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Structural change and inequality in general equilibrium

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Structural change and inequality in general equilibrium

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Abstract
We study the evolution of wealth inequality in an economy undergoing structural change. Economic intuition hints that structural change should imply increased income inequality, at least transiently. Economic intuition is more ambiguous for the effects on wealth inequality. On the one hand, increased dispersion in incomes implies increased dispersion in the ability to accumulate wealth across individuals. On the other hand, workers experience greater uncertainty, which may push them to more precautionary savings, which works towards equalizing wealth distribution. The net effect of these two opposing forces is essentially an empirical question. We build an overlapping generations model which features heterogeneous sectors and workers. Using this model, we quantify the role of demographics and the structural change in the evolution of wealth inequality in Poland as of 1990.

Keywords:
structural change, demographic change, inequality

JEL Classification
L16, E20, D63

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1 Introduction and motivation

We study the evolution of income and wealth inequality in an economy undergoing structural change. In an economy with frictions, structural change implies a rise in income inequality, at least transiently. The rationale is as follows: as an economy enters structural change, wages become more dispersed because some workers are still employed in the declining sector, whereas the rest of the labor force is already working in the emerging ones. This polarization is transitory in the sense that when the structural change is over, the wages eventually become less dispersed.[1] Economic intuition is more ambiguous for the effects on wealth inequality. On the one hand, increased income dispersion implies increased dispersion in the ability to accumulate wealth across individuals. On the other hand, workers experience greater uncertainty, which may push them to more precautionary savings, which works towards equalizing wealth distribution. The net effect of these two opposing forces is essentially an empirical question. In addition, it remains unclear whether episodes of structural change have lasting effects on wealth distribution. Finally, the extent to which, if at all, redistribution policies can effectively mitigate the rise in wealth inequality remains to be clarified. We seek to address these questions in a general equilibrium model.

The relevance of these question is emphasized by broad empirical evidence on the evolution of wealth and income inequality in countries undergoing structural change. It was extensively documented that economies transitioning from central planning to market-based systems have been experiencing a rise in income and wealth inequality (Milanovic 1998, Flemming and Micklewright 2000, Milanovic and Ersado 2012). This rise was attributed to the differences between preferences of social planners (who presumably tend to equalize incomes and reduce wealth accumulation) and market mechanisms (who are characterized by dispersed rewards to workers and strong incentives for wealth accumulation; Münich et al. 2005, Tyrowicz and Smyk 2019). It is too often overlooked, however, that transition economies experienced profound structural change, not only through the growth of the private sector, but largely through the declining role of manufacturing (especially heavy industry) and the boom in market services.

Our paper offers several contributions to the existing literature. First, our novel model sheds light on the nexus between structural change and wealth inequality: structural change *reduces* wealth inequality, at least over the first few decades. Second, the rise in wealth inequality is mainly driven by rising longevity. We show the microfoundations of these findings as well as the role of the general equilibrium. Third, with a structural model we study if greater redistribution helps to alleviate the rise in wealth inequality. We provide insights for why income redistribution actually amplifies wealth inequality. We calibrate our study to the case of Poland: a country which underwent a transition from a centrally planned to a market economy. This transition is a convenient case of structural change because the beginning of the transition is known exactly, reducing the arbitrariness of modeling choices. The choice of Central and Eastern Europe has one additional appeal: in addition to structural change, these economies also underwent demographic change, notably a spectacular

[1] Economic intuition hints that without economic frictions, structural change should have no effect on inequality, because wages are always fully equalized.

rise in longevity during the same period. Thus, our model features structural change in a calibrated general equilibrium overlapping generations model. Our economy structure mimics that of Von Brasch et al. (2018), but our model reflects the structural changes and the demographic processes.

There are four important limitations to existing empirical studies which we aim to bridge with our study. First, data on incomes and wealth during structural change is scant, which constrains the ability to study *joint* evolution of income and wealth inequality. Second, observational data rarely permit counterfactual analysis, because structural change is typically accompanied by a wide variety of redistribution and structural policies, entangled in a political economy process (see Roland 2002, Beck and Laeven 2006, Aristei and Perugini 2012, 2014, for the context of transition from centrally planned to market economy). Third, most of the inequality measures are by design cross-sectional indicators: they aggregate over the population at a given point in time. Meanwhile, transition countries have experienced a substantial change in demographic structure over this time: a decline in births accompanied by a rise in life expectancy change substantially both the age composition of the population and incentives related to wealth accumulation. The change in composition (lower share of youth and higher share of post-war baby boom generations) implies a mechanical rise in inequality because generations without assets become less numerous and those with assets at lifetime maximum become more numerous. Simultaneously, the change in incentives to accumulate wealth sufficient to smooth consumption over longer lifespans triggers a behavioral mechanism: expecting longer life-spans (especially after retirement), individuals accumulate more wealth before retirement and de-accumulate more slowly after retiring. Fourth and finally, the existing studies do not account for a massive increase in human capital across the transition countries: the share of individuals with tertiary education in a given birth cohort has increased from under 10% to over 50% in less than a decade, which obviously affects the supply and the demand side of skills distribution. Given these limitations, studies based on observational data help little in understanding the effects of structural change on income and wealth inequality. Structural models are needed to provide clear insights.

The existing structural literature typically works with infinitely lived agents who engage in the (possibly frictional) process of reallocation from one sector to another (Aghion and Blanchard 1994, Caballero and Hammour 1996, Castanheira and Roland 2000, Buera and Kaboski 2012, Rogerson et al. 2015).[2] These studies explain the role of human capital accumulation in skill premium and its evolution over time (Buera and Kaboski 2012). However, across the transition economies in Europe and Central Asia, majority of the change in employment structures occurred via demographic change: older birth cohorts retiring from declining sectors and young birth cohorts entering emerging sectors (Tyrowicz and Van der Velde 2018, in fact, job-to-job transitions occurred typically *within* the sector of employment). Models with infinitely lived agents cannot replicate this stylized fact and thus yield insufficient adjustments in income inequality during structural change. To the best of our knowledge, no study offers general equilibrium models with structural change and demographic transition.[3] Our paper fills this gap in the literature.

[2] An extensive overview of the existing models is discussed by Herrendorf et al. (2014).

[3] Guilló et al. (2011) offer a stylized OLG framework of structural change, but in comparative statics. Studies such as Fougere et al. (2007), Kronenberg (2009), Lisenkova et al. (2013) enrich CGE models with overlapping generations structure to study the implications of rising longevity and declining fertility on demand across sectors in the economy.

Through the lens of an overlapping general equilibrium model with structural change we observe the evolution of wealth and income inequality. We use counterfactual scenarios to explore the role of structural change in these evolutions. We also experiment with redistribution designs to establish quantitatively the role of policy in the evolution of income and wealth inequality. Our paper thus is structured as follows. The theoretical model is presented in section 2. Since the crux of the mechanisms studied in this paper relates to *changes* along the transition path, we move directly to full general equilibrium setup. Section 3 describes calibration and the simulation scenarios in detail. We present the results in section 4, together with sensitivity checks. The final section concludes, emphasizing the contribution to the literature and the policy recommendations emerging from this study.

2 The model

We build a general equilibrium, overlapping generations model. Each period in the model corresponds to 1 year. The model features structural change: manufacturing sector (M) declines and service sector (S) expands. The model also features a change in the human capital in economy: the share of individuals with tertiary education (HE) rises and the opposite holds for individuals without university education (LE). Finally, demographic transition occurs in our model: the arriving young cohorts decline in size and life expectancy rises for subsequent birth cohorts.

To address the issue of inequality our model features *ex ante* within cohort heterogeneity and idiosyncratic income shocks (referred to as *ex post* heterogeneity). Ex ante heterogeneity reflects the fact that individuals differ in skill levels and sector of employment. We ignore the decision to invest in human capital and assume that in a given year a given fraction of individuals arrives to the economy with tertiary education and the rest of that birth cohort arrives without it. Further, we rely on empirical evidence from transition countries that structural change in employment occurred predominantly *via* the entirely exogenous inter-generational exchange (Tyrowicz and Van der Velde 2018). To reflect this stylized fact, the young individuals arrive in our model in one of the two sectors and continue in this sector until retirement. Thus, each arriving birth cohort is populated by four types of agents denoted by $h \in H \equiv \{\{HE, LE\} \otimes \{M, S\}\}$. The relative population share of each type in the economy is denoted by $\chi_{j,h,t}$. The size of population for each type h for each age j in period t is denoted as $N_{j,h,t}$ It is determined for each arriving birth cohort as it is entering the model and it is held constant over the life span of this cohort, see Section 3 for details on calibrating these shares.

Households Individuals' age is denoted by $j \in 1, 2, ..., J$. They enter the model at the age of 21, and have period to period probability of survival $\pi_{j,t}$, common for all four types of individuals. All individuals die with certainty at the age of 100. Individuals discount time with δ. We assume that higher educated individuals (HE) are more patient than individuals without tertiary education (LE), $\delta_{HE} > \delta_{LE}$. Because agents face mortality, there are unintended bequests b_t. In each period, unintended bequests are distributed equally among the remaining individuals.

