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The effect of educational expansion and family change on the sustainability of public and private transfers

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ABSTRACT

This paper examines the impact of aging and related socio-economic trends (educational expansion and changes in family structure) on the sustainability of public and private transfers. For this purpose, recently available disaggregated National Transfer Accounts (NTA) are combined with dynamic microsimulation techniques to build the first dynamic microsimulation model that incorporates NTA accounting (microWELT) and is thus able to capture how agents rely on public and private transfers over their lifecycle. The model simulates the major lifetime transitions at the individual level, including education, emancipation, fertility, partnership formation and dissolution, and death. The analysis was conducted for four European countries, representative of four welfare models: Austria, Finland, Spain, and the UK. We compare sustainability indicators for the economy, the public sector, and families in the NTA tradition with enriched indicators that capture additional composition effects. When these additional composition effects are ignored, as in previous literature, we find that the Economic Support Ratio decreases more than the pure Demographic Support Ratio. In striking contrast, we show that composition effects due to educational expansion that interact with changes in family structures lead to the opposite result, alleviating the effects of demographic aging. Unlike public transfers, private transfers are only slightly affected by aging, as they are near zero for the elderly.

Introduction

Population aging affects the proportion between the active and the economically dependent population. Besides decreasing fertility and mortality, the post-war baby boom and the subsequent baby bust created a demographic cycle that enlarged the otherwise gradual aging process. The gradual increase in life expectancy further amplifies the effect of large baby-boomer cohorts reaching retirement age. On the other hand, education improvements, the increasing labor force integration of women, health improvements, and policy reforms leading to a delay in retirement age can mitigate this effect. In other words, traditional purely age-based demographic measures, such as the Old-Age Dependency Ratio – the elderly to working-age population – or the Demographic Support Ratio – working-age population to total population – do not adequately capture the effect of population aging on the economy. Cutler et al. (1990) proposed adding economic meaning to the Demographic Support Ratio by weighting the numerator and denominator by production possibilities and consumption needs. This

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approach was later fostered by the National Transfer Accounts (NTA) project.[7] NTA establishes a procedure to calculate National Accounts by age to investigate how the consumption of the economically dependent population (mainly children and the elderly) is financed through public or private transfers or resorting to asset-based reallocations. These estimates offer comparable data for an increasing number of countries worldwide, opening the opportunity to capture the interplay between economics and demographics in social development and the effects of the consolidation of the welfare state highly influenced by education and the corresponding changes in family structure. Standard NTA estimates by age allowed a new sustainability indicator to be obtained, the so-called Economic Support Ratio (Mason and Lee, 2006), defined as the ratio between effective production (population multiplied by the per capita age profile of labor income) and effective consumption (population multiplied by the per capita consumption age profile).

In this paper, we contribute to this approach, going into greater depth at the micro-level by incorporating into the analysis not only age and gender but also education and family type. For that purpose, we combine disaggregated NTA estimates constructed to that end in Abio et al. (2021) with dynamic microsimulation. This allows us to obtain sustainability indicators throughout the aging process, considering the effects of the education transition and changes in family structures. Additionally, the NTA accounting allows capturing not only public but also private transfers. To assess the potential impact of welfare state designs, we compare four European countries, representative of the four welfare models: Austria (Continental), Finland (Nordic), Spain (Mediterranean), and the UK (Anglo-Saxon).

Istenič et al. (2019) outline the main characteristics of these different welfare state regimes. In short, the continental model relies on traditional family norms, where the state extensively supports motherhood and provides generous transfers to the elderly. Nordic countries belong to the social-democratic model, where the state takes responsibility for children to a greater extent, promoting full employment for women. Social welfare rights tend to be universal and public transfers are high on both sides of the dependent life cycle. The Mediterranean welfare state model is characterized by an important role of the family and a lack of family policies. For this reason, dependents rely more on private rather than on public transfers. Finally, in the Anglo-saxon or liberal welfare state the government takes responsibility primarily for the most vulnerable. Public transfers are mainly geared toward protecting the poorest, while non-dependent individuals rely to a greater extent on the market.

There is extensive literature on projection models assessing the impact of aging on economics and the sustainability of the welfare state system. Models vary according to their focus and the primary disciplinary approach. Our modeling strategy follows a line of models built on an interdisciplinary tradition, combining demographic and economic data. Models can generally follow a top-down (macro) or bottom-up (micro) approach. The difficulties in integrating both approaches lead to a continuum of modeling strategies, with a recurrent trade-off between consistency and applicability. At one extreme, the aggregate benchmark consists of dynamic macroeconomic models designed to capture the economic general equilibrium effects of the aging process, although demographics are considered with more or less realism depending on the focus of the paper.[8] At the other extreme, microsimulation models are based on detailed microdata, reproducing observed behavior by statistical modeling. A series of modeling approaches lie in between, where we can situate some of the projection models built in the NTA tradition. Most of them take an aggregate or macro perspective, considering that individuals differ only in age and gender – the standard dimensions of NTA estimates.[9] Our model fits this tradition, going a step forward in various dimensions. First, employing dynamic microsimulation introduces a novel approach in the literature that has been dominated by aggregate accounting. To that end, the population dynamics are simulated at the individual level, including the detailed modeling of education, affecting successive life events (emancipation, partnership formation, fertility, and mortality).[10] Second, the model incorporates the NTA estimations further disaggregated by educational level and family type. While still being a cross-section measure, thus ignoring all trends within the distinguished population groups, incorporating the education and family dimensions adds some realism by accounting for critical composition effects. For example, higher-educated people on average obtain higher income, stay longer in the labor force, and – during active age – pay higher contributions. At the same time, the highly educated live longer and receive higher pensions.

Some efforts have previously been made to disentangle the effects of the education transition on the aging process. Rentería et al. (2016) proposed decomposing the demographic dividend into age and education effects using NTA age profiles by educational attainment. Our work elaborates on this line, adding richer detail to the analysis by considering education and family structure and the role of welfare state designs. Our projection model – microWELT – allows us to obtain enriched sustainability indicators like the Economic Support Ratio, a less mechanical indicator of the effects of population aging, accounting for improvements in human capital and changes in female labor force participation and family structure. We also obtain similar indicators capturing the sustainability of public and private transfers and find sizeable composition effects.

The rest of this paper is organized as follows. Section 2 gives an overview of the microWELT model and its application from the welfare state regimes' perspective. It also introduces the NTA approach and the disaggregated NTA data used for our analysis. This part is kept short and explained in the appendix, as extensive documentation on the model and data are available in Spielauer et al. (2020a, 2020b) and Abio et al. (2021).[11] Section 3 presents the calculation and projection of the Economic Support Ratio and other sustainability indicators and the related analysis for the four countries studied. The last section contains concluding remarks.

The microWELT model: Combining NTA with microsimulation techniques

This section describes how the NTA methodology and microsimulation have been integrated to create the microWELT projection model to capture the interaction between economic, demographic, and policy variables, all linked through education as the main socioeconomic characteristic of individuals.[12]

The microWELT model is based on standardized data readily available for EU countries. Due to data restrictions concerning the calculation and validation of disaggregated NTA data, the base year is 2010. While reproducing existing (Eurostat) demographic projections as aggregate outcomes, microWELT also produces detailed family-demographic and education projections integrated into a longitudinal accounting

[7] Detailed information about the NTA project can be found at https://ntaccounts.org/. The methodology has been published by the United Nations (2013).

[8] Bommier and Lee (2003) introduce realistic demography in an Overlapping Generations (OLG) model.

[9] See Mason et al. (2016, 2017), Lee and Mason (2010) and Abio et al. (2017).

[10] See Orcutt (1957) for the first microsimulation model devoted to policy analysis including demographic simulation.

[11] See also Spielauer et al. (2020c) for an earlier version of this paper and Spielauer et al. (2021) for results on the lifecycle impact of welfare policies.

[12] The microWELT model is designed as a modular platform, refinable and extendable for a wide range of applications (fully documented at https://www.microwelt.eu). It has been developed alongside an international research project (https://www.weltransim.eu).

framework based on the NTA approach. The starting population is generated from the 2010 EUROMOD model (Sutherland and Figari, 2013), based on the European Union Statistics on Income and Living Conditions (EU-SILC), and various parameters are estimated directly from this dataset.[13] Consumption is obtained from the Household Budget Survey (HBS) for 2010. Other data sources employed are the harmonized European Labour Force Survey, Eurostat population projections, standard NTA by age and sex for 2010 (available from the AGENTA project[14]), and disaggregated NTA by age, sex, education, and family type, recently available from Abio et al. (2021).

From a technical perspective in the dynamic microsimulation literature, the model is a time-based interacting population model. Unlike case-based models where one individual is simulated after the other, all actors are simulated simultaneously and can communicate at any moment in time. In this way, individuals are always linked to nuclear families, our central modeling unit. This methodological choice eases the computation of the overall budget of families and government, and the implementation of adjustments of inflows and outflows in case budgets do not balance. Similarly, it permits the alignment of certain key variables to external targets, like fertility and mortality rates from Eurostat projections.[15] Overall, microWELT is the first dynamic microsimulation model incorporating NTA accounting and, hence, explicit consideration of the lifecycle of individuals in their family context.

The NTA method first disaggregates National Accounts (NA) figures of consumption and labor income by age and sex, obtaining by subtraction the so-called lifecycle deficit. The lifecycle deficit is positive for economic dependents (children and the elderly) and negative for most working-age individuals. It then measures how the surplus is used to finance deficits through public transfers (the welfare state), private transfers (mainly the family), and reallocations based on assets (asset income and dissaving). As a result of this process, NTA also include estimates of family transfers. Here we use disaggregated profiles obtained at the individual level by age, sex, education level and family type. The appendix shows the main disaggregated age profiles, the construction of which is fully described in Abio et al. (2021). Below we detail the population dynamics and the data employed in the model.

MicroWELT population dynamics work as follows: The simulation departs from a starting population, new persons being added due to birth and immigration, and leaving the simulation due to emigration and mortality. All individuals go through several socio-economic processes. As mentioned above, microWELT pivots on education as the main socio-economic category, affecting the transition probabilities of all the other events. Specifically, we distinguish three levels of education: Low (ISCED 0-2), medium (ISCED 3-4), and high (ISCED 5+). In addition, given our focus on changing family structures, we also incorporate the impact of intergenerational transmission of education. The maximum educational level attained influences the timing of emancipation, fertility, and partnership behaviors. This strategy allows us to capture the effects of the education transition and its impact on changes in family structures.[16]

In our education projections, educational dynamics result entirely from the intergenerational transmission process of education, thus from the changing education composition of parents.[17] Fig. 1 shows the distribution by final education level attained by the 2010 birth cohort (panel a) and the projected evolution of the educational distribution for ages 20–59 from 2010 to 2060 (panel b). For the 2010 birth cohort, differences by sex are more considerable in Spain and Finland, where the share of highly educated is higher for women than for men. When looking at the total population (panel b), even though Spain shows a high level of highly educated, it also has the largest share of people at the lowest level, revealing more room for improvement. Austria has an outstanding share of the population in the medium-educated group (for both men and women) for the 2010 birth cohort, resulting from the importance of the dual education system,[18] which is nevertheless predicted to decrease in the future. UK and Finland show a less pronounced educational expansion. Overall, the education expansion observed in the past, together with the projected intergenerational transmission process, leads to considerable improvements in the education composition of the potential workforce, as shown in panel b of Fig. 1.

