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Low Fertility, Labour Supply, and Retirement in Europe

by Svend E. Hougaard Jensen and Ole Hagen Jørgensen

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Abstract

This paper suggests and analyses a policy rule for the retirement age in order to offset the effects on labour supply when fertility changes. We find that the retirement age should increase more than proportionally to a fertility decline in order to account for negative responses of the intensity of labour supply when lifetime leisure is reduced. The robustness of this result is checked against alternative model specifications and parameter values relevant to an economic region such as Europe.

JEL Classification: E62, H55, H66.

Keywords: Fertility, retirement age, endogenous labour supply, overlapping generations.

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1 Introduction

The total fertility rate (TFR) has been falling in Europe since the early 1960s, and it is now well below replacement level in most European countries (see, e.g., Keilman *et al.*, 2008). This demographic development is likely to have major economic effects. For example, a lower birth rate leads to an increase in the dependency ratio which puts financial pressure on pay-as-you-go (PAYG) pension systems, either in the form of higher taxes or lower replacement rates.

This paper focuses on the effects of low fertility on the supply of labour. It is clear that, all else equal, a fall in the fertility rate in a former period reduces the inflow to the labour force in the current period. This may put upward pressure on wages and, as a result, workers might well decide in favour of more leisure. If so, the *effective* supply of labour would be reduced even further. But it might also be that the substitution effect dominates, i.e. that workers react relatively strongly to a higher price of leisure by demanding less of it. In any case, the work-leisure choice is important to address. This motivates the first part of the paper which sketches a general equilibrium framework for modelling economic outcomes of low fertility.

The second part of the paper has a more policy-oriented perspective. Our approach is to formulate a retirement policy where the statutory retirement age increases when fertility falls in order to retain workers in the labour force for a longer period of time. Therefore, a key question is how to design a policy rule for the retirement age that counteracts the effects on labour supply following the decline in the labour force. The paper shows how such a link between changes in fertility and the retirement age can be established.

Our main result is that the decline in the effective labour supply can be offset by an increase in the retirement age, provided that the retirement age increases more than proportionally to the fall in fertility. The reason for this is that workers respond in two ways to an increase in the retirement age: first, they substitute for leisure when fertility falls and the retirement age increases; and second, since the retirement age increases, lifetime leisure will fall, and this will lead to a demand for more leisure during the working period.

Since our benchmark analysis assumes a large economy setting, it is most relevant to Europe as a whole. However, to individual European countries this setting may be less relevant. Therefore, a robustness analysis is conducted to study individual small/medium sized countries within Europe. The benchmark results are also checked against other calibrations, model specifications and types of pension system.

2 The benchmark model

The analytical framework consists of a stochastic model with overlapping generations (OLG) and endogenous labour supply[1]. In the following we briefly describe the building blocks of the model.

[1] The general framework of our model is inspired by Bohn (2001). We refer to Jensen and Jørgensen (2008a) for a detailed description of the model.

Demographics Individuals are assumed to be identical across cohorts, and to live for three periods: as children, workers and retirees, respectively. Adult lifetime is thus the sum of the lengths of working and retirement periods, separated by a statutory retirement age. A low fertility rate in the former period implies a shrinking labour force in the present period. All else equal, if the retirement age increases, the length of the working period will rise at the expense of a falling retirement period. Furthermore, if workers have to work for a longer period, the *effective* labour supply will increase. The supply of labour is elastic with respect to the after-tax real wage and lifetime leisure. Retirees do not work.

Intertemporal setting In an OLG framework workers consume, provide for their children, pay taxes, and save for retirement. Retirees, on the other hand, consume the income they receive from pension benefits and their savings. Thus, savings allow households to smooth their consumption over time. In our model, where labour supply is endogenous, workers not only have to choose how much to save but also how much labour to supply. This choice has general equilibrium effects because a lower labour supply will, through the capital-labour ratio, alter the wage rate of workers as well as the return on retirees' savings. Consequently, if the retirement age increases, current workers need not save as much to finance the shorter retirement period.

Utility We define utility over leisure and consumption in the adult lifetime. Retirees are assumed to leave no bequests. In the utility function of the representative household, the consumption of a retiree is adjusted by the length of the retirement period, reflecting that retirees can enjoy consumption the longer is the retirement period. While this argument applies to the length of the working period as well, we stress that if the working period increases then some of the "sub-periods" in retirement, which are all composed by full leisure, will be substituted by sub-periods that consist of both work and leisure in the working period. This reduces lifetime leisure. Consequently, we scale leisure in the utility function by the length of the working period to account for this disutility. As a result, individuals can account for the disutility of less lifetime leisure by increasing leisure if the retirement age increases. In this case, effective labour supply would initially rise by the full amount of the increase in the retirement age, but this effect will be counteracted if the disutility of less lifetime leisure induces workers to supply labour less intensively.