Incomes Each individual has two components of productivity: ex ante sector specific productivity denoted by $\xi_{h,t}$ (which is discussed in section 3) and idiosyncratic productivity denoted by type-specific $\eta_{h,t}$, which follows a stochastic AR(1) process:

$$\log(\tilde{\eta}_{h,t}) = \varrho_{\eta,h} \log(\tilde{\eta}_{h,t-1}) + \epsilon_{h,t} \tag{1}$$

where $\epsilon_{h,t} \sim N(0, \sigma^2_{\eta,h})$. We discretize this process and approximate it by 5-state discrete time Markovian process with the transition matrix $\tilde{\Pi}(\tilde{\eta}_{j,h,t} \| \tilde{\eta}_{j-1,h,t-1})$. We extend this transition matrix, which reflects pure income shocks, with the sixth state $\eta_{h,6}$ reflecting unemployment, $\eta_{h,t} \in \{\eta_{h,t,1}, \eta_{h,t,2}, ..., \eta_{h,t,6}\}$, and $\eta_{h,t,1} = \tilde{\eta}_{h,t,2}, \eta_{h,1} = \tilde{\eta}_{h,2}, ..., \eta_{h,5} = \tilde{\eta}_{h,5}$. Separation and job finding rates are type-specific and denoted by $\zeta_{h,t}$ and $f_{h,t}$, respectively. The two rates are equal over the first five states. Thus the transition matrix $\Pi(\eta_{j,h,t} \| \eta_{j-1,h,t-1})$ over six states is

$$\Pi(\eta_{j,h,t} \| \eta_{j-1,h,t-1}) = \begin{cases} (1-\zeta_{h,t})\tilde{\Pi}(\eta_{j,h,t} \| \eta_{j-1,h,t-1}), & \text{if } \eta_{j,h,t}, \eta_{j-1,h,t-1} \in \{\eta_{h,1}, ..., \eta_{h,5}\} \\ f_{h,t}/5, & \text{if } \eta_{j,h,t} \in \{\eta_{h,1}, ..., \eta_{h,5}\} \text{ and } \eta_{j-1,h,t-1} = \eta_{h,6} \\ \zeta_{h,t}, & \text{if } \eta_{j,h,t} = \eta_{h,6} \text{ and } \eta_{j-1,h,t-1} \in \{\eta_{h,1} ..., \eta_{h,5}\} \end{cases} \tag{2}$$

Jobless individuals receive unemployment benefits. Wage received is the product of marginal productivity of labor (w_t defined later), and the two components of individual productivity, hence it is type-dependent and within-type state-dependent: $w_{j,h,t} = w_t \xi_{h,t} \eta_{j,h,t}$.

Labor supply is inelastic: each agent supplies one unit of labor if $j < \bar{J}$ and 0 otherwise, with $\bar{J}$ denoting retirement age.

Social security Individuals retire at age $\bar{J}$. During the working period individuals contribute $\tau w_{j,h,t}$ to social security. Social security contributions are exempt from labor income taxation. The retired workers receive social security benefits $p_{j,h,t}$. Social security is of pay-as-you-go character. The budget constraint of social security is given by:

$$\sum_{j=\bar{J}}^{J} \sum_{h \in H} p_{j,h,t} N_{j,h,t} = \tau_t w_t L_t + subsidy_t, \tag{3}$$

where $subsidy_t$ denotes the balance of social security, to be financed by the government.

At retirement, the value of the benefits $p_{j,h,t}$ is obtained as a sum of two components. First, there is a redistributive part that is common for all individuals. It is computed as a fraction ρ_r of the average wage in the economy at the time of their retirement $\bar{w}_t$ (to be defined later). Second, there is a sector-specific component, which uses sector-specific wages. It is computed as a fraction ρ_h of the average sector wage in the economy $\bar{w}_{h,t} = \xi_{h,t} \bar{w}_t$.

After retirement age, pensions are indexed with ι share of payroll growth rate Δ_w (to be defined later). Such design of social security in our model, portrayed by equation (4), reflects Polish legislation.

$$p_{j,h,t} = \begin{cases} \rho_t(\rho_r + \rho_h \xi_{h,t})\bar{w}_t & \text{for} \quad j = \bar{J} \\ p_{j-1,h,t-1} \times (1 + \iota\Delta_w) & \text{for} \quad j > \bar{J} \end{cases} \tag{4}$$

The free parameter ρ_t permits the matching of the share of pensions in GDP in the initial steady state. By manipulating this parameter we can also provide counterfactual scenarios concerning the generosity of social security without affecting its redistributive character.

Budget constraint Households aged below the retirement age earn gross labor income $w_{j,h,t}$, which is subject to social security contribution at the rate τ and labor income tax denoted by $\tau_{\ell,t}$. Note that social security contributions are exempt from labor taxation.

In addition to salary, income also consists of post-tax capital gain $(1-\tau_k)r_t a_{j,h,t}$ (with τ_k denoting capital income tax, r_t the interest rate and $a_{j,h,t}$ assets holdings at age j of an individual working in sector h) as well as pension benefits $p_{j,h,t}$, which households receive once they reach the retirement age. There is no income tax on pension benefits. Moreover, since survival rates $\pi_{j,h,t}$ are lower than one, in each period t there are unintended bequests, which are evenly distributed within a birth cohort, $\Gamma_{j,h,t}$. Households purchase consumption goods $c_{j,h,t}$, which are subject to consumption tax $\tau_{c,t}$ and accumulate assets $a_{j+1,t+1}$. Assets markets are incomplete; only assets with risk free interest rate r_t are available. In summary, the households face the following instantaneous budget constraint:

$$(1 + \tau_{c,t})c_{j,h,t} + a_{j+1,h,t+1} = (1 - \tau_{\ell,t})(1 - \tau)w_{j,h,t} + p_{j,h,t} + (1 + (1 - \tau_{k,t})r_t)a_{j,h,t} + \Gamma_{j,h,t} \tag{5}$$

with non-negative assets holdings constraint $(a_{j+1,t+1} \geqslant 0)$.

Consumer problem An individual state of each household at age j at time t $s_{j,h,t}$ can be summarized by the level of private assets $a_{j,h,t}$ and individual productivity determined by $\eta_{j,h,t}$, $s_{j,h,t} = (a_{j,h,t}, \eta_{j,h,t}) \in \Omega_h$. A newborn household in sector h enters the economy with no assets $(a_{1,h,t} = 0)$ and at each state $s_{j,h,t}$ the household maximizes the expected value of the remaining lifetime utility. The households discount the future with the discount factor δ_h and the conditional survival probability $\pi_{j+1,t+1}/\pi_{j,t}$. We define the optimization problem of the household in a recursive form as:

$$V_{j,h,t}(s_{j,h,t}) = \max_{(c_{j,h,t},a_{j+1,h,t+1})} \frac{1}{1-\sigma} c_{j,t}^{1-\sigma} + \delta_h \frac{\pi_{j+1,t+1}}{\pi_{j,h,t}} \mathbf{E}\big(V_{j,h,t+1}(s_{j+1,t+1}) \mid s_{j,h,t}\big), \tag{6}$$

subject to the budget constraint given by equation (5), formulas for pensions given by (4), and the productivity process given by equation (2). We denote the probability measure describing the distribution of agents of age j working in sector h in period t over the state space Ω_h as $\mathbb{P}_{j,h,t}$.

The aggregate consumption C_t, and aggregate assets A_t are given by

$$C_t = \sum_{j=1}^{J}\sum_{h\in H}\left(\int_{\Omega_h} c_{j,h,t}(s_{j,h,t})d\mathbb{P}_{j,h,t}\right)\chi_{j,h,t}N_{j,t} \tag{7}$$

$$A_{t+1} = \sum_{j=1}^{J}\sum_{h\in H}\left(\int_{\Omega_h} a_{j+1,h,t+1}(s_{j,h,t})d\mathbb{P}_{j,h,t}\right)\chi_{j,h,t}N_{j,t} \tag{8}$$

Firms On the consumer side, we assume that workers differ by education and sector. On the production side, the labor is aggregated across sectors h according to

$$L_t = \sum_{j=1}^{\bar{J}}\sum_{h\in H}\left(\int_{\Omega_h} \xi_{h,t}\eta_{j,h,t}d\mathbb{P}_{j,h,t}\right)\chi_{j,h,t}N_{j,t}. \tag{9}$$

We assume competitive firms. A single consumer good is produced with standard Cobb-Douglas technology. Exogenous technological progress z_t is labor-augmenting, consistent with Smeets Kristkova et al. (2017). The firms produce a single final good using capital and labor as production inputs and generate output according to production function: $Y_t = K_t^{\alpha}(z_t L_t)^{(1-\alpha)}$. Firm's maximization yield formulas for the interest rate r_t and marginal product of labor w_t:

$$r_t = \alpha K_t^{(\alpha-1)}(z_t L_t)^{1-\alpha} - d \quad \text{and} \quad w_t = (1-\alpha)K_t^{\alpha}(z_t L_t)^{1-\alpha}L_t^{-1} \tag{10}$$

In this economy, the average wage is given by $\bar{w}_t = w_t L_t / \sum_{j=1}^{j=\bar{J}-1} N_{j,t}$. Accordingly, the payroll growth is given by $\Delta_w = w_t L_t / w_{t-1} L_{t-1}$

Government The government collects three kind of taxes: labor tax τ_ℓ, consumption tax $\tau_{c,t}$ and capital gains tax τ_k. It uses tax revenues to finance government expenditures G_t and services government debt D_t. It also responsible for balancing the social security $subsidy_t$.

$$G_t + subsidy_t + r_t D_t = \tau_{c,t}C_t + \tau_\ell(1-\tau)w_t L_t + \tau_k r_t A_t + (D_{t+1} - D_t) \tag{11}$$

Throughout the path, we keep tax rates fixed at their initial steady state levels, calibrated to data. Given the balanced budget imposed by (11), we adjust consumption tax rate $\tau_{c,t}$ as expenses and revenues from other taxes diverge. The key sources of the divergence, in quantitative terms, are the changes in the balance of social security given by $subsidy_t$.