Emancipation patterns follow those of education. According to Eurostat data for 2010, significant delays are observed in Spain, where children do not leave home until their late 20s, reflecting the vital role of the family in providing welfare to the young in Mediterranean countries. At the other extreme, in Finland (Nordic model), emancipation occurs on average at 21.9. Austria and the UK's emancipation patterns lie in-between the two previous cases, at an average age of 25.5 and 23.9, respectively.

Regarding fertility, in its base scenario, microWELT reproduces age-specific fertility rates by calendar year, as published and projected by Eurostat. When comparing the historical fertility of 2010 with the projected fertility in 2030, besides a slight move to higher ages, fertility is projected to stay at around 2010 levels for Austria and Spain (resulting in a Total Fertility Rate (TFR) of around 1.4 and 1.3, respectively). By contrast, reflecting the recent decrease, Finnish rates drop from a relatively high level (resulting in a TFR of 1.9 in 2010) to figures similar to the Austrian case. The UK is the only country in our analysis that will have high fertility rates in the future, with an expected TFR of 1.8 (1.9 in 2010). This slight decrease is mainly caused by a reduction in the youngest women's fertility, which is comparably high at the beginning.

In contrast to macro projection models, microWELT does not apply the same fertility rates to all women, regardless of education and current number of children. To simultaneously meet overall rates and account for individual differences, first births are modeled separately, parameterized by age-specific cohort first-birth rates by education. Those values were estimated from EUROMOD/EU-SILC data and calibrated to published estimates of cohort childlessness by education. In the simulation, it is ensured that first births meet these rates. In contrast, the remaining (higher-order) births required to meet overall age-specific fertility are distributed randomly to women of the respective age who are already mothers. The rationale of this approach is to meet two critical fertility targets, i.e., the age distribution at first birth and childlessness by education while being able to reproduce overall age-specific fertility rates.

Childlessness (versus ever being a parent) is a key distinguishing characteristic of the model. It is also applicable for distributional analysis from a longitudinal perspective (accounting transfers over the

[13] EUROMOD is a static tax-benefit microsimulation model mainly based on EU-SILC (https://euromod-web.jrc.ec.europa.eu/).

[14] AGENTA (Ageing Europe, An application of National Transfer Accounts for explaining and projecting trends in Public Finances) was a collaborative research project financed by the 7th Framework Programme, for the period 2014–2017. It provides standard NTA age and sex profiles for 25 European countries in 2010. Results are available at https://dataexplorer.wittgensteincentre.org/nta/. The methodology can be found in Istenič et al. (2016).

[15] See Spielauer et al. (2020a) for a detailed discussion on the design and structure of the model in relation to the literature on dynamic microsimulation.

[16] Intergenerational education transmission probabilities are obtained from the 2009 ad-hoc module of the European Labor Force Survey. Other transition probabilities and parameters are estimated from EU-SILC data and EUROSTAT sources (see Spielauer et al., 2020b). Population by age and gender is aligned to EUROSTAT population projections.

[17] Transition probabilities are estimated from the 2009 ad-hoc module of the European Labour Force survey. The impact of parents' education on education transitions is of comparable magnitude for Austria, Spain, and the UK, while in Finland it is far smaller, consistent with its universalistic welfare state regime. See Spielauer et al. (2020b) for further details.

[18] In Austria, after compulsory school individuals aged 15–18 can participate in what is known as the *apprenticeship system*, which is a work-based vocational education system, where students are both in school and employed as apprentices.

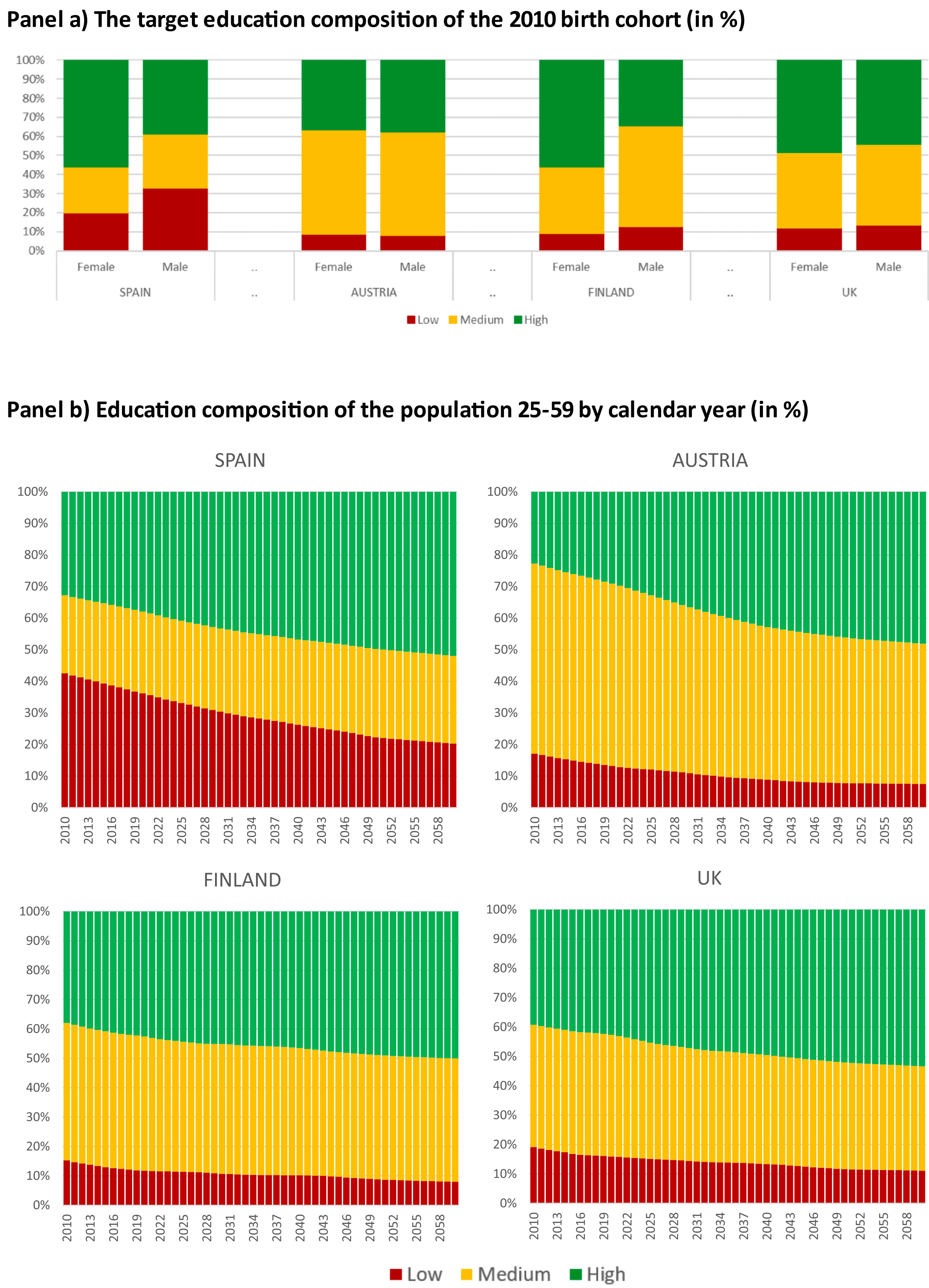

Fig. 1. Education transition: data and projection results. Notes: In panel a, the estimation is based on parameters from the European Labour Force Survey 2014. Panel b shows the simulation obtained by microWELT (base scenario). Source: Authors' calculations using microWELT.

whole life course by population group). Childlessness differs by education, following patterns also linked to welfare state regimes. For example, high childlessness of high-educated women is seen as a typical phenomenon of "specialization" in conservative countries (Spielauer, 2005). Historically, most European countries followed a transition from very high childlessness at the beginning of the 20th century to very low childlessness during the baby boom, followed by a new increase. As a measure of the concentration of reproduction – the distribution of family sizes – it impacts the distribution of family obligations, which are an essential dimension of distributional analysis (Shkolnikov et al., 2004; Spielauer, 2005). microWELT reproduces these patterns and considers different scenarios for the future.

In the base scenario, we maintain the cohort childlessness of the 1960 birth cohort shown in Fig. 2 panel a). While total levels of childlessness are comparable across the four studied countries, childlessness by education follows different patterns. In Austria, Spain and the UK, childlessness is the highest for high-educated women. In Finland, cohort trends have reversed, childlessness now being higher among women

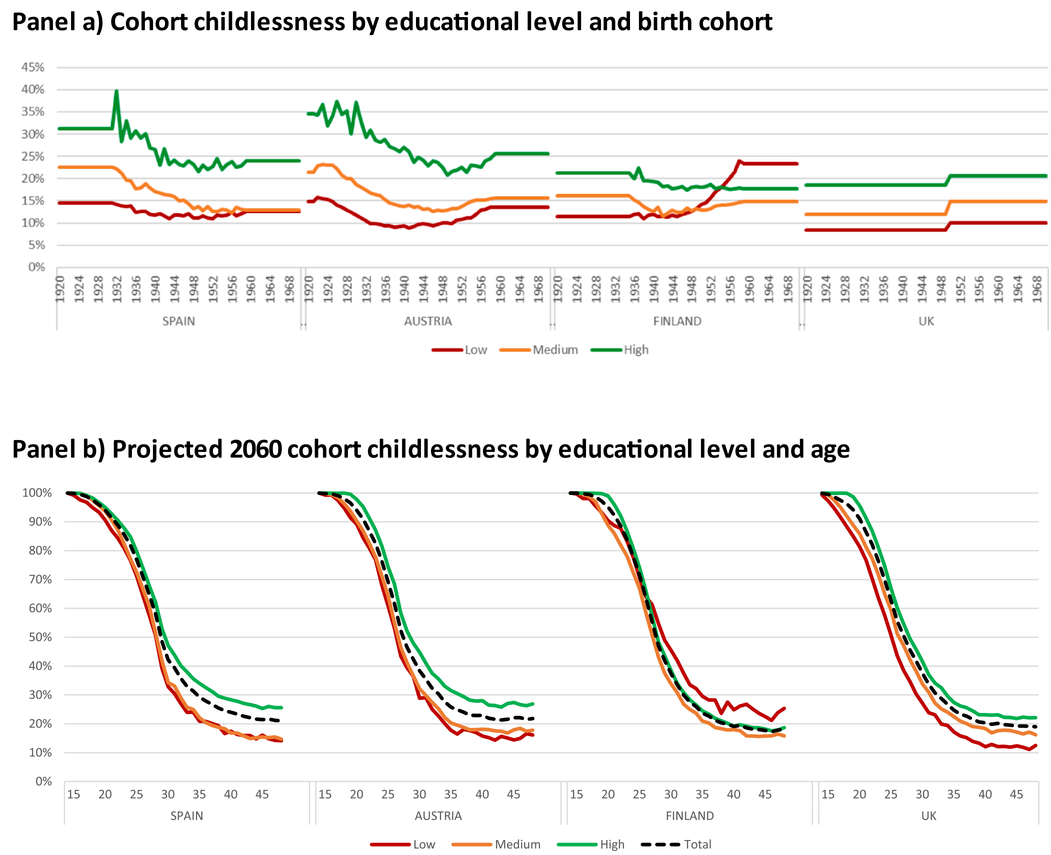

Fig. 2. Cohort childlessness by educational level. Notes: Panel a based on Cohort Fertility and Education database (https://www.cfe-database.org/database/) for Austria, Finland, and Spain. Data for the UK are taken from Berrington et al. (2015). Panel b results from microWELT simulation in a base scenario of constant fertility patterns. Source: Authors' calculations using microWELT.

with the lowest level of education. This reversal is unique, although, in Nordic countries, high-educated women do have lower levels of childlessness compared to the rest of Europe (Rotkirch and Miettinen, 2017).[19] These differences are maintained in the projections, as shown in panel b) of Fig. 2.