Labour supply The paper focuses on three channels through which a fall in fertility may affect the supply of labour. First, there is the direct demographic effect where a fall in the fertility rate shrinks the labour force and thus lowers labour supply; second, if households decide to demand more leisure this will reduce the intensity (intensive margin) of labour supply; and third, if workers have to remain in the labour force for a longer period of time, e.g. if the statutory retirement age is increased (extensive margin), the effective labour supply increases. Therefore, if fertility falls by, for instance, 1% and the government responds by increasing the statutory retirement age by 1% both these events may lead to an increase of households' demand for leisure and thus a fall in labour supply. The consequence is that the government response to a 1% increase in the retirement age may not be enough to counteract the general equilibrium effects that induce workers to reduce their labour supply.

Social Security There is a government sector operating a PAYG pension system which can display either a defined benefits (DB) or a defined contributions (DC) scheme. We adopt the DB system since this is most often instituted in Europe. Evidently, if fertility falls so will the labour force growth rate and contributions must rise to satisfy the fixed benefits.

Production Output is assumed to be produced by capital and labour, and we account for technological progress as well. The capital-labour ratio is linked to the determination of factor prices, such that an increase (decrease) in the capital-labour ratio increases (decreases) the wage rate and decreases (increases) the interest rate. The connection between a fall in the size of the current labour force (due to low past fertility; due to a lower retirement age) and the wage rate of workers is therefore established. Firms are assumed to be identical, and capital is accumulated over time through the savings and investments by households. The degree to which an economy is able to influence its interest rate and wage rate can be adjusted in the model in order to capture the dynamics within small, open countries or regions within Europe.

Solution Our approach facilitates an analytical presentation, where the role of each model parameter can be accurately identified. For example, an expression can be derived that links the retirement age to changes in fertility. By assuming that that the statutory retirement age is under government control, it is possible to derive the *optimal* response of the retirement age in response to, say, a fall in fertility. The results are typically presented in terms of answers to a question like this: "how will leisure change if there was suddenly a decrease in fertility of 1%?". Using this approach we obtain elasticites for the economic variables with respect to both the fertility decline and the change in the retirement age, and we then basically make comparative statics with an otherwise stochastic model (see Uhlig, 1999; Campbell, 1994). The elasticities can be presented analytically, but in this paper we have mainly chosen a numerical presentation of our results. Therefore, we calibrate the analytical expressions of the model with values that we trust are realistic, see table 1.

Table 1. Parameter calibration

Parameter	Value
The capital share in output	1/3
The pension replacement rate[a]	30%
The steady state growth rate of productivity	40%
The rate of capital depreciation	100%
The length of the working period	100%
The length of the retirement period[b]	90%
The rate of growth in the number of children	10%
The weight of leisure in the utility function	1
The consumption discount rate[c]	0.296
The savings rate[d]	20%

[a] The payroll tax rate is derived residually to be 0.25%.

[b] The adult lifetime comprises first and second periods.

[c] Equals 0.963 per year over a 30 year period.

[d] Derived residually.

3 Economic impacts of low fertility

In this section, we discuss the macroeconomic implications of low fertility under two alternative assumptions about retirement policy. We first assume a rather passive policy framework, where no changes are made to retirement policy, and where changes in the retirement age are outside government control. We next assume a more active retirement policy, where the retirement age is under government control. Here we pose our key question: *how much should the statutory retirement age increase in order to neutralise the negative impact on effective labour supply caused by low fertility*?

3.1 Passive retirement policy

3.1.1 Low fertility

The key issue is how work-leisure choices will be determined when fertility has declined. That result is ambiguous, due to a number of counteracting effects. Our simulations show, however, that leisure tends to *increase* after a fertility fall. Thus, the effective labour supply is expected to fall even further, which may have severe implications for European welfare programmes.

This argument warrants a deeper analysis. As noted above, the economy is represented by a model where the coefficient on each economic variable is an elasticity with respect to a 1% change in fertility. The numerical value of these elasticities, based on the calibrated parameters, are reported in table 2. Evidently, a 1% decrease in fertility is seen to produce a 0.001% increase in leisure (fall in labour supply).