2.1 Equilibrium and model solving

Next we define a competitive equilibrium for our economy. Recall that the state of an agent at age j working in sector h at time t is fully characterized by $s_{j,h,t} = (a_{j,h,t}, \eta_{j,h,t}) \in \Omega_h$. Recall that the probability measure describing the distribution of agents of age j in sector h in period t over the state space Ω_h as $\mathbb{P}_{j,h,t}$.

Definition 1 A competitive equilibrium *is a sequence of value functions* $\{((V_{j,h,t}(s_{j,h,t}))_{h\in H})_{j=1}^{J}\}_{t=0}^{\infty}$, *policy functions* $\{((c_{j,h,t}(s_{j,h,t}), a_{j+1,h,t+1}(s_{j,h,t}))_{h\in H})_{j=1}^{J}\}_{t=0}^{\infty}$*, prices* $\{r_t, w_t\}_{t=0}^{\infty}$*, government policies* $\{\tau_{c,t}, \tau_k, \tau_\ell, D_{t+1}\}_{t=0}^{\infty}$*, social security parameters* $\{\tau, subsidy_t, \rho_t, \rho_p, \rho_h, \zeta_w\}_{t=1}^{\infty}$*, aggregate quantities* $\{L_t, A_t, K_t, C_t, Y_t\}_{t=0}^{\infty}$*, and a measure of households* $\{(\mathbb{P}_{j,h,t})_{h\in H}\}_{t=0}^{\infty}$ *such that:*

- **consumer problem:** *for each* j*,* h *and* t *the value function* $V_{j,h,t}(s_{j,h,t})$ *and the policy functions* $(c_{j,h,t}(s_{j,h,t}), a_{j+1,h,t+1}(s_{j,h,t}))$ *solve the Bellman equation* (6) *given prices and government policies;*
- **firm problem:** *for each* t*, prices* (r_t, w_t) *are given by equations* (10)*;*
- **government sector:** *the government budget and the PAYG pension system constraints are satisfied, i.e. equations* (11) *and* (3) *are satisfied;*
- **markets clear**

$$\begin{aligned}
\textit{labor market:} \quad L_t &= \sum_{j=1}^{\bar{J}} \sum_{h\in H} \left(\int_{\Omega_h} \xi_{h,t}\eta_{j,h,t} d\mathbb{P}_{j,h,t} \right) \chi_{j,h,t} N_{j,t}; \\
\textit{capital market:} \quad A_{t+1} &= \sum_{j=1}^{J} \sum_{h\in H} \left(\int_{\Omega_h} a_{j+1,h,t+1}(s_{j,h,t}) d\mathbb{P}_{j,h,t} \right) \chi_{j,h,t} N_{j,t}, \\
K_{t+1} &= A_{t+1} - D_{t+1}; \\
\textit{goods market:} \quad C_t &= \sum_{j=1}^{J} \sum_{h\in H} \left(\int_{\Omega_h} c_{j,h,t}(s_{j,h,t}) d\mathbb{P}_{j,h,t} \right) \chi_{j,h,t} N_{j,t}, \\
K_{t+1} + G_t + \quad C_t &= Y_t + (1-d)K_t;
\end{aligned}$$

- **probability measure:** $\forall j$*,* $\forall h$ *and* $\forall t$ *the probability measure* $\mathbb{P}_{j,h,t}$ *is consistent with productivity processes and policy functions.*

We solve the consumer problem with value functions iterations. We discretize the reduced state space $\hat{\Omega} = \hat{A} \times \hat{H}$ with $\hat{A} = \{a^1, ..., a^{n_A}\}$, and $\hat{H} = \{\epsilon^1, ..., \epsilon^{n_H}\}$, where $n_A = 300$, and $n_H = 4$. We interpolate policy and value functions with piece-wise linear functions (using recursive Powell's algorithm). For each discrete $\hat{s}_{j,t} \in \hat{\Omega}$ we find the optimal consumption and labor supply of the agent using the Newton-Raphson method.

For a given initial distribution $\hat{\mathbb{P}}_{1,t}$ at age $j = 1$, time t, transition matrix $\Pi(\eta_{j,t}|\eta_{j-1,t-1})$, and the policy functions $\{a_{j+1,t+1}(\hat{s}_{j,t})_{j=1}^{J}\}_{t=1}^{\infty}$ we can compute the distribution in any successive age j and period t. It can be interpreted as a fraction of cohort of age j at time t residing at each state of the state space $\hat{\Omega}$.

Once we compute distributions and policy functions for each state, we compute aggregate quantities of consumption, labor and savings. To this end we use the Gaussian quadrature method. Once the consumer problem is solved for a given set of prices and taxes, we apply the Gauss-Seidel algorithm to obtain the general equilibrium. Using the outcome of the consumer problem, the value of aggregate capital is updated. The procedure is repeated until the difference between the aggregate capital from subsequent iterations is negligible, i.e. l_1-norm of the difference between capital vector in subsequent iterations falls below 10^{-12}.

3 Calibration and status quo

The model is calibrated to match features of the Polish economy during the three decades of economic transition from a centrally planned to a market economy, that is years 1989-2020. The model period corresponds to one year.

Demographics. Population evolution data comes from the United Nations. This is also the source of the demographic projection until 2100. After this horizon we make a technical assumption that the population stabilizes in terms of age structure. As input data, we use the birth cohort size in 1989 and subsequent mortality rates and fertility to reproduce population numbers for each year. In scenarios without an increase to longevity, we keep $\pi_{j,t}$ constant at the level of 1989 $\forall t$, but the model features data-driven evolution of each subsequent birth cohort.

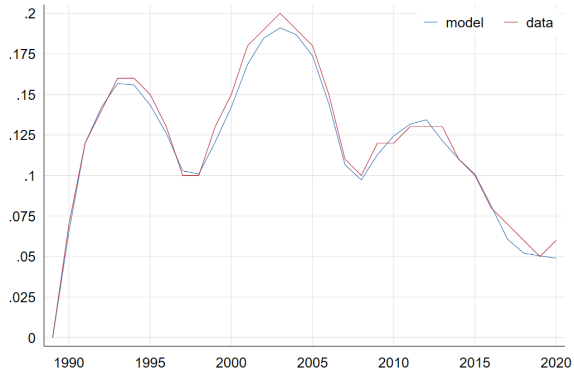
Idiosyncratic productivity shocks (η). We estimate the idiosyncratic component using the Socio-Economic Panel (SOEP) for Germany, because no panel data is available for Poland. The idiosyncratic component is specified as a first-order autoregressive process. We estimate the stochastic process separately for individuals with a tertiary degree (HE) and with less than university education (LE). Likewise, we estimated the processes for the services and manufacturing sectors, but no statistically significant differences were present in the data between sectors. We obtain autoregression $\varrho_{\eta,HE} = 0.9548$ for the individuals with a tertiary degree and $\varrho_{\eta,LE} = 0.9016$ for the others. Likewise, we obtain the variance for those with and without tertiary education at variance $\sigma_{\eta,HE} = 0.0098$ and $\sigma_{\eta,LE} = 0.0347$, respectively. Those results are in line with Fehr et al. (2013) in terms of high-skilled individuals. Our estimates for low-skilled ones, however, yield lower coefficient of autoregressive term and higher transitory variance. Those differences may come from the fact that Fehr et al. (2013) distinguish three education levels (higher, medium and lower education), whereas we combine medium and lower into the LE category. The productivity shocks are constant over time and birth cohorts.

The productivity shocks are augmented with the unemployment risk. We use Labor Force Survey for Poland and estimate the aggregate separation rates and hiring rates following Shimer (2012). Our results are analogous to Strawiński (2009). These estimates were adjusted to reflect differences in the risk of unemployment across sectors and education levels. In other words, each of the four ex ante heterogeneous groups has their own separation and hiring probabilities, consistent with Polish data.

Note that the separation and the hiring rates vary over time, in line with the changes in the Polish economy. For the years 1990-2020 we follow the data. As of 2020, we take the technical assumption that the hiring and separation rates converge to the average levels observed during the past decade, which implies the unemployment rate of 4.7% in the long run. The match between the unemployment rate implied by our model and the data is portrayed in Figure 1.

Ex ante heterogeneity (h, χ) The changes in ex ante heterogeneity govern the structural change in our model economy. We use Polish Labor Force Survey between the earliest available year, 1994,

Figure 1: Unemployment rate (model vs. data)



Note: the unemployment rate from data versus the rate implied by the model, given job finding and separation rates displayed in Figure A.1. Data obtained from Polish Labor Force Survey, following the ILO definition of unemployment. The model is calibrated to replicate the overall activity rate for consistency.

and 2020 to obtain the shares of salaried workers employed in manufacturing sector and in services. We do that separately for the individuals with and without a tertiary degree. We thus obtain four target shares: $\chi_{M,HE}, \chi_{M,LE}, \chi_{S,HE}, \chi_{S,LE}$. We use the data for 1994 to determine the initial employment shares.