For simplicity, the modeling of partnerships is female-driven. Women's partnership status is modeled accounting for age, education, the presence of children, and the age of the youngest child in the family. We do not distinguish between married versus unmarried cohabitation. The probability of women living in a partnership is estimated from the starting population file (EUROMOD, EU-SILC) using logistic regression. We estimated the models separately for women not living with dependent children and mothers. Once a woman enters a partnership, an appropriate male partner is searched for in the population, criteria being age and education. The basic assumption of microWELT for modeling partnerships is that partnership patterns stay the same for women with given characteristics. Future changes at the aggregate level arise entirely from composition effects, for example, due to an increase in childlessness (or an increase in the age at first birth) resulting from the education expansion.

Finally, mortality is modeled based on mortality tables available from Eurostat population projections. In addition to age and gender-specific mortality rates, microWELT considers the different life expectancies according to education. For example, in Austria, men with a university degree live, on average, about six years longer than men with only compulsory schooling (Klotz, 2007; Leoni et al., 2020). The simulation uses parameters for the average remaining life expectancy at ages 25 and 65 by education (Murtin et al. 2017) to calculate relative mortality risks, while data for Spain are based on Requena (2017). It applies the parameters in such a way that overall consistency with the aggregated mortality tables is maintained.

Fig. 3 shows the resulting population projected by microWELT (aligned to Eurostat projections), together with its main drivers (births, deaths, and net immigration flow). Initially, the number of deaths increases in all four countries due to the baby boom generation (which was delayed in Spain). Total births soon fall below total deaths except for the UK, where they remain higher throughout the projection period, thanks to the comparably high fertility in this country. The crossing point is earlier in Spain and Finland (around 2018), while in Austria, it is around 2026. Net migration flows are sufficient to compensate for the natural population decrease in Austria, and therefore total population remains constant in this country. However, this is not the case in Finland, where the total population decreases from around 2025. In Spain, the decrease in total population starts a little later, is less pronounced, and stops before the projection period. The combination of high fertility and high positive migration flows in the UK leads to continuous population growth, a completely different picture to that observed in the other three countries.

Enriched sustainability indicators in the NTA tradition

The most widely used sustainability indicator based on the NTA approach is the Economic Support Ratio (ESR), measuring the changing relation between effective producers (or effective labor) and effective consumers (effective consumption). It builds on the Demographic Support Ratio (DSR), which in its simplest form relates the working-age population (e.g., aged 16–64) to the total population. The ESR

[19] Interestingly, Esping-Andersen and Billari (2015) also find some signs of a reversal in the education gradient of fertility, which could have been caused by reaching a more gender-egalitarian partnership mode, accompanied by policies.

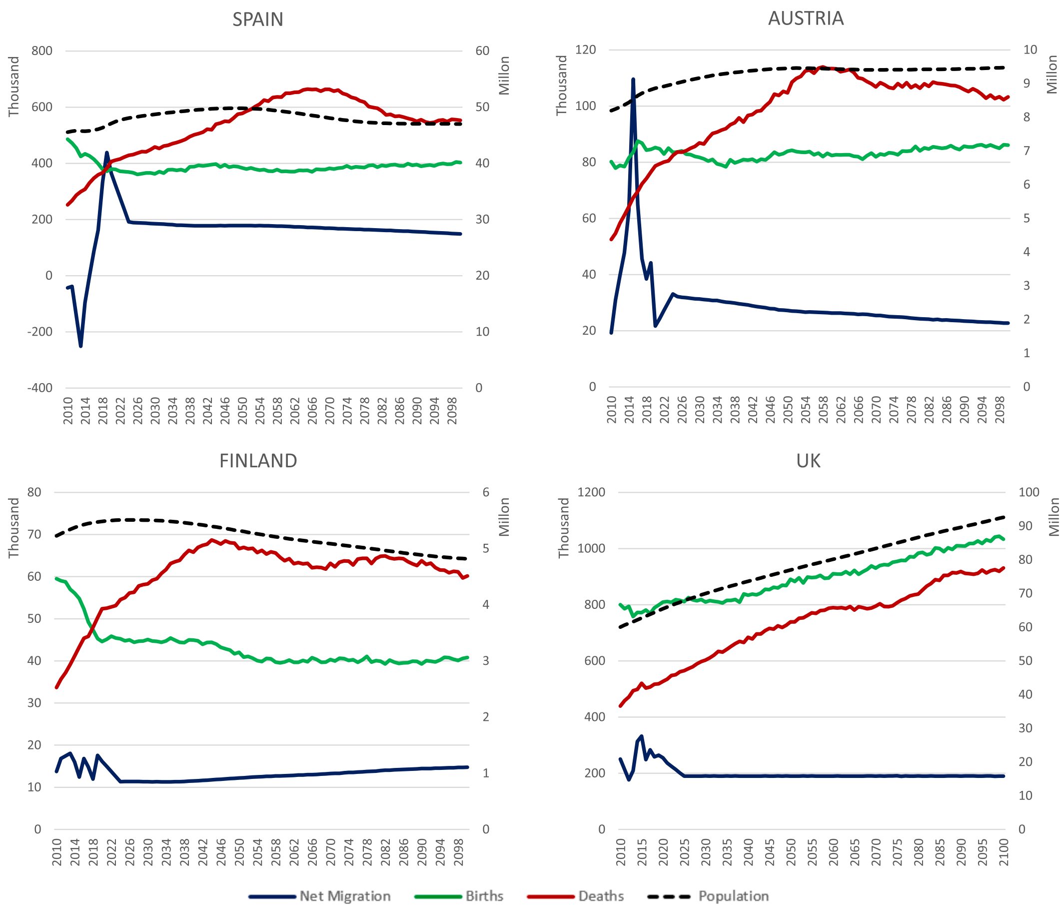

Fig. 3. Population projections. Note: Population in millions (right axis), with births, deaths and net migration flow in thousands (left axis). Source: Authors' calculations using microWELT to reproduce EUROSTAT population projections.

provides a more comprehensive measure by replacing the size of the working-age population with the total population, weighted by the age profile of the current average labor income, in order to gather the available production. Similarly, total population in the denominator is replaced with the population, weighted by the age profile of current consumption to capture current consumption patterns. Projections of the ESR are available for many countries. When the ESR increases, economies experience the so-called demographic dividend (a relative increase in the working-age population with respect to the dependent population). Further discussions on the definition of support ratios can be found in Mason and Lee (2006) and Rentería et al. (2016).

The microWELT model allows us to obtain an enriched ESR, capturing not only the impact of demographic changes but also the education transition interacting with changes in family structures. At the same time, NTA estimates allow us to obtain indicators of the sustainability of public finances (or welfare state transfers) and their interaction with private transfers. Below, in Subsection 3.1, we show the results for the enriched ESR, while Subsection 3.2 shows the results for public and private transfers.

An enriched economic support ratio

As previously mentioned, education expansion is one of the factors that might mitigate the impact of aging on economic sustainability. Rentería et al. (2016) found significant positive effects of education, partly offsetting the future adverse effects of aging. The computations here extend this line of research, including not only the changing education composition but also the potential effect of changes in family structures, capturing the interaction among demographic and economic variables, including welfare state design. Disaggregated NTA profiles are still a cross-section measure and hence might ignore other trends within the distinguished population groups. Still, incorporating education and family type adds realism by accounting for some critical composition effects.

Fig. 4 shows the evolution of the two components of the ESR: effective labor (L) and effective consumption (C) in the four countries analyzed, obtained from the microWELT model. To derive these results, the age profiles of labor income and consumption are taken from the base year (2010) and uprated at a constant growth rate of 1.5% each year.[20] These profiles – specific for each gender, education level, and family type – are combined with the projected evolution of the population – distinguished by the same characteristics. All magnitudes are expressed as an index set to 1 in the base year. Results based on disaggregated NTA data by age, sex, level of education, and family structure are compared to those obtained using traditional NTA data (by age and gender), available from the AGENTA project for the same four countries.

Fig. 4 shows that composition effects change the evolution of both effective labor and effective consumption. Using aggregated NTA age profiles, the evolution of L and C captures substantial demography changes. As seen in Fig. 3 above, the demographic projections imply a long period of births below deaths in all countries except the UK. This gap is closed by migration flows in Austria and, to a lesser extent, in Spain so that the total population stays almost constant. In Finland, the gap is not closed, and the population steadily declines. Because of these

[20] The value of 1.5% is chosen following other papers doing similar projections (European Commission, 1999; Lee et al., 2017).