Table 2. A fall in fertilty*

Variable		Value
Elasticity of workers' consumption	=	0.01
Elasticity of leisure	=	0.001
Elasticity of retirees' consumption	=	0.34
Elasticity of savings	=	0.01

* Elasticities are for a 1% decrease in the previous period's fertility rate.

If labour supply is exogenously determined, the wage rate and pension contributions directly determine the effects on workers' consumption after a drop in fertility (see Jensen and Jørgensen, 2008b). In the present model, however, labour supply is indeed endogenously determined, so consumption and leisure are interrelated and indirectly affect the capital-labour ratio[2]. Therefore, in order to obtain a complete picture of how net labour supply is determined we need to analyse the disaggregated effects:

Substitution effect: a shrinking labour force alters factor payments through an increased capital-labour ratio, so the wage rate increases and the return to capital falls, as illustrated in figures 1A and 1B, respectively. Consequently, the price on leisure will rise so the substitution effect on leisure is negative.

Income effect: by assuming an unchanged level of income we can obtain the "pure" income effect. This implies that the same income can now buy less (consumption and leisure) because the price on leisure has increased. This results in a negative income effect on all goods.

Wealth effect: An increased wage rate produces a positive wealth effect for all goods due to an increased *lifetime* income. The dynamics of leisure and retirees' consumption, for a negative shock to fertility, are illustrated by the simulated trajectories in figures 1C and 1D, respectively[3].

[2] In the case where labour supply is exogenous the only effect on the capital-labour ratio originates from the lower growth rate of fertility (and thus the labour force).

[3] The dynamics of first-period consumption is identical to the simulated trajectory for leisure, though numerically larger.

Figure 1a The wage rate

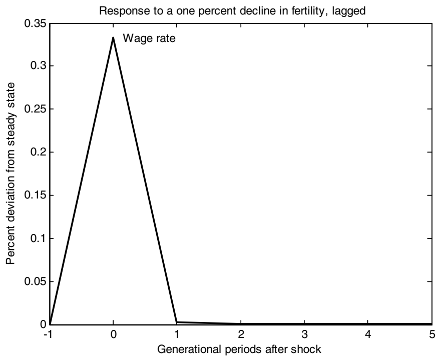


Figure 1b Return to capital

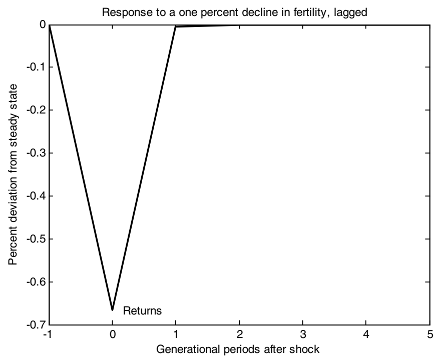


Figure 1c Workers' leisure

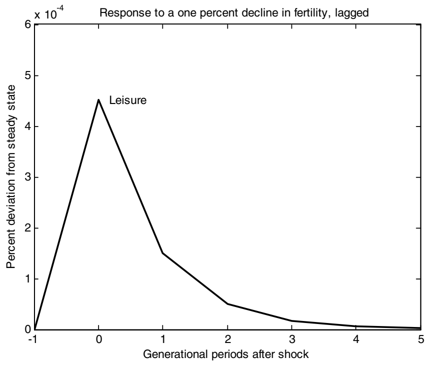
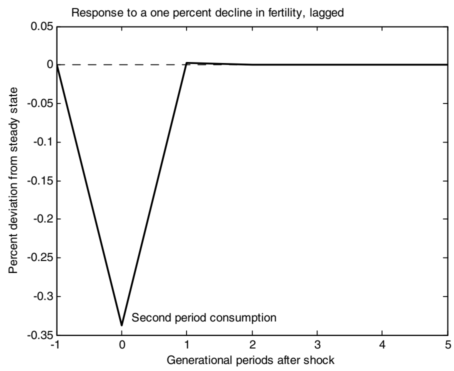


Figure 1d Retirees' consumption



In addition to the well-known effects there are two other crucial aspects to be considered – both of which are directly intertwined with the substitution, income and wealth effects. Due to a changing capital-labour ratio, as well as the presence of a PAYG system, we have to consider *factor price effects* and *fiscal effects*, respectively:

> Factor price effect: the capital-labour ratio increases approximately one generation after fertility has fallen. This period's workers therefore receive a higher wage rate, so the factor price effect is positive for workers. This reflects a *direct* as well as an *indirect* effect: a lower fertility rate *directly* reduces the size of the labour force, and the *indirect* effect is due to the endogenous response of leisure (elasticity of leisure = 0.001). The latter amplifies the former effect on labour supply. Labour supply therefore displays a net fall, since the net change in the capital-labour ratio is positive.
>
> Fiscal effect: a negative fertility shock implies that each worker must pay a higher contrubution rate (because the benefits to retirees are assumed fixed in a DB system). Thus, the fiscal effect is negative.

