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Endogeneous Structural Change in General Equilibrium

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Abstract

We study the evolution of income and wealth inequality in an economy undergoing endogenous structural change with imperfect labor mobility. Our economy features two sectors: services and manufacturing. With faster TFP growth in manufacturing, labor reallocates from manufacturing to services. This reallocation is slower due to labor mobility frictions, which in turn, raises relative wages in services. As a result, income inequality is higher. Moreover, we study the impact of structural change on wealth inequality. Its economic intuition is more ambiguous. On the one hand, increased income dispersion implies increased dispersion in the ability to accumulate wealth across individuals. On the other hand, younger workers who hold the least assets are the most mobile across sectors. Their incomes are improved, which boosts their savings, which works towards equalizing wealth distribution. The consequence of these changes can only be verified with a computational model. To this end, we construct an overlapping generations model with two sectors: manufacturing and services. Our model also features heterogeneous individuals. With our model, we are able to show how the structural change affected the evolution of income and wealth inequality in Poland as of 1990.

Keywords: structural change, demographic change, inequality

JEL Classification: C68, D31, E21, J21

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1 Introduction and motivation

In this paper, we study the impact of structural change on income and wealth inequality in an economy with labor mobility frictions. In our economy, there are two sectors, one with faster technological growth, manufacturing, and the other with slower growing technology, services. The dominant models (for the exhaustive review see Herrendorf et al. 2014) with frictionless labor markets predict that structural change does not affect income or wealth inequality (see for example Hansen and Prescott 2002, Ngai and Pissarides 2007, Buera and Kaboski 2009). In such a framework, labor flows between sectors of the economy, and wages are equalized between them. It is inconsistent with empirical evidence. In the data, we observe a gradual change in employment and a rapid, hump-shaped change in wage ratio (Lee and Wolpin 2006, Ngai and Pissarides 2007). Makarski and Tyrowicz (2022) document a similar pattern for Poland during the economic transformation after 1989.

In contrast, in an economy with labor mobility frictions, the reallocation of labor between sectors is slower. Labor demand in manufacturing declines resulting in a decline in relative wages in this sector. At the same time, demand for labor rises in services, boosting wages there. Due to labor mobility frictions, this change in relative wages is persistent. Nevertheless, as more and more workers change the sector, the relative wage becomes closer to unity. Thus, in an economy undergoing structural change, wages become more dispersed in the medium term, and income inequality is higher.

The impact of structural change is ambiguous as far as its effects on wealth inequality are concerned. On the one hand, increased income inequality should generate dispersion in the ability to accumulate wealth across individuals. On the other hand, it benefits the incomes of younger workers who can potentially increase their asset holdings and usually hold the least assets. The net of these two opposing effects on wealth inequality can be verified only with a computational model. Furthermore, since wealth tends to be more persistent than income, the impact of structural change on inequality can be more persistent in the case of wealth than in the case of income. To study these questions, we construct a two-sector general equilibrium overlapping generations model with endogenous structural change.

Empirical literature shows that transition economies from the former Soviet Bloc and CEE countries experienced a rise in income and wealth inequality (Milanovic 1998, Flemming and Micklewright 2000, Milanovic and Ersado 2012). It was mostly attributed to market economies being more unequal than centrally planned, aiming to achieve greater equality. However, literature somehow overlooked the fact that those economies were experiencing profound structural change. This change involved not only the rise of the private sector but also the declining role of manufacturing (especially in terms of the employment share, which is the key for our analysis, less so in terms of the GDP share) and the rise of services. Empirical studies struggle with disentangling the aforementioned effects. First, there is no good panel data on incomes and wealth; most data on inequality are cross-sectional indicators. Second, it is hard to perform counterfactual experiments in observational data studies.

Structural models conveniently overcome these limitations. We study the effects of structural change in a two-sector computable general equilibrium overlapping generations model. We use the OLG model because it allows taking into account an essential feature of the data. Namely, as Tyrowicz and Van der Velde (2018) document, employment reallocation materialized mostly through older workers exiting the declining sectors and young workers entering primarily the rising sectors. Typically, individuals changing jobs stay in the same sector. Models typically used to study structural change feature infinitely lived agents, so they cannot replicate this stylized fact. Guilló et al. (2011) use an OLG model to study structural change, but only for comparative statics. We directly control for age, and thus we can incorporate this data feature into our model. Therefore, we fill an important gap in the literature. The novelty of our model is that there are two sectors, manufacturing and services, with agents endogenously choosing in which sector to work subject to labor mobility frictions.