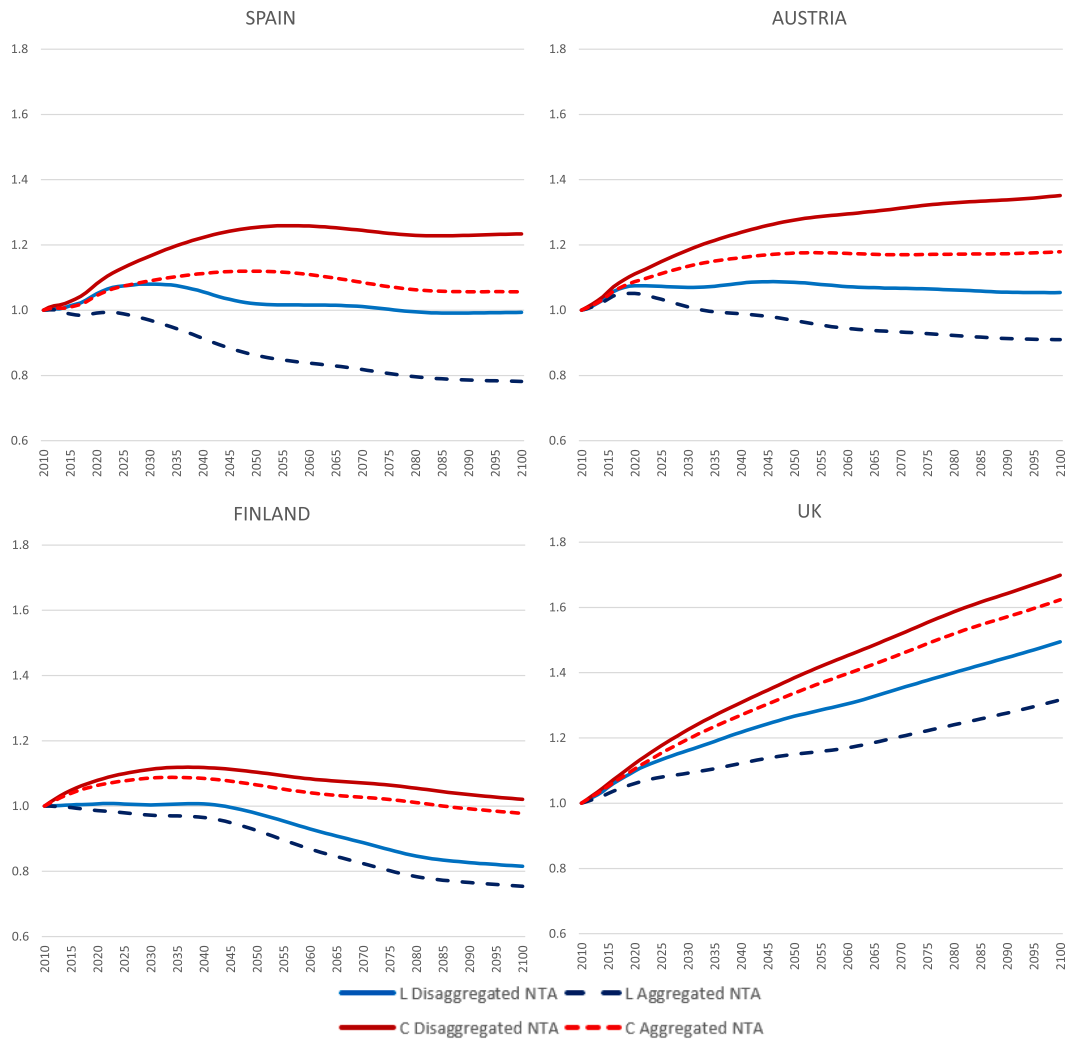

Fig. 4. Projected evolution of effective Labor (*L*) and effective Consumers (*C*), (2010 = 1). Note: Results based on NTA profiles by age, sex, education, and family type ("disaggregated") as available in Abio et al. (2021), compared to outcomes based on NTA by age and sex ("aggregated") from the AGENTA project (http://www.agenta-project.eu/en/dataexplorer.htm, accessed December 2021). Source: Authors' calculations using microWELT.

demographic trends, effective labor decreases in these three countries (especially Finland and Spain), while it only grows in the UK (thanks to its population increase). When using NTA profiles further disaggregated by level of education and family type, the negative evolution of *L* is softened. The main reason is that considering the positive effect of the education and other composition effects mitigates the decrease in effective producers. An increase in *L* is observed for some years at the beginning of the projection in Spain and Austria. In Finland, it remains constant, initiating the decrease much later, finishing the projection with a level of effective labor below the initial one. In the UK, accounting for composition effects produces an even higher increase in effective producers than observed with aggregated NTA profiles.

Concerning effective consumers, the aging process leads to significant growth in the UK, while in Austria, the increase is moderate and disappears starting from 2050. Spain and Finland also show an initial increase, which later stops and reverses (from 2050 in Spain; 2035 in Finland). Finland ends the projection period with a level of effective consumption even below the initial value. When NTA profiles are further disaggregated by level of education and family type, the composition effects accentuate the positive evolution in the UK and moderate the negative trend in Finland. However, the most considerable effects are observed in Austria and Spain.

The difference between effective consumption using aggregated and disaggregated NTA data is smaller than that observed for effective producers. This is so even though consumption affects a broader population than labor income (each individual consumes, but only working-age individuals produce). The reason is the smaller differences in consumption between different groups of people compared to the differences in labor income profiles (see Fig. A.1 in the appendix). Overall, the effects of (not) ignoring composition effects are considerable: e.g., for Spain, changes in effective consumers and effective producers more than double when basing the calculation on disaggregated NTA.

Fig. 5 shows the projected evolution of the ESR in each country, obtained by dividing effective producers by effective consumers. Again, the results obtained with disaggregated NTA (by age, sex, level of education, and family type) are presented against those resulting from standard NTA profiles (only by age and sex). Additionally, the pure DSR (the quotient between population aged 18–64 and total population) is provided to obtain an isolated measure of the impact of aging.

Fig. 5 reveals several findings. First, the evolution of all the measures is clearly negative, especially during the first half of the projection period. That is, the impact of aging on sustainability is significant. Second, purely demographic measures like the DSR, obtained in this study do not adequately capture the actual impact of aging. Our results show that the expected evolution of the DSR is less negative than the evolution of the ESR, which considers the production capacity and the

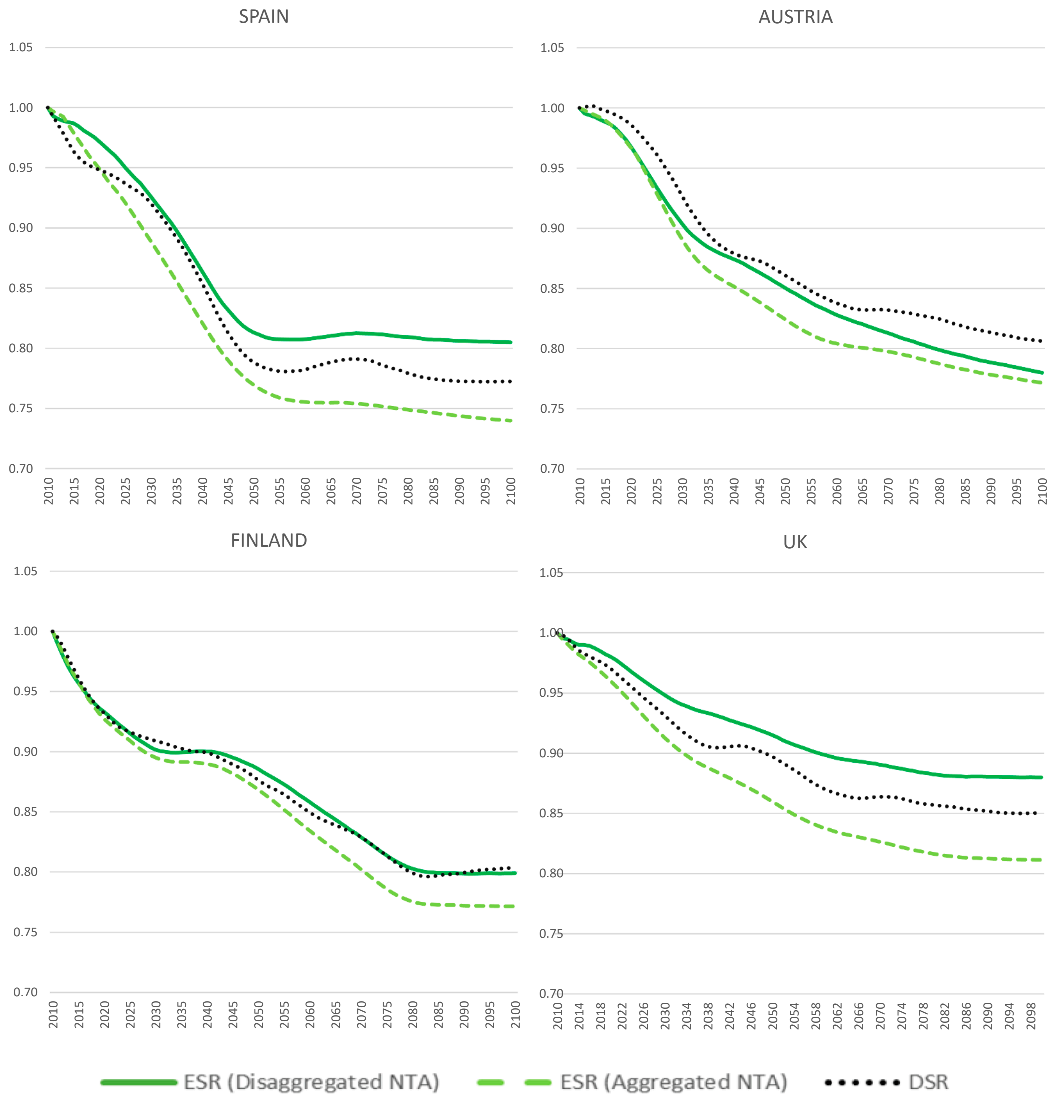

Fig. 5. Projected evolution of the support ratio (2010 = 1). Note: Results based on NTA profiles by age, sex, education, and family type ("disaggregated") as available in Abio et al. (2021), compared to outcomes based on NTA by age and sex ("aggregated") from the AGENTA project (http://www.agenta-project.eu/en/dataexplorer.htm, accessed December 2021). The demographic support ratio is obtained by dividing the population 18–64 by the total population. ESR stands for Economic Support Ratio and DSR for Demographic Support Ratio. Source: Authors' calculations using microWELT.

effective consumption needs in each country according to NTA profiles. Aggregate results are in line with previous findings in NTA literature, which has promoted the ESR as a more realistic indicator of the effect of population aging compared to purely demographic measures based on the relation of age groups. For example, Prskawetz and Sambt (2014) found that, in Europe, the ESR gives a more dramatic outlook than purely demographic measures. However, our analysis reveals that results can reverse when accounting for additional composition effects. As pointed out by Rentería et al. (2016), aggregate NTA ignore improvements in human capital by not considering differences in consumption and production by the level of education, together with the education expansion.

When using disaggregated NTA, accounting for the effects of education and family structure, we find that the evolution of the ESR significantly improves. In particular, in Spain and the UK, the evolution of the disaggregated ESR is more favorable than that observed for the pure DSR. In the case of Finland, it is very close, while in Austria, it remains lower, although, in both cases, it clearly improves regarding the ESR computed with aggregated profiles. The differences in the education transition path shown in Fig. 1 above and the differences in consumption and income age profiles (shown in the appendix) explain these results. More specifically, Fig. 6 summarizes the differences in labor income profiles by educational level in the four countries.