Distortions from taxes to fund PAYG pension systems are by Weil (2006) found to be the most important mechanism through which aggregate income and welfare is affected by population ageing. This mechanism is also present in our model with endogenous labour supply, where the price on leisure depends on the pension contribution rate. This distorting tax rate leads to a domination of the wealth effect over the (negative) sum of substitution and income effects.

In sum, while the net effect on leisure is found to be theoretically ambiguous, our numerical simulations show that when the labour supply has initially fallen due to low fertility, leisure will indeed increase and further diminish the effective labour supply. We have demonstrated that workers are expected to gain in terms of consumption and leisure and retirees lose in terms of consumption. Thus, there will be an uneven intergenerational distribution of the economic effects following a fall in fertility. While this issue will not be pursued further in this paper, it is an interesting topic for future research.

3.1.2 A rise in the retirement age

The purpose of this sub-section is to analyse how an *exogenous* increase in the retirement age affects key economic variables. We only study the *effects* that a given change in the retirement age entails. In section 3.2, on the other hand, we present a *normative* analysis, assuming that the statutory retirement age is in fact under government control as a policy instrument to increase the effective labour supply.

If the retirement age increases, no matter why, households may decide to work less. This can be interpreted as if people may retire earlier, based on their own savings, which represents a fall in the *effective* retirement age. So, how will leisure (and thus labour supply) change when the retirement age increases? Theoretically, the result is ambiguous. Numerically, however, we find that leisure increases by 0.09% when the retirement age increases by 1%, see table 3.

TABLE 3. A RISE IN THE RETIREMENT AGE*

Variable		Value
Elasticity of workers' consumption	=	0.12
Elasticity of leisure	=	0.09
Elasticity of retirees' consumption	=	0.23
Elasticity of savings	=	0.55

* Elasticities are for a 1% exogenous increase in the retirement age.

When the statutory retirement age increases, the length of the retirement period will be residually lowered. This important mechanism induces workers to save less; consume more; and work less. The net effect on leisure is determined again through the same channels as was the case for fertility:

> FACTOR PRICE EFFECT: when the retirement age increases, the net effect on the capital-labour ratio will be a fall if the intensity of labour supply does not fall more (endogenously) than the retirement age has initially increased. The net effect on capital returns therefore remains positive and the wage rate falls, i.e. a negative factor price effect.
>
> FISCAL EFFECT: after the increase in the retirement age, workers will face more subperiods during which they have to finance the fixed PAYG benefits of retirees. This implies less need for savings to finance the now shorter

retirement period. Consequently, workers free resources for leisure and first-period consumption by saving less. This leads to a positive fiscal effect.

Substitution effect: due to the fall in the price on leisure (because the capital labour ratio increases when the statutory retirement age increases) the substitution effect is positive for leisure.

Income effect: the fall in the price of leisure means that an unchanged income will need to cover a lower opportunity cost of consumption and the "pure" income effect is positive for leisure.

Wealth effect: lifetime income falls proportionally to the fall in wages, so a negative wealth for leisure is generated by the dynamics of factor payments.

The negative wealth effect will not offset the positive sum of the substitution and income effects (due to distortions from the PAYG system), so the elasticity of leisure with respect to the retirement age remains positive. As a result of the dynamics above, the net impact on *effective labour supply* is an increase of 0.91% (1% from the retirement age and 0.09% from the endogenous response of leisure).

The fact that an increase in the retirement age does *not* yield an equal increase in effective labour supply complicates the analysis of the optimal policy rule for the retirement age when lagged fertility has declined which we shall see in the following section.

3.2 Active policy framework

In this section, we use the benchmark model (and the results above) to derive how much the retirement age should increase in order to offset the decline in the labour force, under the explicit assumption that the retirement age is under government control. Note, that our analyses are completely independent of the social desirability of any intergenerational distribution of the associated effects.