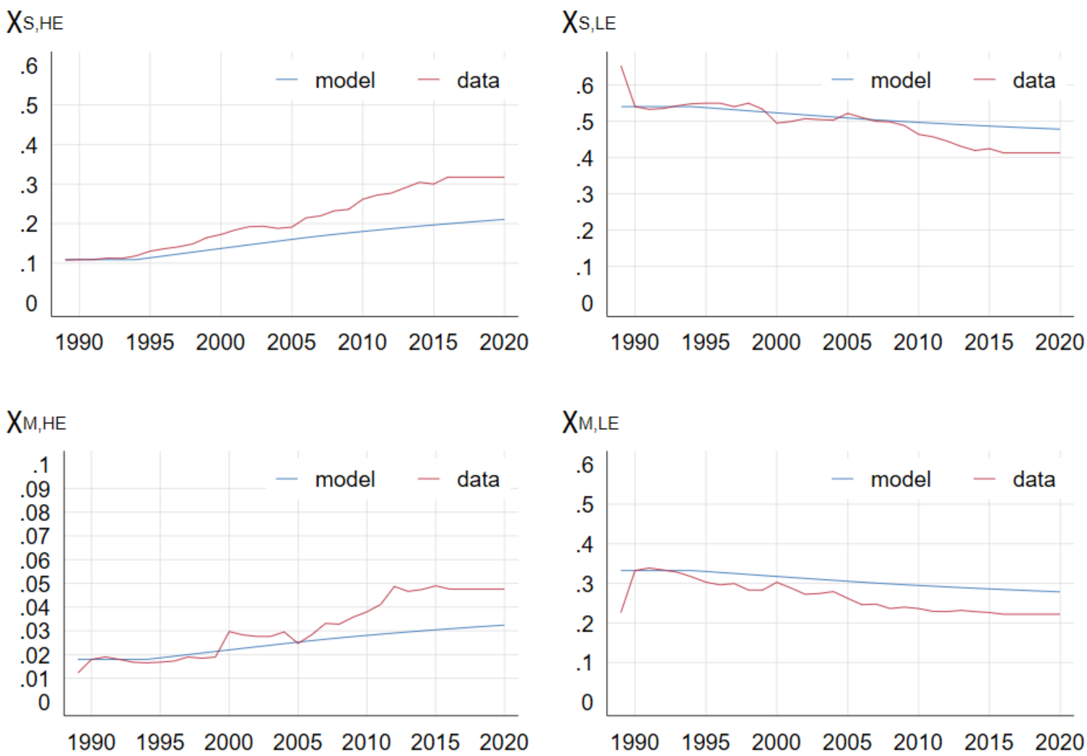
In our model, the change in the structure of employment occurs via the labor market entry of new cohorts and exit of the elderly. For the first 40 years, the exits of the elderly are determined by the initial employment shares. The entry shares among the youth were set to match the aggregate evolution of the employment structure. We utilize the data for the youth entry from Polish Labor Force Survey and model implied exits of the elderly. Figure 2 portrays data and model shares.

Productivity growth (γ_t). The model specifies labor augmenting growth of technological progress $\gamma_{t+1} = z_{t+1}/z_t$. For 1989-2019 we use the TFP data from Penn World Tables (CTFP variable). We apply HP filtering to smooth the original data to ease the computational difficulty. For the years 2020 and later we take levels implied by long-term projections of the Aging Work Group of the European Commission. The implied technological progress amounts to 1% per annum as of 2070. Productivity growth is adjusted for the changes in the labor composition according to the equation (12):

$$\tilde{\gamma}_t = \gamma_t / \frac{\sum_{j=\bar{J}}^{J} \sum_{h \in H} \xi_{h,t} \chi_{j,h,t} N_{j,h,t}}{\sum_{j=\bar{J}}^{J} N_{j,h,t}}. \tag{12}$$

Preferences The discount factor δ was set at 0.9740 to match the interest rate of 3% in the final steady state. To reflect the differences in longevity, we set that discount factor for HE individuals higher and lower for LE individuals. We calibrate the h-type specific adjustment of δ such that wealth inequality in our model matches wealth inequality in the data. There are no measures of wealth inequality for 1989. The earliest available estimates suggest a Gini coefficient on wealth close to approximately 60 (Davies et al. 2011). The implied multiplier of δ for $h = HE$ amounts to 1.024 (which implies $\delta_{HE} = 0.9960$) and for the $h = LE$ agents it is 0.976 (which implies $\delta_{LE} = 0.9496$).

Figure 2: Employment shares



Note: The initial shares established using the data for 1994. The data come from Polish Labor Force Survey. The shares are fed into the model gradually converge to levels.

Following the empirical evidence, the risk preference parameter θ ought to be set at values between 2 and 4 (Brown et al. 2021). For the lower of the estimates, the individuals are on average risk neutral. For the higher of the estimates, the individual exhibits sizable levels of risk aversion. The risk aversion parameter is particularly relevant in our study, given that the structural change on the aggregate translates to altered income uncertainty for individuals. With higher levels of risk aversion, precautionary motives will play a more dominate role than in the case of lower risk aversion. To address this issue, we present the results for these two extreme values, with the premise that they represent the lower and upper bounds on the role of precautionary motives. The risk preference parameter θ is common across types.

Social security parameters. Retirement age eligibility occurs at 62, which is the average effective retirement age over this period, following OECD. We follow Mendoza et al. (1994) to set the contribution rate to social security, using OECD data to obtain the share of social security contributions in GDP.

We calibrate the parameters of the benefits step wise. First, we assume that $\rho_t = 1$ in the initial steady state. We then set the redistributive component of the pension benefit in line with the legislation to $\rho_r = 0.24$. Finally, we set ρ_h such that the social security is balanced in the initial steady state. This implies $\rho_h = 0.175$.

Taxes and public debt. Taxes are calibrated using Mendoza et al. (1994) approach. The capital income tax was set to 15.8%, to match 4.0% ratio of the capital income tax revenues to GDP in the early 1990s. The marginal tax rate consumption was set to 16.07% to match 10.7% ratio of consumption income tax revenues to GDP in the initial steady state, while at transition path and in the final steady-state, the tax rate is adjusted to balance the government budget constraint (11). The labor tax rate is set to 12.175% to reflect the ratio of labor tax revenue to GDP of 7.3%. The data on ratios between tax revenues and GPD come from the OECD data, see Table A.1. We set the ratio of government expenditure to GDP in the initial steady state to 0.27 to close the budget and match the debt to GDP ratio at 60%.

Table 1: Calibrated parameters

Macroeconomic parameters		Calibration		Target	Value	Model outcome
Income shocks		HE	LE			
$\varrho_{h,\eta}$	persistence	0.9548	0.9016	estimation		
$\sigma_{h,\eta}$	variance	0.0098	0.0347	estimation		
α	capital share	0.33		literature		
Calibrated for $t \in <0, 10>$ using the targets from 1990s						
	risk preference	for $\theta = 2$	for $\theta = 4$	literature		
g	government	17%		expenditure [a]	17% [b]	17%
τ_ℓ	labor tax	12.2%	12.1%	revenue [a]	7.3% [b]	7.3%
τ_c	consumption tax	16.1%	14.6%	revenue [a]	10.7% [b]	10.7%
τ_k	capital tax	15.8%	13.0%	revenue [a]	4.0% [b]	4.0%
$\bar{J}$	retirement age	62 years			OECD	
τ	social security contr.	10.5%	9.5%	benefits [a]	7.5% [b]	7.4%
ρ_r	redistributive ρ	24%		legislation		
ρ_h	individual ρ	17.5%	17.5%	$subsidy_{t=0}/Y_{t=0}$	0.0%	-0.02%
ι	indexation	25% of payroll growth		legislation		
Calibrated using the targets from the final steady state						
δ	discounting rate	0.973	0.943	r in $t = T$	3%	3.1%
d	depreciation rate	5.8%		$\Delta K/Y$ in $t = 1$	-	19.0%
$\{\delta_{LE}; \delta_{HE}\}$	δ multiplier	$\{0.976; 1.024\}$	$\{0.95; 1.05\}$	wealth Gini	65	65

Notes: [a] denotes ratios as a % share of GDP; [b] denotes OECD as a data source. Tax rate calibrations following Mendoza et al. (1994), see Table A.1, using averages of tax shares in GDP from the years 1995-1999. The final steady state investment rate is unknown. Throughout the 1990-2020 period, the investment rate fell slightly short of 19% of GDP on average, whereas the initial steady state investment rate implied by our model is 18%.
The scaling factor of pensions $\rho_t = 1$ for $t \in <0, 10>$. In the baseline scenario, ρ_t adjusts to match the expenditure as a share of GDP along the transition path. In the counterfactual scenario we keep ρ_t constant throughout the transition path.
Consumption tax rate τ_c equals to the calibrated value for the first ten periods of the model. After that it adjusts freely to balance the budget, given other tax rates, government expenditure, the balance of the social security and debt.

4 Results

We present results in three substantive parts. First, we discuss the role of structural change and demographic change in wealth inequality. We then explain the mechanisms behind the observed trends. Finally, to gauge the efficacy of available policies at reducing inequality, we present the results for a counterfactual scenario. Our analysis focuses on wealth inequality.

4.1 Trends in wealth inequality

The structural change in our model occurs in two forms: first, the TFP growth varies over time and second, there is an adjustment in employment shares due both to rising educational attainment as well as the decline in the role of manufacturing. This structural change occurred in parallel with the demographic change: rising survival rates translate to stronger incentives for old-age saving *ceteris paribus*. These two main processes are the main drivers of the adjustment in inequality. We show the evolution of wealth inequality in Figure 3: the left panel shows the results for calibrations with $\theta = 2$ and the right panel shows them for $\theta = 4$. For ease of interpretation, we present the level of inequality relative to the initial steady state. This way, it is intuitive to compare the role of structural change and demographic change: positive values signify a rise in inequality and negative values signify a decline in inequality. The scale reflects the percentage points on Gini wealth inequality index.