The extent of the educational transition is substantial in Spain, increasing the proportion of the highly educated at the expense of the low educated. In Austria, there is also a sizeable change, but it is mainly from medium to high educated, where the gain in terms of labor income is more limited. In the case of the UK, the transition is not strong, but the income differentials are high, which explains the distance between the results obtained with aggregated and disaggregated NTA. Finally, in Finland, neither the transition nor the income differentials are strong, so there are no sizeable differences.

The education expansion is the primary explanation for the observed differences in the two estimations of the ESR, but changes in family structures also have some influence. Over the last few decades, the average household size has declined across Europe. For instance, in Austria, from 2.9 members in 1971 to 2.3 in 2010 (UN, 2019). Simultaneously, the share of one-person households has significantly increased in European countries, although differences remain between the North and the South. In 2010, one-person households represented

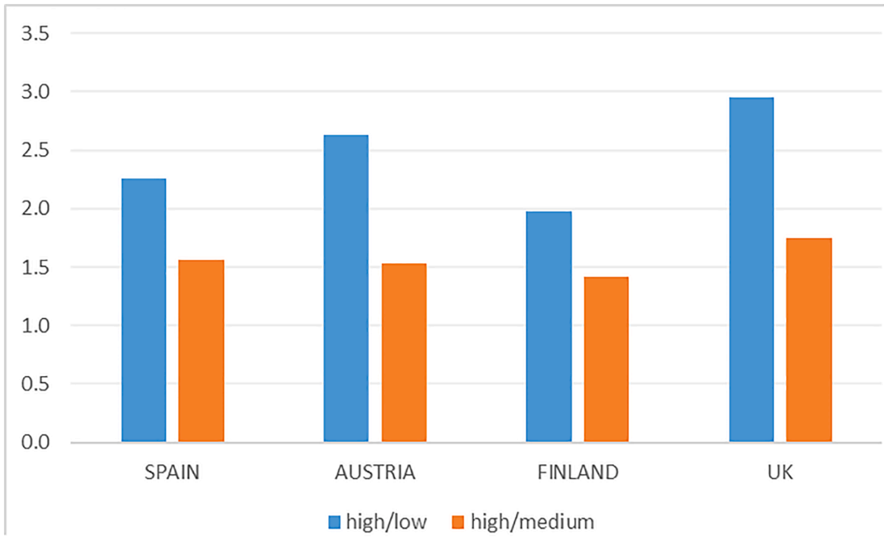

Fig. 6. Labor income differentials between education levels in the base year. Note: Ratio of the per capita average labor income of the high educated with respect to the low (high/low) and to the medium (high/medium) educated. Source: Authors' calculations based on NTA profiles by age, sex, education, and family type available from Abio et al. (2021).

Table 1
Economic Support Ratio (ESR) and Demographic Support Ratio (DSR) in 2010 and 2100.

		SPAIN	AUSTRIA	FINLAND	UK
2010	ESR	83.9%	88.5%	82.3%	77.6%
	DSR	65.9%	64.3%	63.1%	62.8%
2100	ESR (aggregated)	62.1%	68.3%	63.5%	62.9%
	ESR (disaggregated)	67.0%	68.4%	65.4%	67.6%
	DSR	50.9%	51.9%	50.7%	53.4%

Source: Authors' calculations using microWELT.

41% of households in Finland, 36% in Austria, and 31% in the UK, while only 23% in Spain. The decrease in household size continues in our projection, affecting economies of scale at the household level. The average number of children per family decreases by 14% in Finland, 11% in Spain, 10% in Austria, and 6% in the UK from the base year (2010) to the end of the projection period (2100). In addition, the average number of children per parent also falls.

These changes have an impact on the ESR. As detailed in Abio et al. (2021), disaggregated profiles by parenthood and partnership status reveal that parents have lower consumption than childless individuals, a pattern that is common in the four countries which is related to the presence of economies of scale at the household level. At the same time, labor income is higher for men in a couple, although this is not necessarily true for women. Besides, parents have a lower labor income at young ages but a higher labor income at older ages, as compared to childless individuals. All these patterns interact with the education transition affecting the evolution of the ESR. In general, the influence of family composition is more complex and it is not as strong as the effect of the education transition.

To complete the information given by Fig. 5, Table 1 collects the initial values of the ESR (using both aggregated and disaggregated NTA profiles) and the DSR, as well as the values expected by the end of the projection. From Table 1, we can observe that the four countries start from relatively different positions to face the aging process, the UK being the worst situated (in terms of both ESR and the purely DSR). By contrast, Austria (in terms of ESR) and Spain (in terms of DSR) depart from the best situation, the latter probably due to its delayed baby boom. However, by the end of the projection period, the UK becomes the least affected when looking at the pure DSR (thanks to its smoother aging process because of its high fertility rate), while Austria presents the highest ESR. Spain and Finland show the lowest DSR due to their low fertility rates, and in the case of the latter, also low immigration. Interestingly, no relevant differences are found for Austria when accounting for the composition effects linked to education and family structure which, in turn, become crucial in the UK and even more so in Spain.

As a tool for comparative studies supporting a longitudinal perspective, microWELT projections account for longevity differentials by education. Two what-if scenarios were created to assess to what extent such detail affects summary measures such as the ESR. The first one eliminates differences in mortality rates by level of education. This scenario does not affect overall age-specific mortality but affects who dies at a given age and sex. Hence, it ignores the fact that high-educated people, on average, not only consume more but also live longer. In a second scenario, fertility differentials by level of education are switched off. In this way, the effect of the differences in the distribution of family sizes by education (the concentration of reproduction; see Spielauer, 2005; Shkolnikov et al., 2004) on the ESR is studied. While microWELT accounts for differences in timing and quantum of fertility by education, in this scenario, the assumption is a low concentration of reproduction, setting childlessness to a very low level (5%) regardless of education, and applying the same fertility patterns to all education groups. This scenario does not affect overall age-specific fertility rates but distributes children more evenly among women.

Results of both what-if scenarios compared to the base scenario using disaggregated NTA profiles are depicted in Fig. 7. Specifically, it displays the evolution (2010 = 1) of the ESR projected in the base scenario versus that obtained without mortality differentials by education and with the same concentration of reproduction for all education groups. The observed effects are limited in both cases since total mortality and fertility are kept in line with the baseline population projections but still noteworthy. As expected, ignoring longevity differentials would lead to a smaller decline in the ESR in all four countries. High-educated individuals tend to live longer and consume for a more extended period. When longevity differences by education are not considered, effective consumption decreases and ESR increases. The effect of the concentration of reproduction is of comparable magnitude or even lower. However, in the case of Austria and the UK (and Spain from 2020), it goes in the opposite direction. By eliminating fertility differences between education groups, high-educated women will have more children

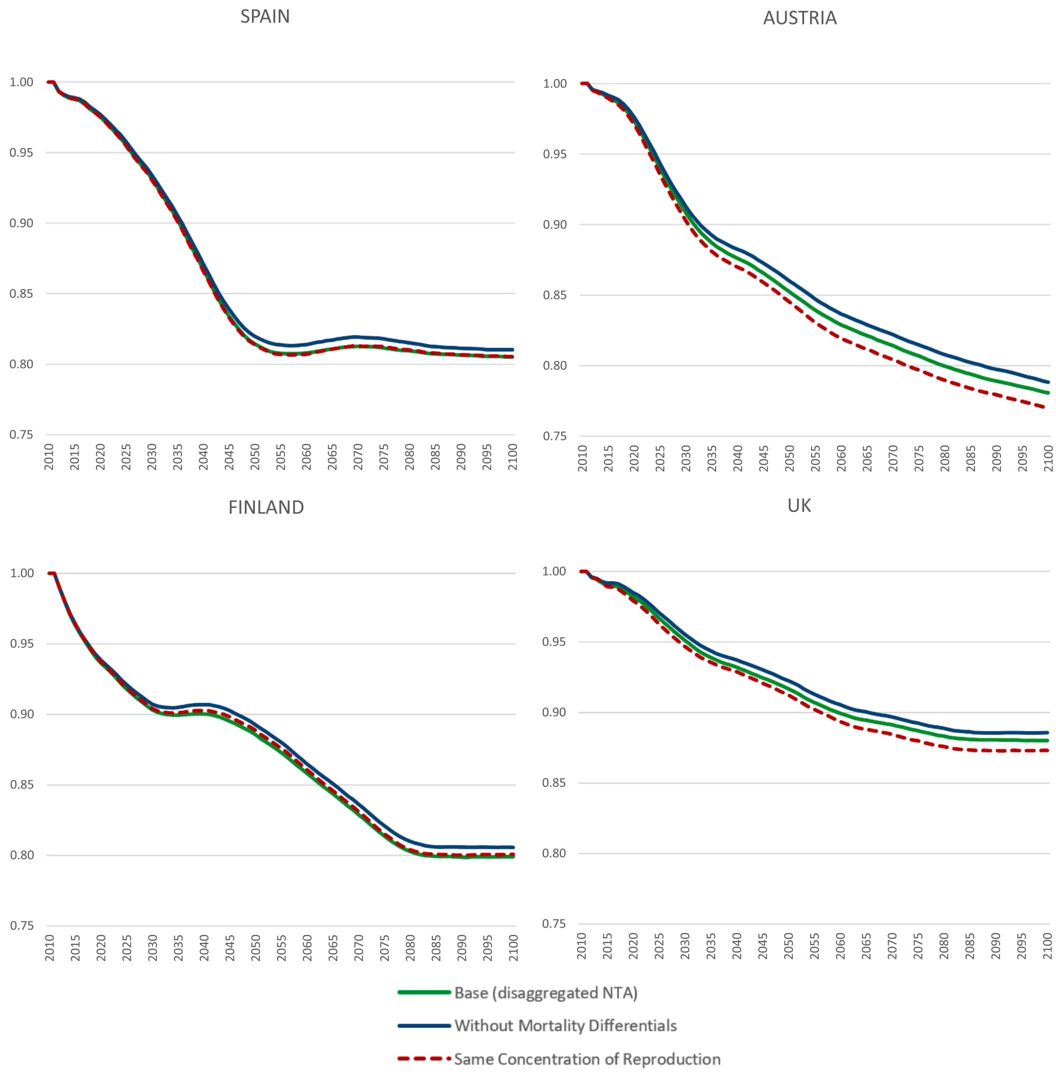

Fig. 7. The effect of mortality and fertility differentials on the Support Ratio. Evolution of the enriched ESR (2010 = 1). Source: Authors' calculations using microWELT.

(increasing also education consumption) and less income. The opposite will occur for the low educated group. The final effect on the ESR depends on the strength of those effects in each country. Except in Finland where the fertility gradient is inverted (see Fig. 2a), the ESR slightly reduces as compared to the base scenario. The simulation shows that the size of the effect is most extensive in Austria because of high differences in childlessness by education level and the UK because of the importance of private education expenditure.

