The impact of the demographic, green and digital transformation on economic and health inequalities in five European countries: A microsimulation study.

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Long abstract

The paper examines the impact of the major demographic, macroeconomic (green transition) and technological (digital transition) shocks on the future of regional labour markets in five European economies (United Kingdom, Italy, Poland, Hungary and Greece), characterised by different economic models and welfare regimes.

To this aim, we build on an innovative micro-analytical framework to project individual life course trajectories. The framework, originally developed for the UK (Bronka et al., 2025), is applied to four EU countries, and extended to include regional disaggregation at the NUTS-3 level and incorporation of macroeconomic scenarios derived from a dynamic input-output macro model. This allows us to shed new light on the distributional impact of the ongoing economic and social transformations, beyond the broad picture and simplifying assumptions made in standard macro approaches. Further, our dynamic framework integrates in every simulated period inputs from a static tax-benefit model (EUROMOD for the EU countries, UKMOD for the UK; see van de Ven et al., 2023), permitting analyses of the short-, medium- and long-run effects of fiscal policies.

Value added

The advantages of our micro-analytical approach are manyfold:

- Modelling not only what happens to regions, but also what happens inside regions. Our framework fully takes into account the heterogeneity of the population within and between regions, focussing on correlation between individual risks, characterising vulnerable segments of the population, modelling to a fine level of detail the effects of policies, identifying stress areas for public budgets and challenges to regional labour markets, such as those coming from population ageing, human capital accumulation and human capital mobility, including processes of brain drain.
- Reconstructing regional dynamics from the bottom up. Starting from individual life course experiences, we can aggregate at any meso- or macro- level of interest. As an

example, our framework allows us to focus and shed more nuanced light on the core-periphery and urban-rural dynamics, which are essential to regional labour market dynamics.

- Constructing policy counterfactuals. Our integrated tax-benefit / dynamic model permits testing the short-, medium- and long-run effects of existing and counterfactual social protection policies, from universal basic income schemes to new carbon-neutral policies. Our modelling approach extends the power of tax-benefit models to the next level, by considering longer time horizons to assess the distributional and budgetary effects of policies and policy changes. Considering the role of policies is important not only because they directly affect individual welfare, but also because they affect individual choices, for instance with respect to labour supply, which, in turn, has direct consequences on regional labour markets. Crucially, since tax-benefit systems operate at the individual and household level, considering them in a less than highly stylised and superficial way requires a model that has individuals and households in it, as in our framework.
- Another advantage of the approach is the inclusion of health and family dynamics as drivers of labour market outcomes. This is particularly relevant in the context of rapid population ageing and decreasing fertility. Our framework maintains family linkages, permitting consideration of care duties to elderly relatives – possibly challenging the continuation of the current trend towards increasing female labour market participation. Health and family dynamics co-evolve with labour market outcomes, and the model is able to take into account the feedback between these three different life domains. Demographic change suggests that the interplay between socio-economic and health inequalities will become increasingly important in the years to come. On the one hand, health deteriorates rapidly in older age groups, while on the other hand, pensioners are to some extent insulated from socio-economic changes – in particular, the labour market impact of the twin green and digital revolutions – although with vast disparities in pension coverage and adequacy such that elderly poverty remains an important concern, especially in some EU regions. The question whether the correlation between regional socio-economic inequalities and health inequalities will go up or down remains therefore open and can be answered only using a modelling framework where both economic outcomes and health outcomes are considered, such as ours. The inclusion of the health domain, in a context of rapid population ageing, is also crucial as it interacts with mobility, and poses big constraints to public budgets, limiting the resources that are available for other social protection measures as well as other growth and cohesion policies.

Microsimulation modelling

The purpose of microsimulation models is to generate data that does not otherwise exist, usually describing some counterfactual situation which can be compared with the existing state of play. In microsimulation, the state of micro units (individuals, households, firms…) are modified starting from some initial configuration, typically taken from survey data or artificially constructed, on the basis of some biological, institutional or behavioural rules. Examples of biological rules are ageing and death. Examples of institutional rules are tax and benefits systems, or policies more in general. Examples of behavioural rules are any choices that the units can make, for instance, in the case of individuals, related to education, household composition, fertility, labour supply, lifestyle and health behaviour, retirement.