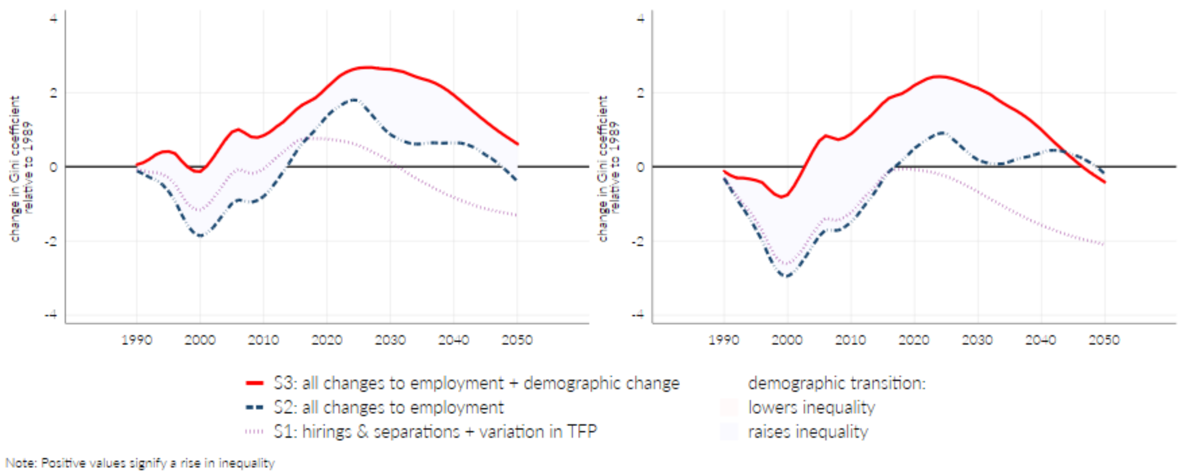
We take the following steps to quantify the role of the two main processes for the growth of inequality. We start from simulating a model in which the only change occurring along the transition is the separation and the hiring rate. All other exogenous factors are kept constant, at the level of the initial steady state. This is our benchmark. We then simulate a model which *additionally* includes a first component of the economic change: the technological progress varies as it did in the data. This scenario is denoted in the Figure 3 as S1. Next, we *additionally* consider the change in the structure of employment following the patterns portrayed in Figure 2. This scenario is denoted as S2 in Figure 3. Finally, we include scenario S3 with all these changes and *in addition* the demographic change. In this scenario, we allow the data-driven evolution of economic structures and the data-driven evolution of the survival rates. The individuals have longer lifespans than in the benchmark, which is reflected in their accumulation and dis-saving patterns. The shaded area between the penultimate and ultimate lines displays the role of demographics whereas the distance between the zero line and the line shows the role of structural change attainment and decline in the manufacturing sector.

The left panel of Figure 3 reveals that absent demographic change, wealth inequality would have been lower. Specifically, the first two decades of economic transition would observe a decline in wealth inequality by as much as two percentage points, relative to the pre-transition levels (three percentage points for $\theta = 4$ calibration). Demographic change contributes an additional two percentage points during this period to the Gini wealth index (approx. 2.5 percentage points for $\theta = 4$ calibration). As a result, towards 2020, the inequality due to rising longevity is approximately two percentage points higher than in the pre-transition situation.

As demographic structure stabilizes, the relative role of rising longevity declines, whereas the role of structural change intensifies. Thus, towards the later decades, the gradual increase in tertiary education and shift towards service sector from manufacturing sector gains in importance and contributes a greater share of total change in inequality. In roughly five decades of demographic and economic change, the Gini wealth index is higher by three percentage points than in the pre-transition starting point.

Overall, the fact that the economy underwent a structural change actually *lowered* wealth inequality in the initial decades, whereas the effects of rising longevity eventually fade out. In other

Figure 3: Wealth inequality



Note: the left panel shows the results for a calibration with $\theta = 2$ and the right panel shows them for a calibration with $\theta = 4$. Scenarios are additive: every next scenario includes the transition path of the previous scenario. The line denoted as "S1" accounts for time-varying evolution in TFP across manufacturing and services. The line denoted "S2" accounts *additionally* for an increase in educational attainment and decline of manufacturing shares. The line denoted "S3" accounts *additionally* for a rise in survival probabilities. The shaded area between the penultimate and the ultimate line quantifies the pure role of demographic change in an economy undergoing structural change.

words, if the economy underwent only demographic change, but not the structural change during the same period, wealth inequality would have increased more. In fact, structural change reduces the growth in wealth inequality to about half of what it would have been without change in employment and educational structure. These effects are large compared to the role of TFP. Our model predicts a further rise in wealth inequality, as the rise in longevity progresses

The calibration with higher risk aversion reveals a steeper rise in wealth inequality due to demographic change and a larger downward effect from the structural change in the first three decades of the transition. The downward pressure from TFP appears to be quantitatively the most relevant driver of the effects of structural change on wealth inequality during this period. These results in the high risk aversion calibration ($\theta = 4$) are driven by the fact that the precautionary motive is stronger relative to a calibration with lower risk aversion. A higher precautionary motive amplifies the role of longevity and reduces the role of change in employment structure. This is because employment structure is deterministic, whereas surviving until old age becomes a powerful driver for asset accumulation (as a means of reducing the higher valued risk of old-age poverty).

Note that the evolution portrayed in Figure 3 reflects a combination of the exogenous structural change and demographic change on the one hand, and adjustment in macroeconomic variables on the other hand. We delegate the figures portraying the evolution of the macroeconomic variables to the Appendix in the interest of space, discussing the main patterns below.

4.2 Macroeconomic adjustment

Structural change occurs by reallocating labor to sectors with higher productivity of labor, which raises effective labor supply. The evolution of effective capital stock (K_t/z_t) is portrayed in Figure B.1. First, notice that the effect of unemployment on capital formation is very small. On the one hand, due to unemployment risk consumers want to save more, i.e. the precautionary savings motive. On the other hand, the unemployed consumers have less income so they save less. Quantitatively, the overall effect is a slight decline in capital stock, see the black dashed line. Note that the scenarios with TFP growth cannot be directly compared to scenarios without TFP growth, because z_t is higher in those scenarios. The role of TFP growth is straightforward: since consumers incomes grow faster they save less, thus the aggregate capital declines due to faster TFP growth, see violet dotted line and the subsequent ones.[4] The structural change has some effect on aggregate capital, but it is not economically large. With higher effective labor supply, returns to capital increase, thus consumers want to save more, see blue dash-dotted line. By contrast, rising longevity fosters old-age saving, thus raising capital stock, see the red solid line. Higher risk aversion amplifies the accumulation of savings for old age due to the precautionary motive. This evolution of capital is portrayed in Figure B.1. The total rise in capital due to demographic change amounts to roughly 35%, which is commensurate with the rise in longevity. The rise in capital is higher for $\theta = 4$ calibration, reaching as much as 50% increase.

The behavior of the interest rate is a mirror image of the adjustments to capital, with the main difference that interest rate mirrors capital per effective unit of labor, rather than aggregate capital. This evolution is portrayed in Figure B.2. This is why the interest rate exhibits a deviation by as much as 2 percentage points in the horizon of 3 decades. This is because the rise of capital stock due to rising longevity has yet to accumulate, before it effectively affects the K/L ratio and thus interest rate. Thus, the structural change channel kicks in immediately, whereas the demographic change channel operates with a delay.

Finally, recall that any change to the fiscal balance has to be compensated by adjustment in consumption tax rate to maintain stable debt-to-GDP ratio. Structural change and demographic change both imply fiscal consequences. For example, even if only transitory, a rise in the interest rate increases the costs of servicing the debt and thus triggers a rise in τ_c, unless it is fully compensated by a rise in revenues from other taxes. Unlike the case of the interest rate, the tax rate adjusts immediately to demographic change. This is because a rise in longevity implies higher saving and thus immediately lowers consumption. Unless the government revenue from taxing capital gains compensates a decline in consumption, τ_c has to rise. This evolution is portrayed in Figure B.3. Despite an immediate decline in tax rates due to structural change, the gradual introduction of demographic change pushes the tax rates up in the long run, mostly due to a decline in consumption share in GDP. The rise of consumption tax rate is lower in the $\theta = 4$ calibration because the rise in capital income tax base is larger in this calibration.

[4] Note that our consumers have perfect foresight, thus they accommodate for any variation in TFP. In reality, TFP variation is more of an aggregate shock, for which the consumers may want to make precautionary provisions, thus in general raising further voluntary savings.

Summarizing, structural change raises the interest rates which amplifies differences in asset holding within birth cohorts, thus raising within-cohort inequality. With higher interest rates all cohorts save more, which reduces between-cohort inequality and works towards reducing the Gini coefficient on wealth. In addition, structural change implies a decline in consumption taxes. As evidenced by Figure 3, the forces which reduce inequality quantitatively dominate. Demographic change in the form of rising longevity suppresses the interest rates and causes the taxes to rise, which amplifies inequality.