The sustainability of public and private transfers

The ESR gives information about the sustainability of the economy as a whole, considering both production (labor income) and consumption, while the system of transfers to reallocate resources among ages is only implicitly reflected in public consumption. Using the information provided by the NTA, we can derive a Fiscal Support Ratio (see, e.g., Lee et al., 2014), which is defined as the ratio between the public transfers that individuals pay to and receive from the government (TGO or TGI, respectively, in NTA terminology).[21] Fig. 8 displays the evolution of this indicator over the projection period, obtained with both standard NTA profiles (aggregated) and further disaggregated by education and family type (disaggregated). As in the case of the ESR, the evolution of the aggregate figure mainly shows the demographic evolution that leads to more than a 20% decrease, except for the UK. In addition, the composition effects captured when considering changes in education and family type significantly improve the evolution of the public transfer system's sustainability indicator. The clearest case is Spain where, after a first period of decreasing (to a lower extent than the aggregated

[21] Public transfer inflows (TGI) include both cash (e.g. public pensions) and in-kind transfers received by individuals from the government (consisting of public individual consumption like public health and education, and collective consumption expenditure like street lighting). Public transfer outflows (TGO) include taxes, social contributions and other revenues paid by the private sector to the government. See UN (2013) for more details.

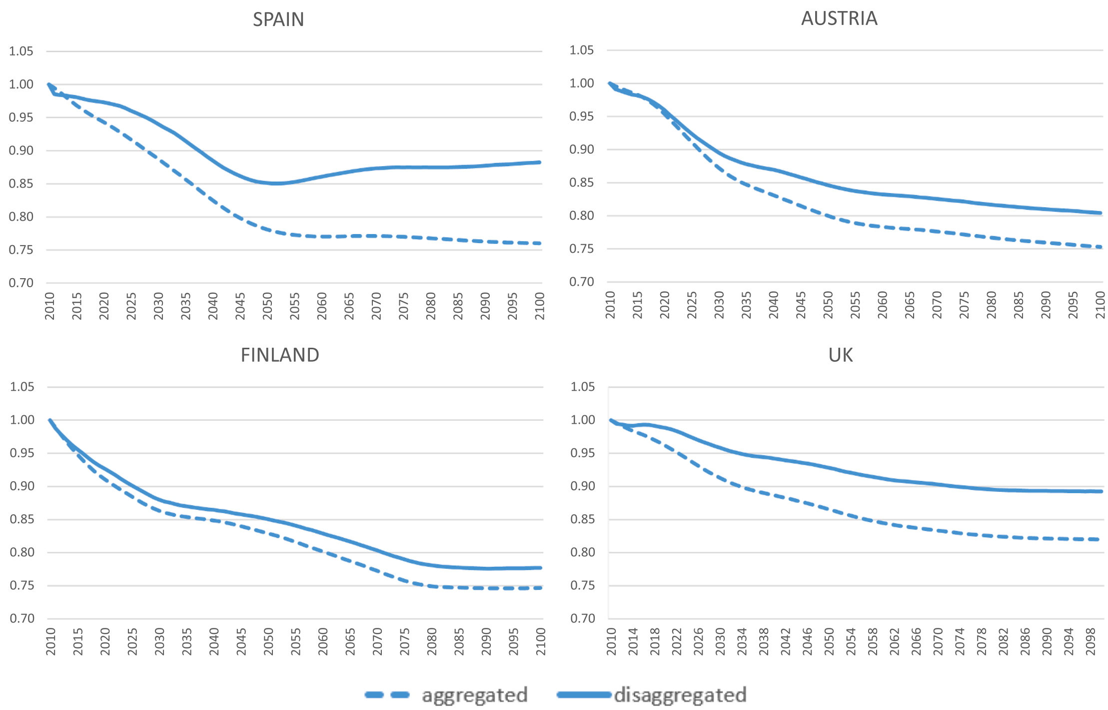

Fig. 8. Sustainability of public transfers. Evolution of the Fiscal Support Ratio (2010 = 1). Note: Fiscal Support Ratio of the public finances, obtained as the ratio between public transfers paid by individuals to the public sector (TGO) and public transfers paid by the public sector to individuals (TGI). Results obtained using aggregated NTA (by age and sex) from AGENTA project (http://www.agenta-project.eu/en/dataexplorer.htm, accessed December 2021) and disaggregated NTA (by, age, sex, level of education and family type) from Abio et al. (2021). Source: Authors' calculations using microWELT.

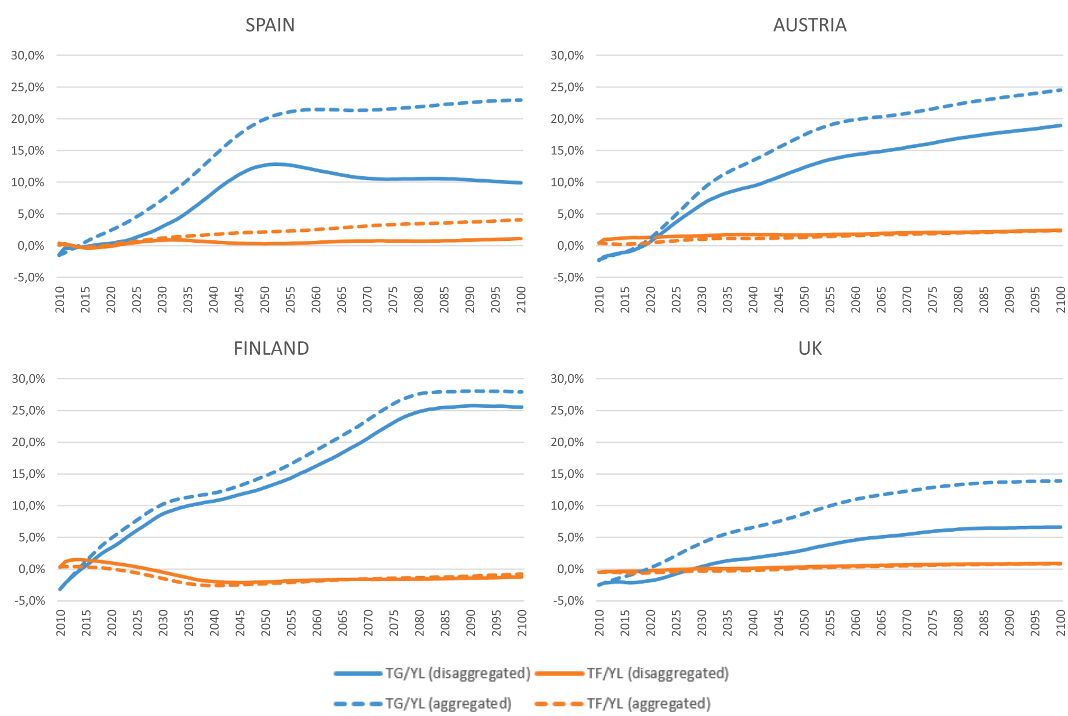

Fig. 9. Evolution of net public (TG) and private (TF) transfers, as share of labor income (YL). Source: Authors' calculations using microWELT.

figure), it starts to increase from 2050 on, to end at around 90% of its initial value (while near 75% when aggregated profiles are used). Differences are smaller in the other countries but still sizeable.

The difference in the evolution of the aggregated and disaggregated Fiscal Support Ratio (FSR) mainly comes from the education transition. There are two effects that our enriched indicator based on disaggregated NTA can capture due to the change in the educational composition of the population. The first is on taxes paid: higher educated people pay more taxes throughout their lives as they have higher incomes and consume more; the second is on transfers received: there is not much difference in

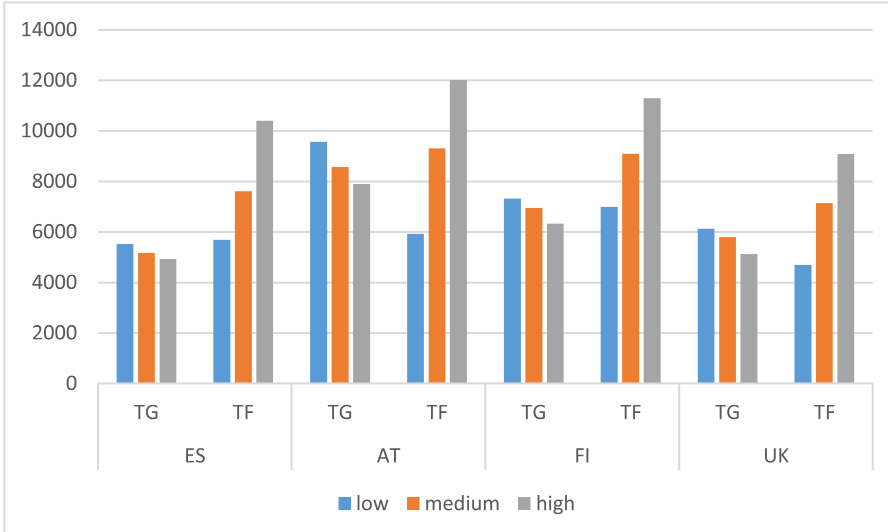

Fig. 10. Net Private (TF) and Public (TG) transfers as a share of total consumption (C) for ages 0–24 according to parents' level of education (in € per capita). Source: Authors' calculations using microWELT.

public transfer inflows at childhood and working ages by education level, but there is at old age: higher educated people receive higher pension benefits from the public pension system. The first effect increases the numerator of the FSR while the second effect increases the denominator, although the latter change is smaller as it is concentrated at the retiring phase of the life cycle. Hence the impact on the size of effective beneficiaries is smaller than the change in the size of effective taxpayers, increasing the FSR. The largest difference is in Spain and the lowest in Finland, in line with the extent of the education transition shown in Fig. 1.

Together with the public transfer system, families also play a crucial role in individuals' wellbeing. One of the main contributions of NTA data is precisely that they provide a measure of the private transfers taking place in the economy at a given moment. Our projection model, as based on NTA profiles for the base year, also allows us to investigate the role of private transfers in the future, i.e., to what extent private transfer inflows and outflows are balanced in the face of a change in population age structure.[22] In this case, inflows and outflows cannot be isolated, as they were not published in the AGENTA profiles used to validate the model. Hence, we derive an additional sustainability indicator relating total net transfers to total labor income, so as to reflect the payment capacity and to ease cross-country comparability. In order to put private transfers into perspective, we compute this indicator for both public and private transfers.

Fig. 9 displays the evolution of these indicators in each country over the projection period. Both indicators (especially in the case of private transfers) start from values near zero, although their projected evolution is very different.[23] Without considering any adjustment to balance budgets, public transfers significantly increase over the projection period in all four countries, especially Finland, showing the impact of aging and the bigger size of the welfare state. In line with what was observed in Fig. 8, using disaggregated NTA profiles moderate the evolution of the projected indicator. The education transition lowers net public transfers because taxes paid by higher educated individuals increase more than the transfers they receive from the public sector. The size of the difference between the results obtained using aggregated and disaggregated NTA profiles is proportional to the importance of the education transition projected in each country.