SimPaths

Our micro-analytical framework, labelled SimPaths, captures the following trends, and their interaction: (i) demographic trends, including increased longevity and decreased fertility, (ii) trends to-wards increasing levels of education and postponing entry in the labour market, (iii) a trend towards delaying the moment when individuals leave the parental home and set up their own household, (iv) a trend towards delaying the formation of relatively stable partnerships, (v) a trend towards increasing levels of homophily between partners (the degree to which partners share similar socio-economic backgrounds, levels of education and labour market outcomes), (vi) more ambiguous trends towards higher fragmentation in family life (partnership dissolution and re-partnering), (vii) trends towards increased career mobility, or fragmentation in working life (including increasing job insecurity, especially for younger generations), (viii) trends towards better health outcomes by age, (ix) a trend towards postponing labour market exit (retirement). These trends are estimated separately in the longitudinal data, by including cohort effects among the covariates explaining the different outcomes. Every force in the model pushes in a potentially different direction, some reinforcing, others counterbalancing. SimPaths operates as a collector of all those forces, and a calculator of their interaction and composition. For instance, the effects of population ageing on the labour force can be counteracted by increasing female labour force participation, although the need to provide care to elderly relatives might attenuate it. Another example is the effects of automation and digitalisation in the labour market, which can be attenuated by increasing levels of education of the workforce. On the other hand, population ageing can be made worse off by human capital mobility, a process further reinforced by worsening economic conditions which incentivise further segments of the population to move out of the region. Clearly, when the forces in place are not balanced, we cannot expect that they will continue to exercise their explosive behaviour forever: at some point, some adjustment mechanism will be triggered, such that some individual or institutional behaviour will change. These changes might be brought about by political processes activated by the same forces that create the imbalance in the first place. Generally, the modelling of these endogenous correction mechanisms is outside the scope of the analysis, in microsimulation modelling. The role of microsimulation models is in this case to highlight the imbalance, pointing to the necessity of some correction mechanism to be put in place.

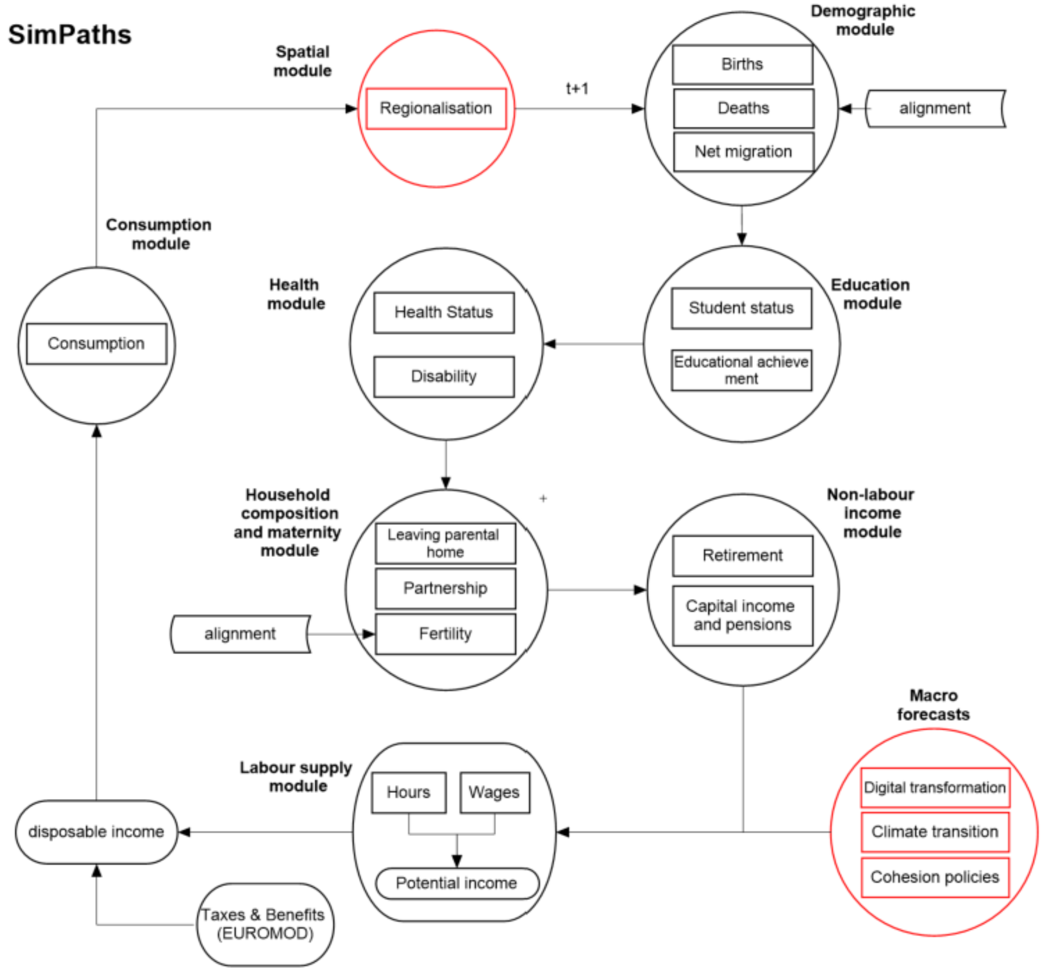
SimPaths is coded in JAS-mine, a Java-based simulation platform explicitly conceived for dynamic microsimulation and agent-based modelling (Richiardi and Richardson, 2017). SimPaths considers the following individual characteristics for the simulated population: age, gender, region, education, health status, family composition, employment status, hours of work, labour income, benefit income, pension income, capital income, taxes, consumption and savings.