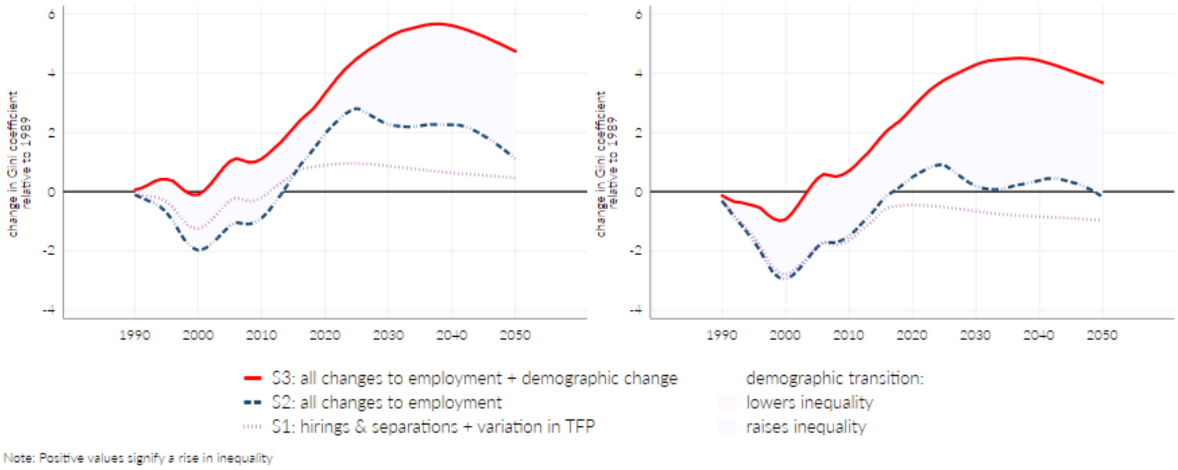
4.3 Counterfactual scenario: higher generosity of social security

The growth of wealth inequality is driven particularly strongly by the demographic transition. During the first three decades of transition, generosity of social security declined substantially. The effective replacement rate declined from roughly 60% to approximately 30%, which reinforced the precautionary motive related to rising longevity. We use our model to provide insights on the evolution of wealth inequality in the counterfactual scenario when the generosity of social security remains constant. This counterfactual analysis is relevant for two reasons. First, in the baseline simulations presented in section 4.1, old-age savings prove to be the main force behind rising inequality. Second, in the face of rising inequality stakeholders typically consider redistribution scenarios, which are intended to reduce dispersion of incomes or wealth. In our setup, labor supply is exogenous and variation in income is driven by idiosyncratic shocks, whereas wealth is endogenously accumulated and is used to smooth these shocks and co-finance old-age consumption. Thus, studying the role of social security is relevant from both the model and the policy perspective.

The counterfactual scenario keeps the replacement rates unchanged relative to the initial status quo, that is the social security is eventually twice as large as it is in the main simulations. Two mechanisms start operating. The first mechanism is related to income effect: expecting higher old-age pension benefits, the individuals who receive adverse income shocks are less concerned about accumulating wealth for the old age. Similarly, individuals who receive favorable income shocks are more concerned about accumulating wealth for old-age in order to maintain smooth consumption. Thus, this mechanism implies that greater generosity of social security *raises* dispersion in wealth accumulation and consequently wealth inequality. The second mechanism is related to a wealth effect: higher pension benefits for all reduce the overall incentives to save for old-age consumption, thus overall accumulation of capital is reduced, which narrows down the gap between people close to retirement (and the peak of wealth accumulation) and people at the extreme ends of the age spectrum (very young or very old) whose accumulated assets are close to zero. Summarizing, greater generosity of social security raises within cohort dispersion of wealth, but reduces the between cohort dispersion in wealth. It is an empirical question which of the two effects dominates. Furthermore, the role of structural change is not clear *a priori*. On the one hand, structural change reinforces the within cohort dispersion of wealth. On the other hand, the general equilibrium effects associated with the structural change, as discussed in section 4.2, attenuate its direct effect on wealth inequality.

The results portrayed in Figure 4 demonstrate that the forces raising inequality are quantitatively

Figure 4: Wealth inequality in a counterfactual economy with more generous social security



Note: the left panel shows the results for a calibration with $\theta = 2$ and the right panel shows them for a calibration with $\theta = 4$. Scenarios are additive: every next scenario includes the transition path of the previous scenario. The line denoted as "S1" accounts for time-varying evolution in TFP across manufacturing and services. The line denoted "S2" accounts *additionally* for an increase in educational attainment and decline of manufacturing shares. The line denoted "S3" accounts *additionally* for a rise in survival probabilities. The shaded area between the penultimate and the ultimate line quantifies the pure role of demographic change in an economy undergoing structural change. The behavior of macroeconomic indicators in the counterfactual economy with more generous social security is reported in Appendix C.

dominating the forces towards attenuating inequality. With more generous social security, the Gini coefficient on wealth would have increased by as much as 5 percentage points, or 50% more than when social security generosity declined in line with the data. The paramount role of income effect is consistent with the earlier results that demographic change may be the key driver of the early rise in wealth inequality, as the structural change leads to reduced inequality in the early decades of transition. As the demographic change fully realizes and structural change progresses, the rise of wealth inequality steepens. This rise is larger with more generous social security.

Note that the rise in inequality is larger in calibrations with moderate risk aversion (left panel) when compared to the high risk aversion environment (right panel). Also the role of structural change is larger for $\theta = 2$ simulations, indeed larger contribution from the structural change is the key driver of the higher rise in wealth inequality in the left panel. This is because in our setup lower generosity of pension benefits is actually consistent with lower transfers to households, which is equivalent to providing households with less insurance against income uncertainty. All households – rich and poor – raise their savings, which reduces wealth inequality. Hence, the precautionary motive can have an attenuating effect when all households raise savings, and an amplifying effect when only some of the households raise savings.

5 Conclusions

Our objective in this study was to isolate the role of structural change in an overlapping generations economy. Our setup is consistent with empirical regularities observed for Central and Eastern Europe:

most of the change in employment structure occurred via demographics (older cohorts leaving the declining sectors and younger cohorts with better educational outcomes joining the rising sectors).

With finitely-lived agents, changes in employment structure have different implications for the intra-temporal as well as inter-temporal choice when compared to infinitely lived agents. First and foremost, in models with infinitely lived agents, the inequality between-cohorts is absent. Admittedly, age and life expectancy at retirement are important determinants of the individual asset holding patterns and between-cohort differences. It takes an overlapping generations model to be able to reproduce these patterns and quantify them in a computational setup. Second, with finitely-lived agents, unless some specific friction is introduced, reallocation occurs instantaneously, preventing the emergence of income inequality and its transmission to wealth inequality. Empirical evidence shows that the structural change occurs mainly via generational exchange: the older agents exit the labor market over time and the choices of the young agents are different. Thus, in an OLG setup, the reallocation is by design gradual, reflecting the empirical patterns.

Our setup also features demographic change in the form of rising longevity. This demographic change is relevant for decision making of finitely-lived agents: longer lifespans at retirement incentivize greater wealth accumulation and thus boost the between-cohort inequality in wealth. In other words, demography is a powerful force for changes in wealth inequality whether or not structural change occurs. We add to the literature with infinitely-lived agents which analyzed the link between structural change and inequalities in incomes and wealth.

Our findings show that structural change *per se* lowers wealth inequality, at least initially. This finding is interesting because the intuition based on Kuznets curve suggests the opposite: during structural change inequality in incomes is expected to rise and propagate to inequality in wealth. However, with finitely lived agents, given the empirical regularity that probability of changing sector declines with age, this intuition is no longer valid. It is younger agents who change sectors, and older agents remain in the old sector. This friction slows down structural change, and leads to our main finding that wealth inequality declines.

In addition, while rising longevity implies a rise in wealth inequality, this rise is lower in an economy undergoing structural change. In fact, structural change reduces the growth in wealth inequality to about half of what it would have been without change in sectoral and educational composition of the labor force. Theoretically, it is possible that a more protracted and profound structural change than the one which we studied can effectively counterweight the effects of rising longevity on wealth inequality.

The new results of our paper are of concern to policy-making. Our novel model shows that redistributive policies at an old age (in our case: more generous social security) amplify wealth inequality rather than reduce it. In other words, governments face trade-offs between equalizing lifetime incomes and wealth during structural change, especially if it is accompanied by a rise in longevity, thus calling for caution in designing the redistributive instruments. This finding is particularly relevant given the fact that structural change is typically associated with compensating redistribution towards individuals hit by asymmetric job destruction and lower job creation. In addition to labor market policies, governments engage in redistribution towards working-age individuals (e.g. raise the generosity and duration of unemployment benefits, higher social assistance, etc.). These transfers may help to alleviate poverty and income inequality, but through general equilibrium effects and through demography channel, they amplify the initial rise in wealth inequality.

Our model delivers several novel results, but it also raises new questions. First, structural change is exogenous in our setup. With exogenous labor supply, all adjustment in our model occurs via inter-temporal choice. A model with endogenous structural change could deliver lower effects on wealth inequality, but this attenuation may be quantitatively immaterial, especially with labor market frictions. Second, due to data limitations, our calibration does not account for birth cohort-specific income uncertainty. Preliminary research into the US data demonstrates that later generations have higher variation and lower persistence of income shocks than earlier generations. This additional channel of structural change, especially in an endogenous setup, may reveal further non-linearities in the relationship between structural change, longevity and wealth inequality. Third, structural change can involve a change in consumption basket. In such setups, felicity from aggregated consumption is not a sufficient statistic and studying consumption inequality with diverse consumption goods can deliver further insights.