The effective labour supply comprises, first, the growth rate of the population (the fertility rate); second, the length of the period workers are in the labour force (exogenous margin limited by the retirement age); and third, the intensity with which workers work (intensive margin). If labour supply was an exogenous variable, then this third effect would be absent from the analysis, and a 1% fall in fertility could be directly offset by a 1% increase in the retirement age. However, labour supply is indeed endogenous. Therefore, changes in fertility and/or the retirement age may affect the intensity of labour supply, as analysed in detail above, where three main forces are operating when the fertility rate and/or the retirement age changes: the factor price effect; the fiscal effect; and the endogenous intensity of labour supply (determined through substitution, income and wealth effects).

Since we found that leisure would *increase* when, first, the fertility rate had fallen and, second, the retirement age increased, the initial effect from the fertility decline on labour supply will be reinforced, and the retirement age would have to increase by even more than 1%. The optimal response of the retirement age is found to equal

$$\widetilde{\chi}_t = \left[\frac{1 \quad \pi_{lf}}{1 \quad \pi_{l\chi}}\right] \widetilde{f}_{t-1} = 1.10\%$$

where:

$\widetilde{\chi}_t$ is the percentage change in the retirement age (χ)

$\pi_{l\chi}$ is the elasticity (π) of leisure (l) with respect to the retirement age

π_{lf} is the elasticity of leisure with respect to the fertility rate (f)

$\widetilde{f}_{t-1}$ is the change in the fertility rate (one period *earlier* which influences the size of the labour force in the *current* period)

Note that if $\pi_{lb1} < \pi_{l\chi}$ the optimal response is $\widetilde{\chi}_t > 1$ if the fertility shock was negative ($\widetilde{f}_{t-1} < 0$). We indeed find this to be the case and conclude, therefore, that in order to offset the negative impact on the effective labour supply, the retirement age must increase by *more* than the fertility rate fell. This reflects the *endogenous* response of leisure to the changes in fertility and the retirement age, respectively. The offsetting response of the retirement age, when $\widehat{f}_{t-1} = \quad 1\%$, amounts to $\widetilde{\chi}_t = 1.10\%$.

Our finding shows that policy makers should be aware of the *endogenous* declines in labour supply when they device policies to overcome the problem of *exogenously* declining labour supply. An important insight is that retirement policies need to be even more "expansionary" than previously believed.

The exact size of the optimal response of the retirement age depends on our benchmark model, and is therefore influenced by the size of parameters and the structure of model itself. The benchmark model is designed to replicate the dynamics within a *large* economy, such as Europe. In order for the model to be applicable to smaller countries or regions within Europe, we need to make model adjustments and robustness checks. This is the purpose of the next section. The benchmark result, that the optimal response for the retirement age should be positive and larger than 1%, is then tested in relation to various re-specifications.

4 Robustness

The benchmark model above has addressed the economic implications of low fertility in a large economy – such as the European economy. It is also of interest to study the economic effects of low fertility in smaller regions of a large economy – such as the individual European countries. The benchmark model is formulated to mainly replicate the dynamics within a large economy, and not directly to analyse the dynamics within small open economies. Therefore, in this section, we present modified versions of the benchmark model and various robustness checks in order to account for the dynamics of both small and large economies within economic regions such as Europe.

The individual European member countries may be charaterised as being either relatively large (e.g. Germany and France) or relatively small economies (e.g. Austria and Denmark). The economic effects of low fertility will be more in line with the predictions of our benchmark model when the country is larger, while a smaller country would be likely to display some important differences in their economic structures such that the economic effects of low fertility may be either amplified or reduced. For instance, a small open economy within Europe has to treat the interest rate as an exogenous variable, which is given from the large economic region surrounding the small open economy. In addition, there may be differences among countries in Europe in their preferences for leisure and consumption over time and, for instance, their welfare arrangements (such as pensions) may vary in scale and scope. Such features should be taken into account when analysing the economic impact of low fertility in the different countries in Europe. Furthermore, in order to correctly measure how much the retirement age should increase in order to neutralise the effect of low fertility on the effective labour supply, it is crucial to incorporate the differences that smaller economies exhibit into the benchmark model.

This section consequently extends the benchmark model to address a variety of model specifications, alternative parameter values, and other potential policy instruments other than the retirement age to alleviate the pressure on labour supply. Our aim is to illustrate how the economic effects of low fertility may be different across European member states insofar their economic structures differs from a large economy such as Europe as a whole.