SimPaths is currently composed of seven different modules: (i) Demography, (ii) Education, (iii) Health, (iv) Household composition, (v) Non-labour income, (vi) Labour supply, and (vii) Consumption. Each module is in turn composed of different processes or sub-modules, for example ageing process in the demographic module, or a wage setting process in the labour supply module. In each period, agents first go through the demographic module. Then, the education module determines whether students should remain in education, or – for individuals who are no longer in education – re-enter education. Students are assumed not to work and therefore do not enter the labour supply module. Individuals who leave education have their level of education determined (for those who returned to education, their level of education can only go up) and can become employed. The health module calculates an individual's continuous health score and evaluates whether the individual is long-term sick or disabled (in which case, he / she is not at risk of work). Next, in the household composition module, adult children who still live with their parents can leave the parental home, and couples are formed matching the level of homophily between partners observed in the data.[1] Females in couples can then give birth to a child, as determined by the fertility process. Fertility is modelled at the individual level. Individuals then enter the labour supply module, in which a) their potential wage is calculated using a Heckman-corrected wage equation, b) the closest matching EUROMOD/UKMOD household (in terms of key characteristics relevant for the tax and benefit policies, such as health, number of children, region, and age) is selected and the net income calculated, c) the utility-maximising choice of number of hours of work supplied by the members of the household is determined using a structural labour supply model, whose parameters are estimated on the EUROMOD/UKMOD input data. That determines household's actual disposable income. Finally, a simple consumption module transforms disposable income into consumption by applying a homogenous saving rate, calibrated on the data. The same saving rate is also used when calculating capital income. The structural labour supply model is replaced by stochastic transitions in 2020 and 2021, to consider the effects of the Covid-19 pandemic. All monetary variables are uprated each year by (nominal or real) growth rates which are specified by the user as scenario parameters.

Figure 1 shows the structure and order of processes modelled in SimPaths. The figure also highlights the main processes of interest to this study (in red), namely the incorporation of macro scenarios and the regionalisation of model outcomes.

[1] Homophily is the degree of similarity between partners' characteristics, an important driver of inequality (see e.g. Nolan et al., 2019).

Figure 11 – Structure and order of processes modelled in SimPaths



Data

SimPaths uses four types of data as input:

i) The initial population to be evolved over time, which, in the case of EU countries, comes from EU-SILC data, while for the UKL comes from the UKHLS (a.k.a. Understanding Society).

ii) Donor populations from the static tax-benefit model (EUROMOD for the EU countries, UKMOD for the UK) to provide data on the effects of particular policy schedules. Each year, simulated individuals and house-holds are statistically matched to individuals and households from the appropriate EUROMOD/UKMOD donor population in order to transform gross incomes into net incomes, as specified by the policy schedule.

iii) Estimated parameters for the processes modelled in the simulation, where estimation is performed, for the EU countries, on the longitudinal version of EU-SILC, while for the UK it is performed on the UKHLS longitudinal panel.

iv) Scenario parameters coming from external sources and analyses, such as birth and death rates.

References

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