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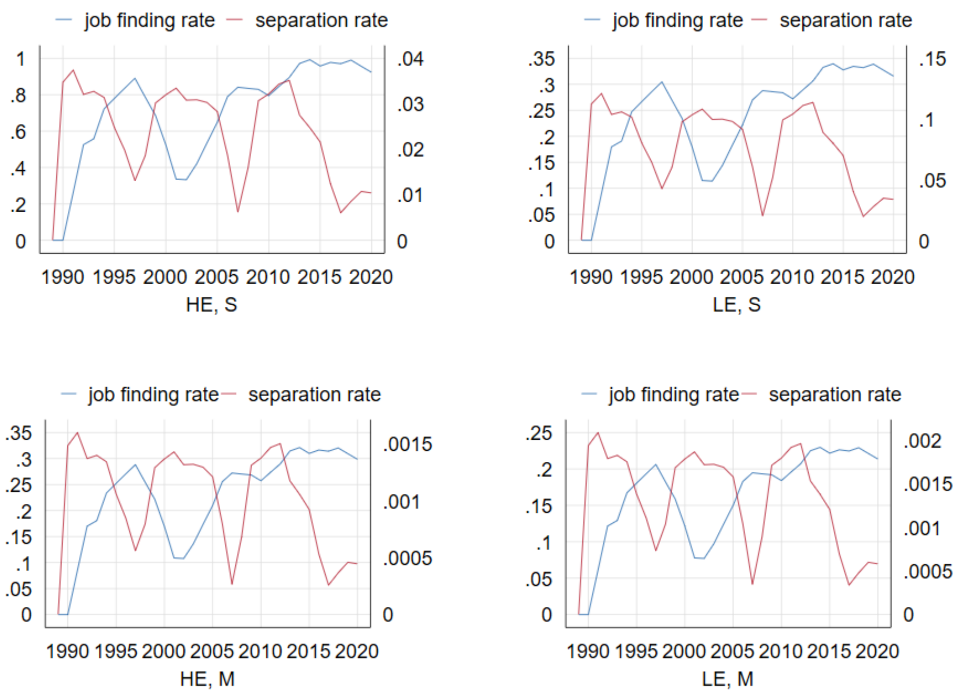
A Calibration

Table A.1: Tax revenue

Macroeconomic parameters		Calibration		OECD code
	risk preference	for $\theta = 2$	for $\theta = 4$	
τ_l	labor tax	12.2%	12.1%	1110
τ_c	consumption tax	16.1%	14.6%	5110, 5121
τ_k	capital tax	15.8%	14.6%	1120, 1200, 4100, 4400

Notes: Tax rates calibrations following Mendoza et al. (1994), using averages of tax shares in GDP from the years 1995-1999.

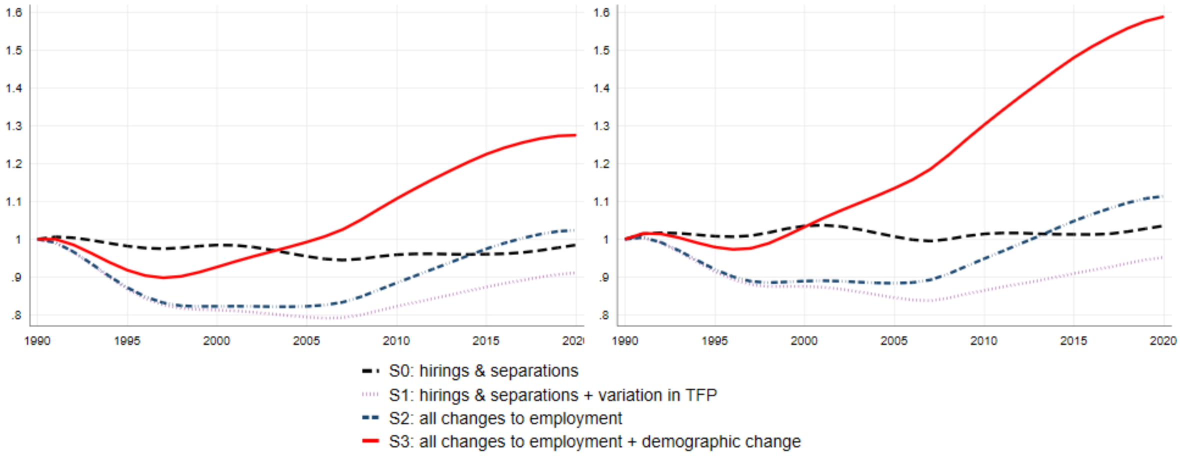
Figure A.1: Job flows



Note: The graph reports the separation rates and hiring rates across education levels and sectors. The rates were obtained using self-reported changes from the previous year. The data come from Polish Labor Force Survey.

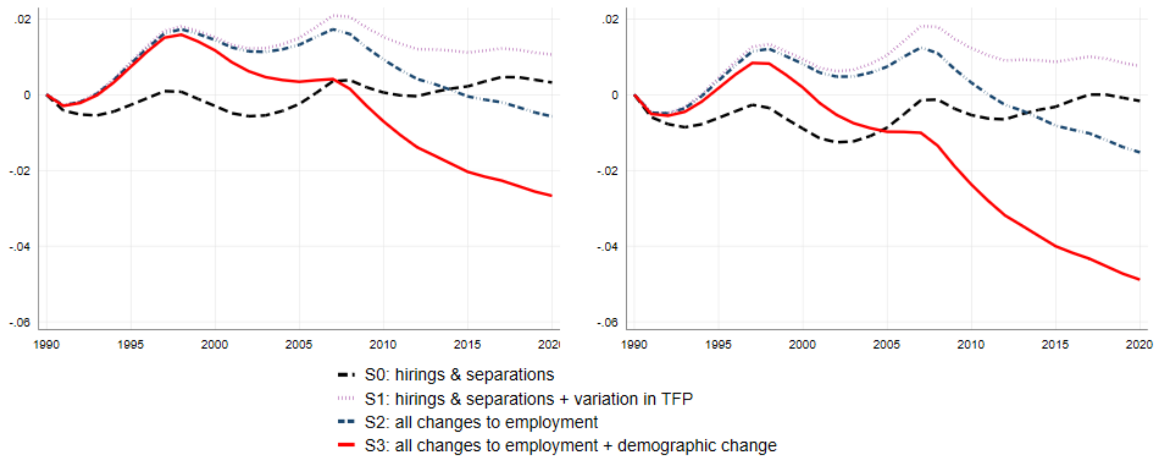
B Macroeconomic changes

Figure B.1: Aggregate stationarized capital (K_t/z_t): structural change vs. demographic change



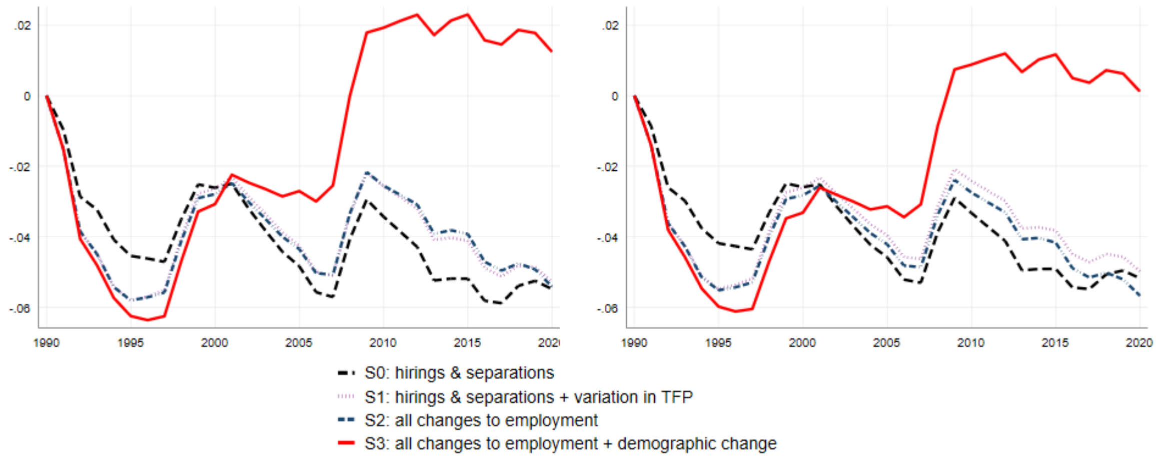
Note: Figure reports the aggregated capital across scenarios for the two calibrations considered in the study: $\theta = 2$ and $\theta = 4$. The changes in capital are expressed as a ratio to 1990, e.g., 1.2 denotes 20% increase.

Figure B.2: Interest rate (r_t): structural change vs. demographic change



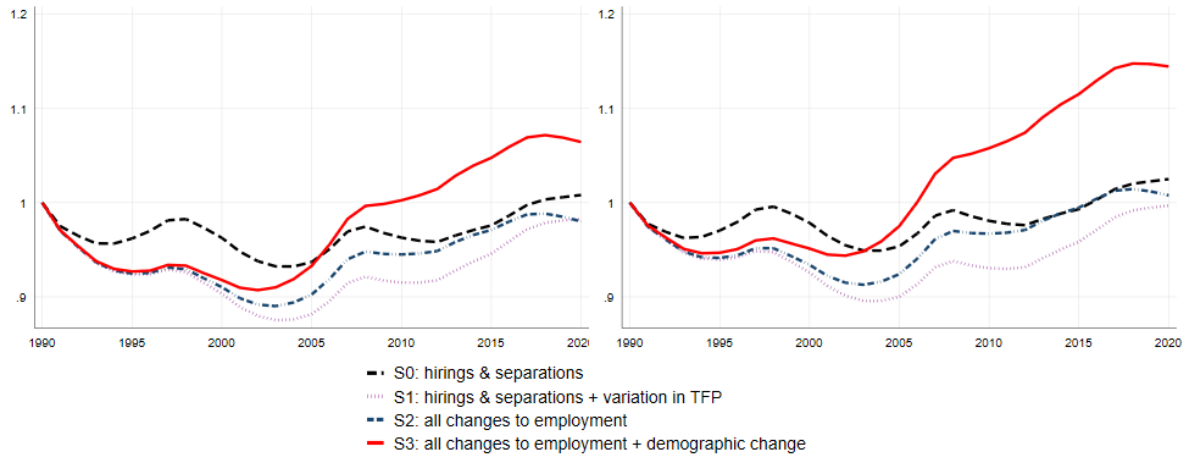
Note: Figure reports the interest rate across scenarios for the two calibrations considered in the study: $\theta = 2$ and $\theta = 4$. The changes in interest rates are expressed in terms of difference to 1990 level, e.g., 0.02 denotes 2 percentage points increase.