With respect to private transfers, however, the projection does not show significant changes from the initial situation. There are several differences between public and private transfers that explain this. The main reason is that the profile of private transfers is near zero for the elderly in all the countries analyzed and hence they are not affected by aging. In addition, the nature of public and private transfers is very different, and this implies an inverse education gradient. Fig. 10 shows the share of consumption financed by net public (TG) or private (TF) transfers for the population aged 0–24 by education level. As expected, public transfers act as an intragenerational redistribution tool and, hence, are lower the higher the education level. Nevertheless, the opposite occurs in the case of private transfers.

Another reason is that, except for migrant remittances, family transfers are necessarily balanced in the base year for each family (if one member receives, another one has to give) and hence at the aggregate level. But still some imbalance arises during the status quo projection due to changes in family structure and the educational and demographic transitions. Looking at the results using aggregate NTA profiles, the most remarkable increase is observed in Spain, where the projection leads to almost 5% of net private transfers as a share of labor income. This is due to a more pronounced change in the population age composition in this country. In Finland the ratio decreases for a long period of time and even becomes negative, due to the decrease in population, especially children and the young (those who are net receivers of private transfers). These trends are in line with what we observe in the population projections in Fig. 3, where the number of births decline in Spain, and specially in Finland. The fertility decline eventually leads to a decrease in the working age population and consequently in labor income, the denominator of the indicator in Fig. 9.

The divergences between aggregated and disaggregated figures result from changes affecting both the numerator and the denominator of the ratio. The education transition has opposite effects on private transfer inflows for children and outflows for parents (as children receive higher transfers from their more educated parents). This has an ambiguous effect on the numerator, which is also affected by changes in

[22] Private transfers include both inter-household and intra-household transfers, excluding bequests but including the private transfers from and to the rest of the world. See UN (2013) for further details.

[23] Private transfers tend to be zero on aggregate except for the flow of migrant remittances. Hence, the initial value corresponds to the balance with the rest of the world. In the case of public transfers it also includes the imbalance between inflows and actual outflows (taxes and other revenues), a balancing item known as "transfer deficit" in NTA.

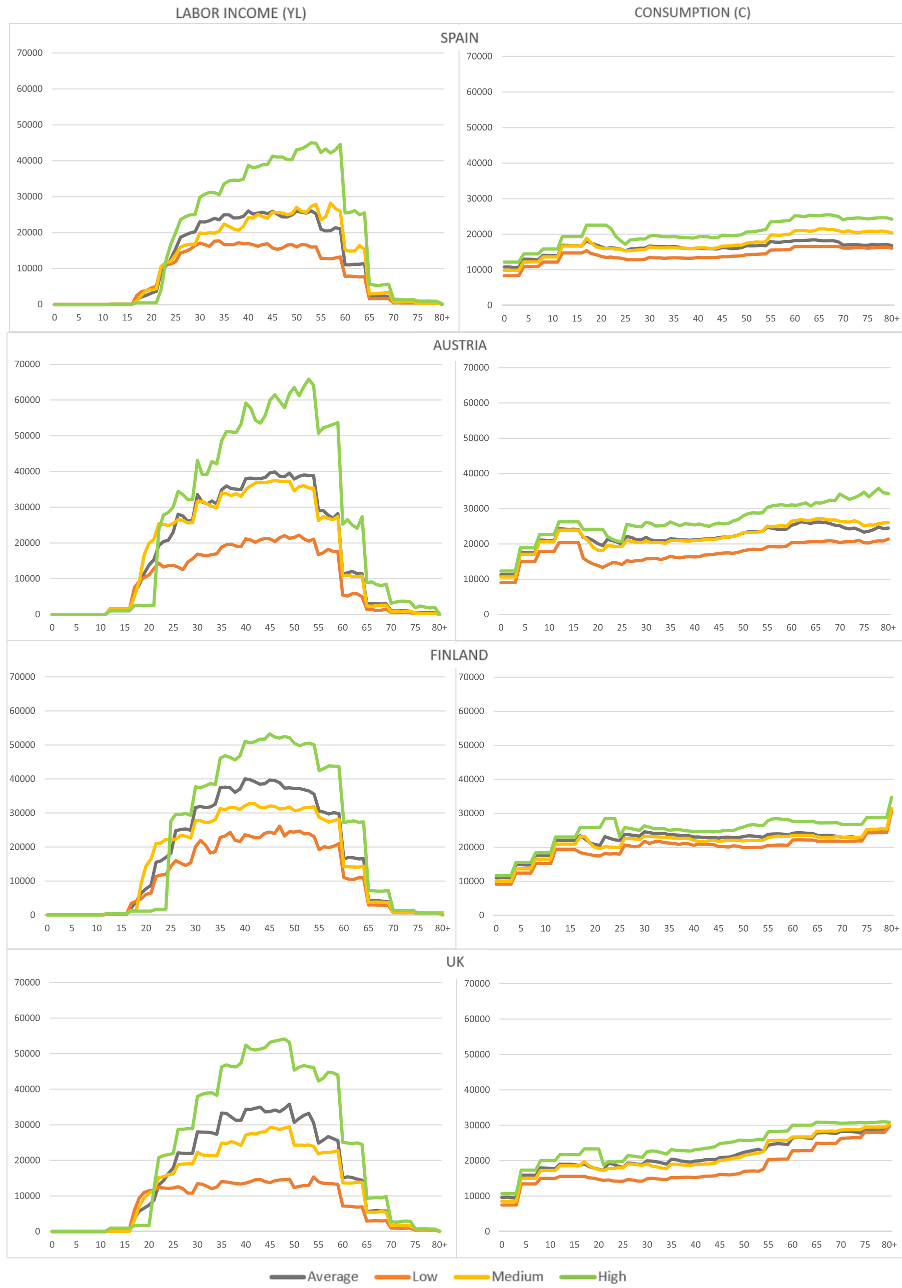

Fig. A.1. NTA age profiles of labor income (YL) and consumption (C) by level of education (low, medium and high). Source: Reproduced from Abio et al. (2021).

the number of children. At the same time, the changes in the composition of labor income due to the education transition affect the denominator. All these effects result in a better balance in the case of Spain for the whole period, being only slightly affected in the other countries.

Overall, our results show that the education transition and changes in family structure tend to mitigate the impact of aging on the public sector, while the opposite can happen in the case of private transfers, although to a smaller extent.

Summary and conclusions

This paper combines disaggregated National Transfer Accounts (NTA) estimates with dynamic microsimulation techniques to capture the interaction among economic, demographic, and policy variables, all linked through education as one of the main socio-economic characteristics of individuals. The resulting model, microWELT, is the first dynamic microsimulation application that incorporates the accounting logic of the NTA method and thus explicitly accounts for how agents rely on public and private transfers over their lifecycle, also as family members.

MicroWELT models the major lifetime transitions at the individual level, starting with education, influencing all subsequent life events (emancipation, fertility, partnership formation, and death). The model incorporates NTA estimates by age and gender, further disaggregated by level of education and family type. As a result, the microWELT projection scenarios reflect not only the effects of aging, but also those of educational improvements and corresponding changes in family structure. In addition, to analyze the potential impact of welfare state designs, the analysis was conducted for four European countries, representative of the four welfare models: Austria (Continental), Finland (Nordic), Spain (Mediterranean), and the UK (Anglo-Saxon).

This simulation strategy allows us to build enriched sustainability

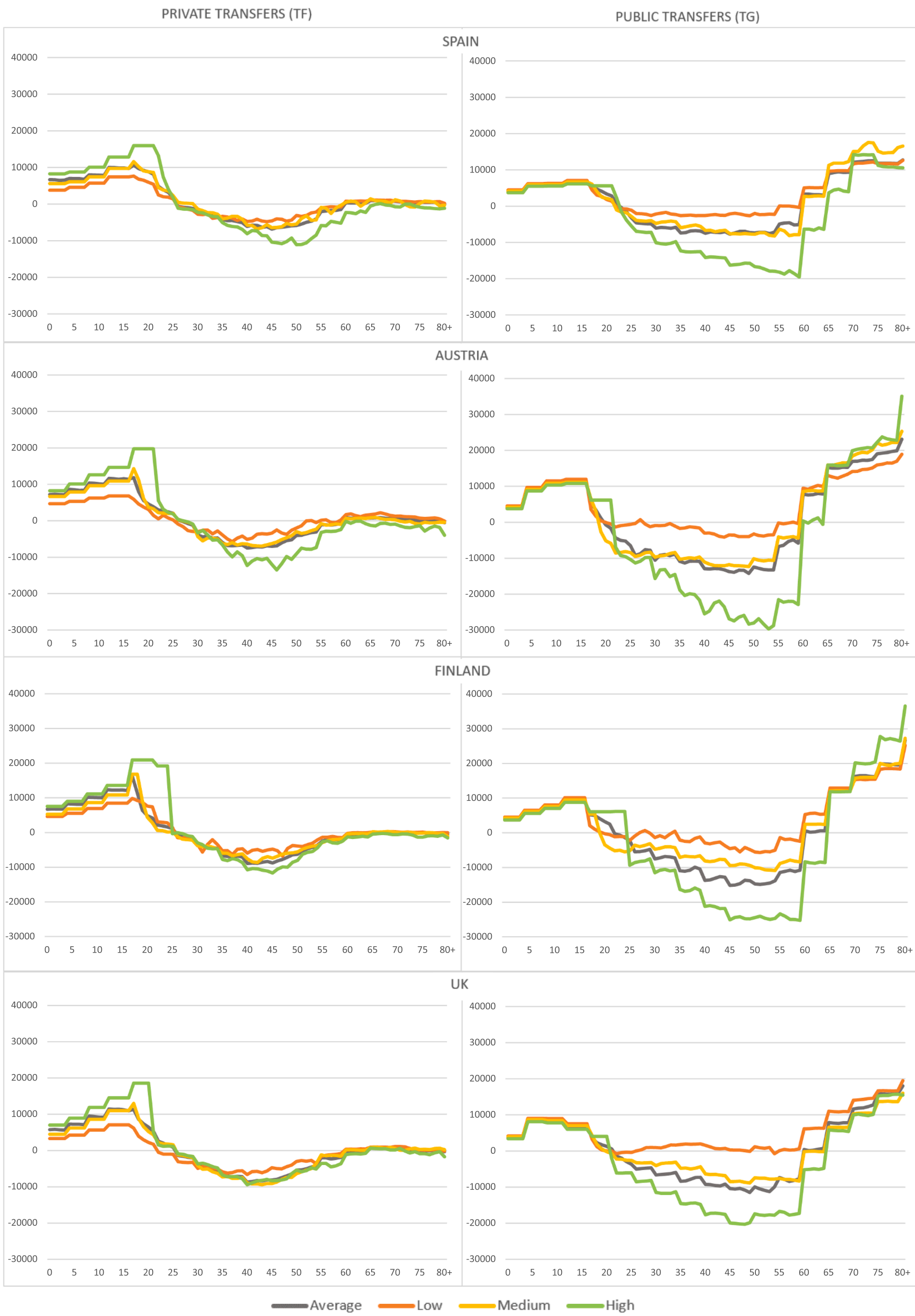

Fig. A.2. NTA age profiles of net private (TF) and public (TG) transfers by level of education (low, medium and high). Note: Values correspond to year 2010, and are expressed in annual euros (per capita). Source: Reproduced from Abio et al. (2021).

indicators in the NTA tradition and to compare them with those coming from standard NTA estimates by age and sex, revealing important composition effects.