4.1 Alternative calibration

When low fertility has economic implications, and if households assign an increasing value on leisure, this would affect their choices of labour supply and consumption over time. If the relative weight on leisure in the utility function increases, the elasticity of leisure with respect to an increase in the retirement age will also increase. This relationship is displayed in figure 2.

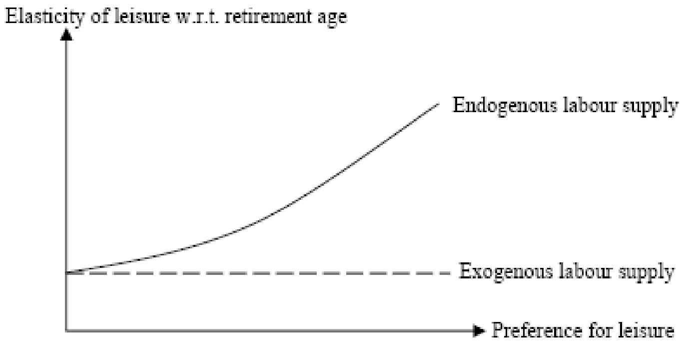


FIGURE 2. LEISURE AND THE RETIREMENT AGE

An increase in the retirement age (which yields less lifetime leisure) would induce workers to supply less and less labour. Such dynamics amplify the optimal response of the retirement. We found that the optimal response of the retirement age was 1.10% but if the value on leisure is doubled, for instance, then the optimal response of the retirement age would increase to 1.11%. On the contrary, a drop in the value of leisure in utility would imply less impact on labour supply from an increase in the retirement age and, consequently, the retirement age would need to increase by slightly less than 1.10% to neutralise the effect on effective labour supply from low fertility.

In the figure, we also highlight the fact that a model which does not incorporate labour supply as an endogenous choice variable cannot capture such dynamics. Our model therefore extends the framework in e.g. Bohn (2001) by allowing for endogenous labour supply decisions. It is indeed feasible in our benchmark model to simulate the impacts of low fertility for various parameter values for the weight of leisure in utility. Furthermore, we find that our result for the response of leisure to a change in the retirement age is very robust.

4.2 Small open economies

In order to obtain an estimate for the economic effects of low fertility in smaller regions or countries within Europe a key difference from the benchmark model is to assume little, or no, factor price determination within the economy. The benchmark model is, by construction, able to address such dynamics within a small open economy. Technically, we cancel the wage and interest rate effects in the benchmark model after a fertility fall. Consequently, the net impact on macroeconomic variables are merely partial equilibrium effects, since the general equilibrium effects on endogenous factor payments are assumed to be independent of a changing capital-labour ratio.

The exact dynamics depend again on assumptions regarding the type of pension system: if we assume a DB PAYG system then retirees are unaffected (in terms of both types of income: interest returns; pension replacements) by a drop in fertility. This result, as shown in table 3, is due to the absense of interest rate declines (opposite to the benchmark model where factor prices were endogenous) and, furthermore, there are no effects on pension replacements because these are fixed in a DB system. In addition, a smaller labour force is obligated to pay pension contributions which is why workers' consumption and leisure change.

TABLE 3. FACTOR PAYMENTS AND LOW FERTILITY[a]

Variable		Value			
		DB		DC/Funded	
		γ=0.1	γ=0.3	γ=0.1	γ=0.3
Elasticity of workers consumption	=	0.08	0.24	0	0
Elasticity of leisure	=	0.01	0.05	0	0
Elasticity of retirees' consumption	=	0	0	0.14	0.33
Optimal resp. of retirement age[b]	=	1.09	1.42	1.07	1.22

[a] Elasticities are for a 1% decrease in the past period's fertility rate.
[b] The optimal response of the retirement age takes into account a 1% decrease in the past period's fertility rate and the effects of increasing the retirement age.

Due to the presence of a pension system the labour-leisure decisions are distorted, which implies that labour supply falls by 0.05% when fertility falls. If we assume a DC system (or a funded system) the effect on replacements is reversed because pension contributions are then fixed. As a result, the consumption of retirees declines by 0.33% when fertility falls, and both the consumption and leisure of workers is unchanged (again, because wages are unchanged).

