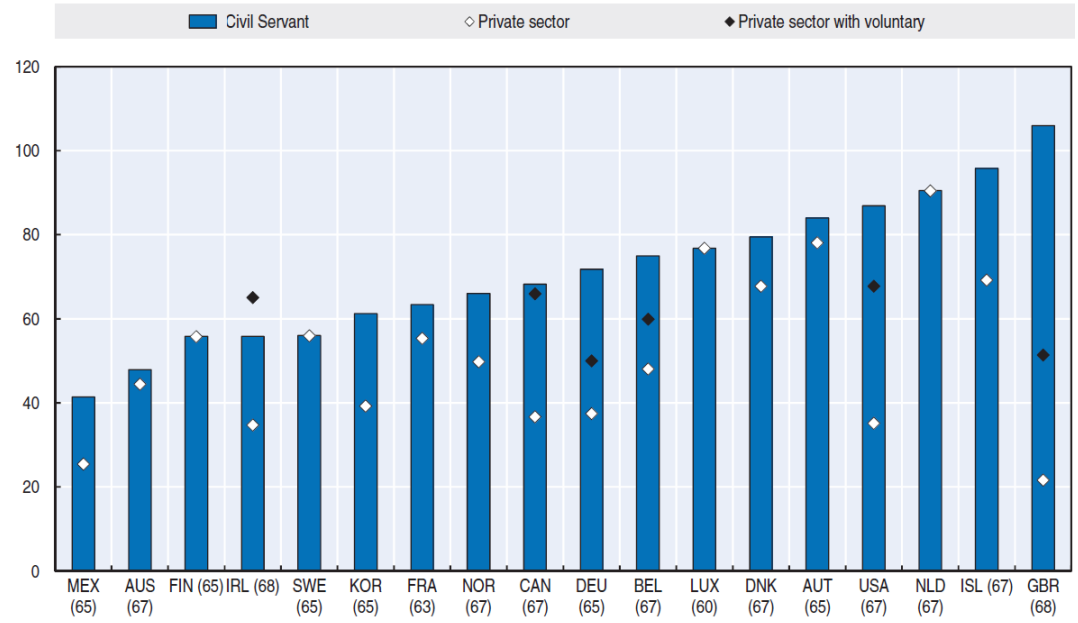
Figure A4: Recent Reforms Of Public-Sector Retirement Schemes In OECD Countries, Pensions in a Glance

Table 6.3. **Reforms to civil service pension schemes over the last 25 years**

Reform	Country
Increase in pension age	Australia, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Korea, Portugal, Spain, Sweden, United Kingdom
Restriction of early retirement	Austria, Australia, Belgium, Canada, Finland, Germany, Italy, Korea, Portugal, Spain, Sweden, United Kingdom
Reduction of pension generosity or increase in career length	Austria, Finland, France, Germany, Greece, Iceland, Korea, Norway, Portugal, Spain, United Kingdom
Increase in contributions	Austria, Canada, Finland, France, Greece, Israel, Italy, Japan, Korea, Netherlands, Portugal, Sweden, United Kingdom
Integration/alignment of civil service with the general state scheme	Austria, Canada, Greece, Israel, Italy, Japan, Luxembourg, New Zealand, Portugal, Spain, Turkey

Figure A5: Summary Of Replacement Rates And Retirement Age, Pensions in a Glance

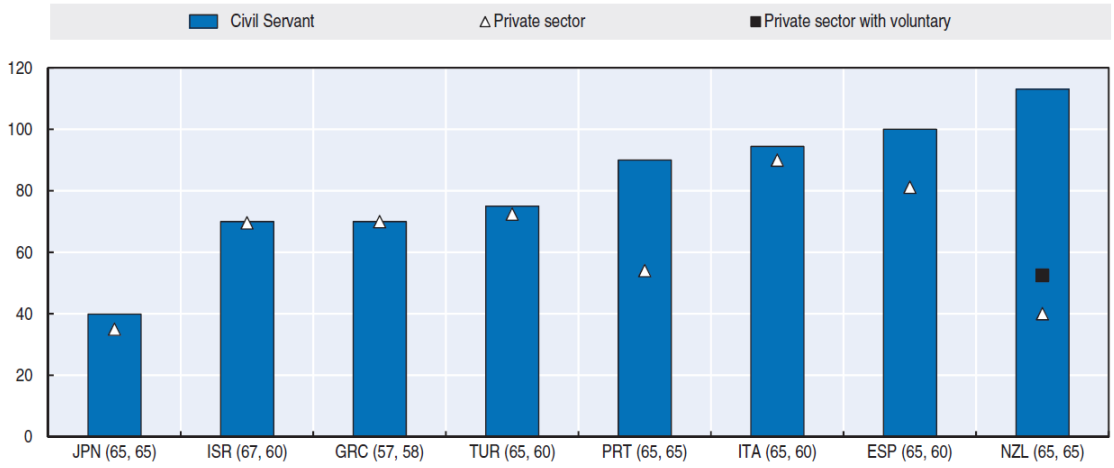
Figure 6.2. **Long-term gross replacement rates for civil service and private sector average earners, entering at age 20 in 2014, %**



Note: Retirement age (in brackets) is the same for both civil servants and private sector workers.
Source: OECD pension models.

Figure A6: Summary Of Replacement Rates And Retirement Age cont., Pensions in a Glance

Figure 6.3. **Long-term replacement rates for civil servants and private sector average earners, before the civil service reform**



Note: Retirement ages are given in brackets, with private sector first.

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