Figure B.3: Consumption tax (τ_c): structural change vs. demographic change



Note: Figure reports the consumption tax across scenarios for the two calibrations considered in the study: $\theta = 2$ and $\theta = 4$. The changes in consumption tax rates are expressed in terms of difference to 1990 level, e.g., 0.02 denotes 2 percentage points increase.

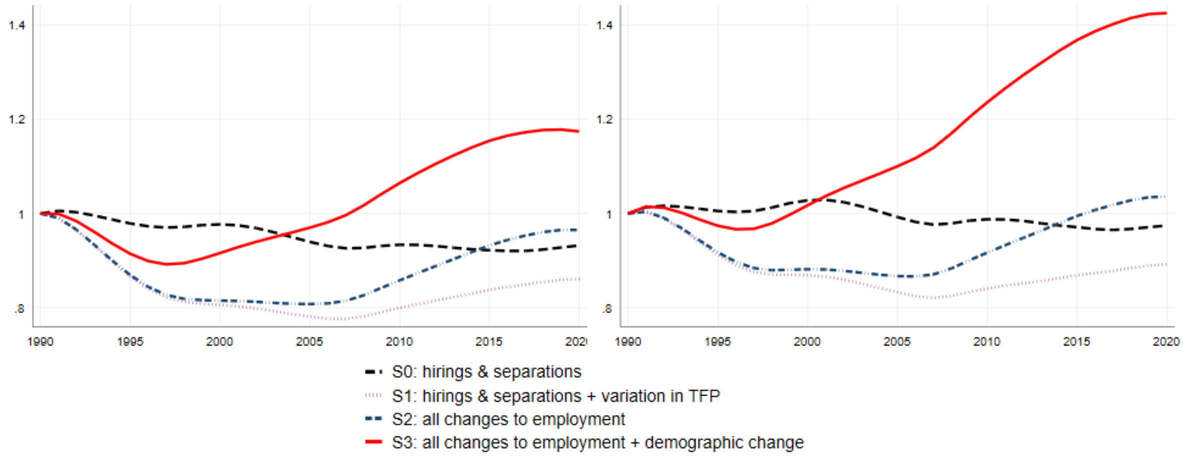
Figure B.4: Mean (effective) wage: structural change vs. demographic change



Note: Figure reports the mean wage across scenarios for the two calibrations considered in the study: $\theta = 2$ and $\theta = 4$. The effective wage is wage divided by productivity. The changes in mean wage are expressed as a ratio to 1990 level, e.g., 1.2 denotes 20% increase.

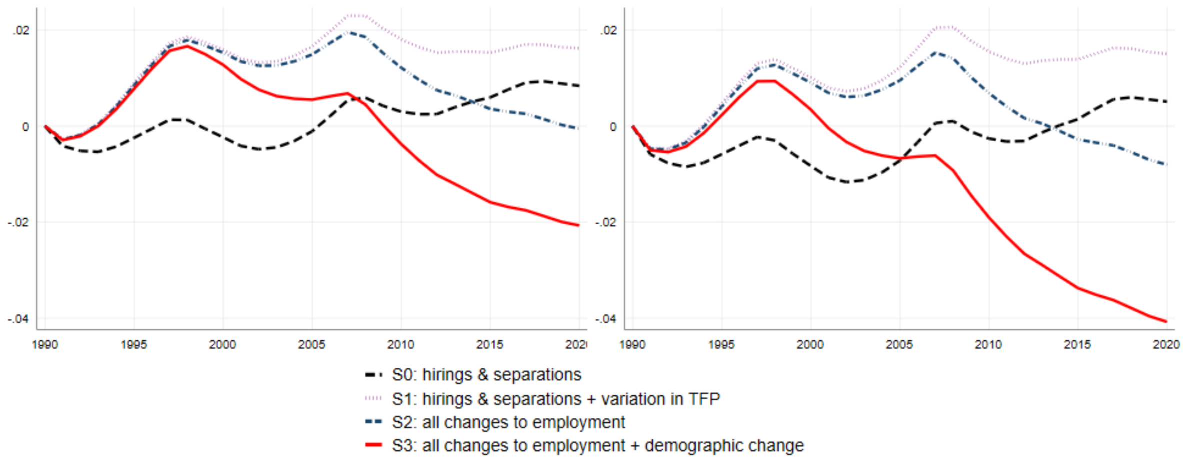
C Macroeconomic changes in the counterfactual economy

Figure C.1: Aggregated capital: structural change vs. demographic change



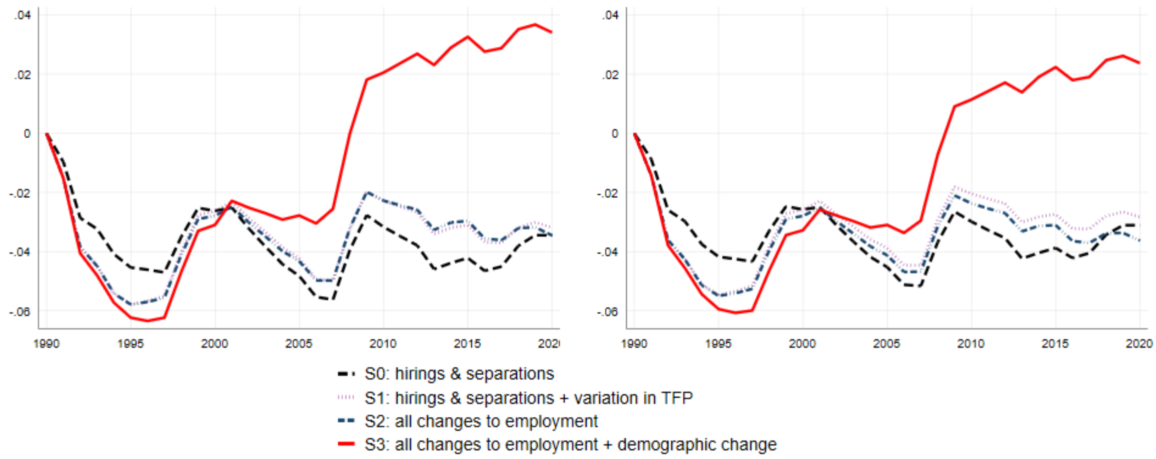
Note: Figure reports the aggregated capital across scenarios for the two calibrations considered in the study: $\theta = 2$ and $\theta = 4$. The changes in capital are expressed as a ratio to 1990, e.g., 1.2 denotes 20% increase.

Figure C.2: Interest rate: structural change vs. demographic change



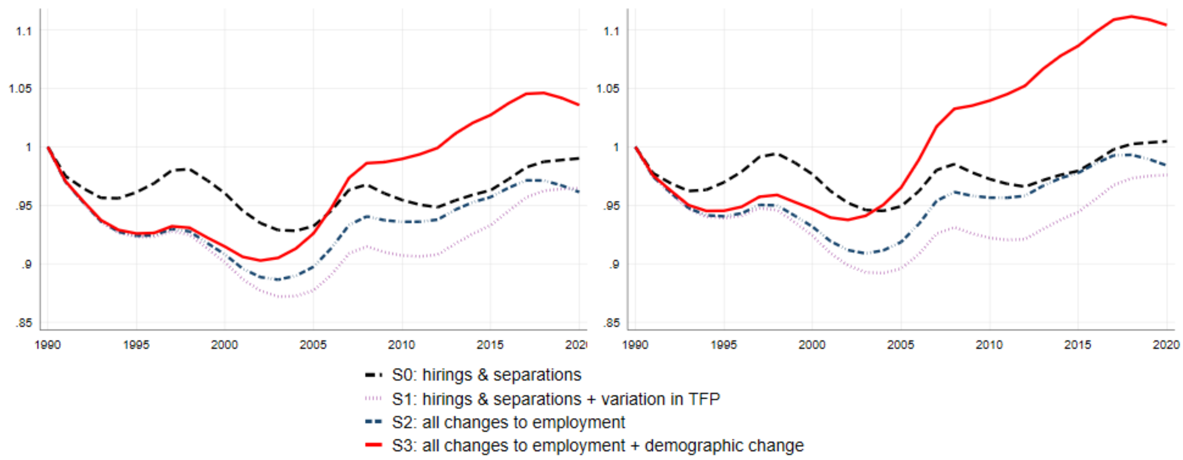
Note: Figure reports the interest rate across scenarios for the two calibrations considered in the study: $\theta = 2$ and $\theta = 4$. The changes in interest rates are expressed in terms of difference to 1990 level, e.g., 0.02 denotes 2 percentage points increase.

Figure C.3: Consumption tax: structural change vs. demographic change



Note: Figure reports the consumption tax across scenarios for the two calibrations considered in the study: $\theta = 2$ and $\theta = 4$. The changes in consumption tax rates are expressed in terms of difference to 1990 level, e.g., 0.02 denotes 2 percentage points increase.

Figure C.4: Mean wage: structural change vs. demographic change



Note: Figure reports the mean wage across scenarios for the two calibrations considered in the study: $\theta = 2$ and $\theta = 4$. The changes in mean wage are expressed as a ratio to 1990 level, e.g., 1.2 denotes 20% increase.