By recognising that European countries display variations in the scale of their pension systems we investigate the implications of such dynamics by allowing for different levels of replacement rates (γ). There will be less distortion of work-leisure choices when the size of the DB pension system is smaller (e.g. $\gamma = 10\%$). However, when replacements are larger so will be the distortions and also the impact on leisure (for instance, when γ increase from 10% to 30%). In a DC system workers remain unaffected – both for a small and large pension system. When replacement are generally low, retirees have less to lose and they only experience a decline in consumption of 0.14%.

In terms of retirement policy, the optimal response of the retirement age depends on the implications for labour supply of, first, a lower fertility rate and, second, a higher retirement age. The larger is the pension system the larger is the degree of distortion of work-leisure choices and the more the retirement age needs to increase in order to offset the decline in effective labour supply. This is illustrated by an increase in $\widetilde{\chi}_{t,optimal}$ from 1.09% to 1.42% in a increasingly large DB system, and from 1.07% to 1.22% in a increasingly large DC/Funded system. These results take into account, first, the exogenous factor prices which are more in line with small open European economies and, secondly, a varying size of European pension systems.

Note that a larger country within Europe would be assumed to have an increasing ability to influence its wage and interest rates. To the extent this is possible for larger economies (e.g. Germany and France), the optimal response of the retirement age would be more in line with the predictions of the benchmark model. Note also, that the benchmark model produces an optimal reponse of the retirement age of 1.10%. This result lies within the range of optimal changes in the retirement age for a small open economy – even with different sizes of pension systems, see table 3. We therefore conclude that all countries within Europe, small as well as large, would need to change their retirement ages by more than the fertility decline. In this perspective the robustness of the benchmark model is remarkably strong and, by neutralising the relevant model elements (e.g. factor payments; type of pension system), the model seems relevant to any European economy – small or large.

4.3 Alternative pension systems

The scale of public pension systems varies across countries within Europe. Denmark, for instance, has adopted relatively high pension replacement rate while the UK offers less publicly financed pension benefits. Pension benefits can be financed in several ways, and our benchmark model incorporates a PAYG system with defined benefits (DB). Pension benefits could also vary with the size of the dependency ratio, i.e. pension contributions could be fixed (DC PAYG system). Furthermore, the system could be fully funded, a scenario where people must fund their own retirement through mandatory savings.

With our benchmark model we found that workers actually gained after a fall in fertility (pension contributions increased but so did wages), while retirees lost (interest rate fell). A DB PAYG system has the redistributional benefit that it keeps the benefits of retirees unchanged, despite the drop in the size of the labour force. If contributions were instead fixed, as in a DC system, then fewer workers would pay a constant contribution rate and the sum of replacements would fall. This would reinforce the effects on both workers and retirees, so workers would gain even more (fewer workers would not have to finance a fixed level of replacements) and retirees would lose even more (in terms of lower interest returns and now also in terms of lower replacements). In conclusion, a DB system transfers the burden of low fertility across generations to a higher extent than a DC system does. In terms of numerical results, we present the modified elasticities in table 4, where the elasticities of the benchmark model (DB system) are compared to a DC system.

Table 4. Defined benefits vs Defined contributions[a]

Variable		Value	
		DB	DC/Funded
Elasticity of workers consumption	=	0.01	0.33
Elasticity of leisure	=	0.001	0.02
Elasticity of retires' consumption	=	0.34	0.69
Optimal response of the retirement age[b]	=	1.10	1.01

[a] Elasticities are for a 1% decrease in the past period's fertility rate.

[b] The optimal response of the retirement age takes into account a 1% decline in the past period's fertility rate and the effects of increasing the retirement age.

Since workers in a DC system gain even more after a fertility decline, there is a strong tendency in our simulation towards higher demand for leisure. However, when the retirement age is used to neutralise the effect on effective labour supply the elasticities have opposite signs: workers are forced to remain in the labour force for a longer period of their life, and also forced to pay fixed pension contributions in each subperiod. This reduces their lifetime income and induces workers to demand less leisure, so labour supply increases[4]. Thus, the impact on the optimal response of the retirement age is ambiguous, but our simulations show that the negative effect on leisure from the higher retirement age dominates the positive effect from low fertility. This implies that the optimal retirement age should be lower than in our benchmark model: a DC system implies an optimal response of 1.01% (rather than 1.10% from the benchmark model). Note that, even in a DC system, the optimal response of the retirement age is still positive.

In its effects on replacements, it turns out that a funded system is similar to a DC system. This is because neither a DC system nor a funded system imposes higher contribution payments on workers when the dependency ratio increases – whereas a DB system does. Consequently, we subsume our analysis of a funded system under the analysis of a DC system, implying that with a funded system a smaller increase in the retirement age is required.