First, we obtain an enriched Economic Support Ratio (ESR). As in the previous literature, we find that the ESR (relating total labor income and consumption) declines more than the pure Demographic Support Ratio (DSR). However, we also find that composition effects due to the educational transition and changes in family size work in the opposite direction over time, compensating or even reversing the difference in the evolution of ESR and DSR. By applying enriched ESR, this difference is offset in the case of Finland and even reversed in the case of Spain and the UK. These results can be explained by several factors that affect each

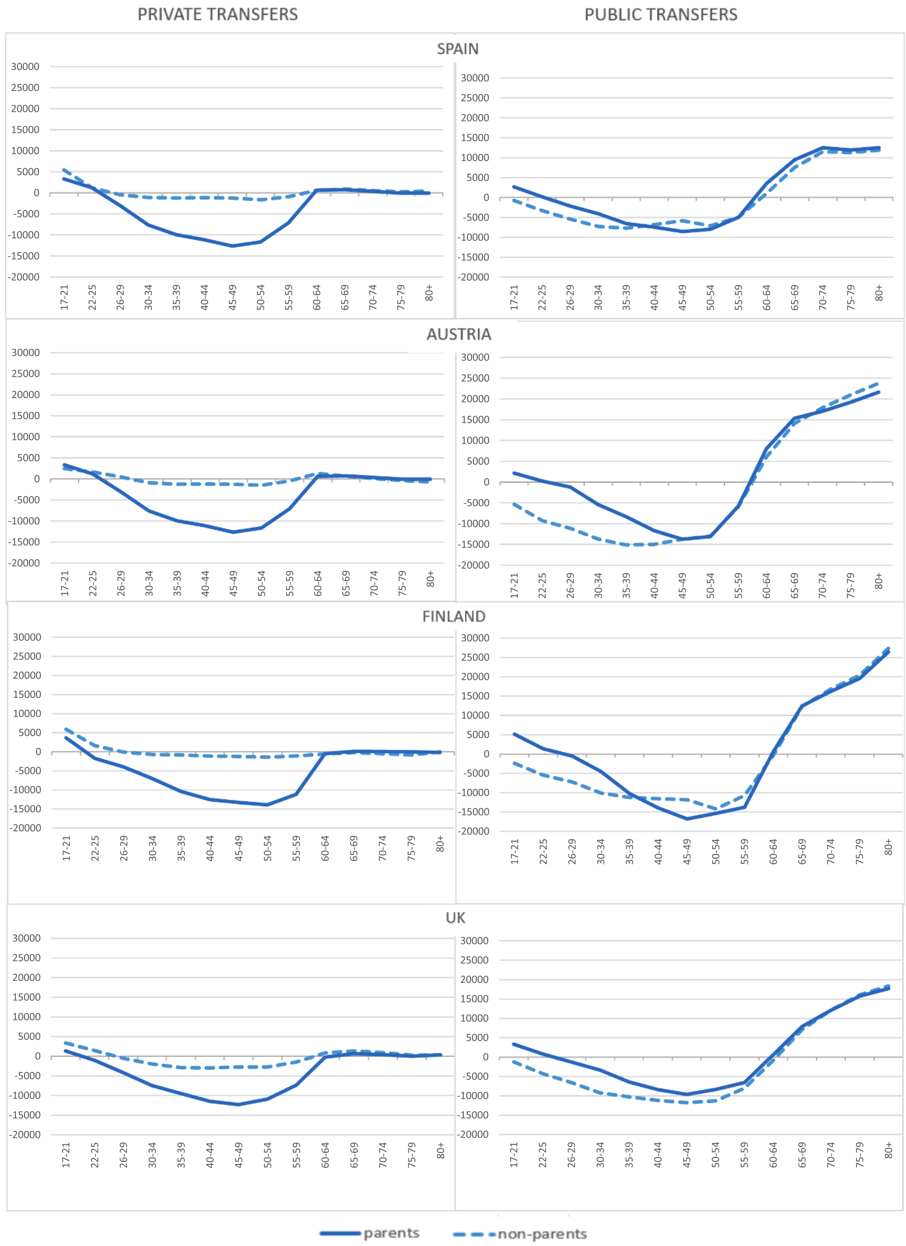

Fig. A.3. NTA age profiles of private (TF) and public (TG) transfers by parenthood status. Note: Values correspond to year 2010, and are expressed in annual euros (per capita). Source: Reproduced from Abio et al. (2021).

country differently. Spain experiences the strongest aging process in this period. It starts with the highest DSR, reflecting a delayed baby boom, and experiences the sharpest declines, down to a value close to the lowest exhibited by Finland, with the sharpest decline in household size. This is partially offset, however, by substantial improvements in education, reducing, in particular, the share of individuals with low levels of education, where the potential gains in labour income are higher. In Austria the demographic prospects are not as negative, but they are not offset by the educational transition (concentrated in an increase in the highly educated at the expense of the medium educated). Finland is characterized by a negative demographic evolution with little potential for improvement in education, and a strong role of the welfare state. Finally, the UK experiences the best demographic prospects, but little room for educational improvements. In this case, the potential gains are due to the large differences in labor income by level of education.

Second, by taking advantage of the NTA approach, we also build indicators of the sustainability of public and private transfers. We calculate the public sector Fiscal Support Ratio as the ratio of public transfer outflows (taxes and contributions) to public sector inflows (mainly transfers), excluding adjustments needed to keep public budgets balanced during the projection. Our results show that the composition effects identified above also improve the sustainability of public finances, with the strongest effect in Spain and the lowest in Finland. Finally, to capture the sustainability of private transfers, we derive an additional indicator that relates total private net transfers to total labor income (reflecting the families' payment capacity). While public transfers are strongly affected by the aging process, private transfers do not show significant changes from the initial situation. The main reason is that the profile of private transfers for the elderly is near zero, and hence they are not affected by aging. Total family transfers are necessarily balanced at the beginning. However, some imbalance still arises during the projection because of changes in family structure (like the reduction in the average number of children) and the educational transition. The latter has opposite effects on private transfer inflows for children and outflows for parents. It also has different effects on public and private transfers. The reason is that private transfers increase with the level of education, while the opposite happens with public transfers (which act as an intragenerational redistributive instrument, being lower the higher the level of education). The fact that the effects of educational expansion are opposite for public and private transfers explains why the educational transition and changes in family structure tend to reduce the effects of aging on the public sector, while the opposite may be true for private transfers.

Overall, our results suggest that disaggregated NTA indicators offer interesting insights into the effects of the demographic transition by highlighting sociodemographic trends, such as educational improvements, that may counteract negative effects. By looking at public and private transfers together, this paper also provides a more comprehensive view of the sustainability of the intergenerational transfer system.

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CRediT authorship contribution statement

Martin Spielauer: Conceptualization, Data curation, Methodology, Software, Formal analysis, Investigation, Supervision, Visualization, Resources, Validation, Writing – original draft, Writing – review & editing. **Thomas Horvath:** Conceptualization, Data curation, Methodology, Software, Formal analysis, Visualization. **Marian Fink:** Conceptualization, Data curation, Methodology, Software, Formal analysis, Investigation, Visualization, Validation. **Gemma Abio:** Conceptualization, Data curation, Methodology, Software, Formal analysis, Investigation, Visualization, Validation, Writing – review & editing. **Guadalupe Souto:** Conceptualization, Data curation, Methodology, Software, Formal analysis, Investigation, Visualization, Validation, Writing – original draft, Writing – review & editing. **Ció Patxot:** Conceptualization, Methodology, Funding acquisition, Formal analysis, Investigation, Supervision, Visualization, Project administration, Resources, Validation, Writing – original draft, Writing – review & editing. **Tanja Istenič:** Conceptualization, Data curation, Methodology, Software, Formal analysis, Investigation, Visualization, Validation, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix: Disaggregated NTA profiles by age, sex, level of education and family type

microWELT implements a parallel parameterization of NTA variables by three levels of disaggregation: the initial one by age, by age and sex, and by age, sex, education and family type. To that end, the age profiles previously obtained in AGENTA project (by sex) and in Abio et al. (2021) (by sex, level of education and family type) are used. In both cases, they refer to 2010, which is also the base year in our projection exercise. Below, we show the main age profiles obtained by Abio et al. (2021), both by level of education (distinguishing three levels) and by parenthood status (differentiating between those individuals who are parents and those who are not).

Fig. A.1 shows the NTA age profiles introduced in microWELT to analyze economic sustainability (labor income and total consumption) disaggregated by education level (for children and students up to 25, education refers to parents' education). Labor income profiles show the typical inverted U-shape, with income concentrated in working ages. The high educated reach higher incomes, especially later in their working career, and work until older ages. At the peak, the high education group's average labor income is much higher than for the low educated. The average income for ages 30 to 49 is 3.5 times higher at the high-education level for the UK, while it is 2.7, 2.2 and 2.1 higher in Austria, Spain and Finland, respectively.

Consumption age profiles are much smoother than labor income. Moreover, the differences between education groups are smaller, especially in Finland. The UK consumption profiles seem to converge at the end of life, but this is because the education level cannot be appropriately identified in the consumption survey. Consumption profiles are flatter when using aggregate NTA data, whereas the consumption profiles disaggregated by education indicate different patterns. This is a consequence of the different educational compositions in the various age groups and illustrates one of the problems in applying the current aggregated cross-sectional profiles in the future.

Fig. A.2 displays the age profiles for public and private transfers, also distinguished by level of education. Differences are especially important in the case of public transfers for working ages, when the most educated contribute significantly more to the public coffers than the less educated. In the UK, the low educated are even net receivers of public transfers over most of their working-age period. However, during childhood and old age, differences among the three levels of education are much lower. In the case of private transfers, it is observed that they mainly flow from parents (of working age) to their children, while they remain near zero for the elderly, whatever their level of education. Children (especially until age 20) in high-educated families receive significantly more private transfers than the less educated.

Finally, Fig. A.3 shows the age profiles of net public and private transfers received by individuals, distinguishing between parents and non-parents. As expected, it is in the private transfers where the main differences between parents and childless individuals are observed. Parents need to transfer part of the resources they obtain to their children, while this is not the case of non-parents. From age 60–65 on, however, when children are emancipated, net private transfers become practically zero. The pattern is almost identical in all four countries. With respect to public transfers, they become especially important from age 60 on (with retirement) while, during working ages, both parents and non-parents are net contributors to public coffers. The main differences between parents and non-parents occur during young ages, when childless individuals tend to contribute more than parents.

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