[4] Elasticity of leisure with respect to the retirement age is 0.09 in a DB system and -0.01 in a DC system.

The scale of PAYG systems can be measured by the size of the contribution rate or the replacement rate. A higher replacement rate would distort consumers' decision to a higher extent because then the contribution rate (which is a tax rate) would also tend to increase. The optimal response of the retirement age would also depend on the scale of pension systems: if operating in a DB system and replacements increase from, say, 20% to 30% then labour/leisure chioces would be further distorted leading to less labour supply and thus an increase in the optimal reponse of the retirement age. Thus, welfare states with more comprehensive pension programmes would need to adjust the retirement age to a large extent in order to offset the negative impact on effective labour supply of a fall in fertility.

4.4 Increasing life expectancy

So far we have considered the economic impacts of low fertility. What if this demographic development was accompanied by increasing life expectancy (as experienced by most industrialised countries, see Oeppen and Vaupel, 2002). If an increase in life expectancy has economic effects the demand for leisure may further change. In case the demand for leisure falls when life expectancy increases labour supply would increase and the retirement age need not increase as much as in our benchmark model in order to offset the drop in effective labour supply. This is exactly what we find after incorporating and analysing a simultaneous drop in fertility and increase in life expectancy. Table 5 displays the results for an increase in life expectancy alone, while $\widetilde{\chi}_{t,optimal}$ denotes the optimal response of the retirement age when both demographic changes occur simultaneously.

Table 5. A change in life expectancy[a]

Variable		Value	
		DB	DC/Funded
Elasticity of workers consumption	=	0.06	0.11
Elasticity of leisure	=	0.05	0.08
Elasticity of retirees' consumption	=	0.001	0.002
Optimal response of the retirement age[b]	=	1.11	1.001

[a] Elasticities are are a 1% decrease in the past period's fertility rate.

[b] The optimal response of the retirement age takes into account a 1% decrease in the past period's fertility rate and the effects of increasing the retirement age.

As before, it is clear that a DC system implies amplifies the economic impacts on both workers and retirees. Leisure, for instance, falls by 0.05% in a DB system and 0.08 in a DC system. The optimal reponse of the retirement age is higher than in the benchmark model when both demograhic changes occur simultaneously if the pension system features defined benefits, while it is lower in a DC system. The elasticity indicates that by adding a term for life expectancy and by given that the elasticity of leisure with respect to life expectancy is negative we find a downward adjustment of the result in our benchmark model in the DC system.

5 Conclusion

It is an empirical fact that fertility rates in Europe have fallen to historical lows, and in most countries the total fertility rate is now below replacement level. This paper has offered some economic perspectives on this demographic phenomenon, by focussing on the implications for the supply of labour. Specifically, within an analytical framework where the retirement age is treated a policy instrument, and labour supply is endogenous, the paper has studied to what extent the retirement age should increase in order to offset the decline in the labour force following the fall in fertility.

We find that the relative increase in the retirement age has to be numerically bigger than the relative fall in fertility. More precisely, we find that the optimal increase in the retirement age is close to 1.1% whenever fertility decreases by 1%. The reason for this more-than-proportionate increase is that the supply of labour falls endogenously when fertility falls. When the retirement age increases the intensity of labour supply falls as a result of less lifetime leisure. Therefore, the demand for leisure increases when the retirement age increases, which could be interpreted as an endogenous change in the voluntary early retirement age. In other words, increasing the statutory retirement age will induce workers to retire earlier, based on their own savings, and this is exactly the opposite of what is intended by the policy rule.

The benchmark result, that the retirement age should increase more than proportionally to the fertility fall in order to offset the negative impact on labour supply, is tested against alternative model specifications. The European member states mainly operate with DB PAYG systems but for countries with DC systems, or in a transition process towards funded systems, the benchmark model has been extended to account for such aspects. We find that the benchmark result still holds. Furthermore, a small-open-economy setting is particularly relevant to some of the member states of the European Union, and we have modified our model to take into account the key dynamics in such economies. Again, our benchmark result is not overturned. Our baseline result also seems to hold when we examine a simultaneous increase in life expectancy.

We have modelled household behaviour according to our best beliefs of how to incorporate the value of leisure and the lengths of periods, and our benchmark result is very robust to changes in the weight on leisure in the utility function. However, the robustness of our result should be examined in greater detail for alternative specifications of the utility function, which is a topic for our future research agenda.

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