In our model, relative wages are determined endogenously. We use information productivity growth across sectors and calibrate reallocation frictions to match the worker flows observed in the data. Equilibrium wages emerge from this process as the outcome of optimal sector allocation decisions by individuals. As is standard in OLG models, agents make consumption savings decisions that affect the accumulation of assets in this economy.

We bring two new results to the literature. First, the structural change temporarily raises income inequality, and the extent of this increase is determined by the degree of labor mobility frictions. The structural change materializes through older workers exiting the declining sector and younger workers entering mostly the emerging sector. Second, structural change also raises wealth inequality, and the effects on wealth inequality persist longer.

We build on several strands of literature. First, there is mentioned above literature on structural change in a frictionless environment. Second, there is literature on labor market frictions which improved our understanding of the effects of new technology adoption on employment (see Mortensen and Pissarides 1998, Pissarides and Vallanti 2007, Miyamoto and Takahashi 2011, among others). Third, the literature on structural change, with Alonso-Carrera and Raurich (2018) arguing that wage gaps are essential for jointly explaining the structural change in the sectoral composition of both GDP and employment (see also Sim and Oh 2017, for the case of Japan). Fourth, literature on the "optimal speed of transition" from the centrally planned to the market economy for CEE countries (Aghion and Blanchard 1994, Castanheira and Roland 2000, Tichit 2006).

Our paper is structured as follows. The model setup is presented in section 2. Sections 3 and 4 detail the calibration of the model and our treatment of structural change, respectively. Next, we present results in section 5. The final section concludes.

2 The model

We construct a two-sector computable general equilibrium, overlapping generations model. The model features endogenous structural change: the manufacturing sector declines and the service sector expands. Furthermore, our OLG model features demographic transition: the arriving young cohorts decline in size, and life expectancy rises for subsequent birth cohorts.
To address the issue of inequality, consumers in our model are heterogeneous with respect to two factors. First, they work either in manufacturing or services, with wages determined endogenously in each sector. Second, they are exposed to idiosyncratic income shocks (referred to as *ex-post* heterogeneity). Moreover, following empirical evidence, we do not allow working individuals to change the sector. Tyrowicz and Van der Velde (2018) show that structural change in employment happened through older workers exiting declining sectors and younger workers entering growing sectors. In our framework, to reflect this stylized fact, we allow only new workers to select a sector where they work (after incurring a cost). They continue to work in the chosen sector until retirement.

Demographics Individuals live for $j = 1, 2, ..., J$ periods. One period in our model corresponds to 1 year. The first period of life $j = 1$ corresponds to the age of 21, which usually is the age individuals enter the labor market. At $\bar{J} = 40$ they retire. Finally, they die at the age of $J = 80$.
Each individual works in one of the two production sectors $h \in \{m, s\}$, where m denotes manufacturing and s services. The relative population share of each type in the economy is denoted by $\chi_{j,h,t}$. The size of the population of each age j in period t is denoted as $N_{j,t}$. The total share of individuals working in sector h is given by $\chi_{h,t} = \sum_{j=1}^{\bar{J}} \chi_{j,h,t} N_{j,t} / \sum_{j=1}^{\bar{J}} N_{j,t}$.

Incomes Each individual has idiosyncratic productivity denoted by type-specific $\eta_{j,h,t}$. Individual productivity follows a stochastic AR(1) process:

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

where $\epsilon_{j,h,t} \sim N(0, \sigma^2_{\eta,h})$. We discretize this process and approximate it by a 5-state discrete-time Markov process with the transition matrix $\Pi(\eta_{j,h,t} \| \eta_{j-1,h,t-1})$. Labor income received is the product of the marginal productivity of labor in a given sector ($w_{h,t}$ defined later) and the individual productivity component. Hence an individual working in sector h with individual productivity $\eta_{j,h,t}$ earns $\eta_{j,h,t} w_{h,t}$. Individual productivity equals zero once an individual reaches retirement age, $\eta_{j,h,t} = 0$ for $j \geqslant \bar{J}$. Labor supply is inelastic: each agent supplies one unit of labor.

Social security Individuals retire at age $\bar{J}$. Individuals contribute τ share of their labor income to social security during the working period. Social security

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contributions are exempt from labor income taxation. The retired workers receive social security benefits $b_{j,h,t}$.
At retirement, the value of the benefits for the individual working in sector h, $b_{j,h,t}$, is obtained by multiplying the replacement rate ρ by the average wage in this sector prior to retirement. After retirement, pensions are indexed with the payroll growth rate γ_w (to be defined later).

$$b_{j,h,t} = \begin{cases} 0 \quad \text{for} \quad j < \bar{J} \\ \rho w_{h,t-1} \quad \text{for} \quad j = \bar{J} \\ b_{j-1,h,t-1} \times (1+\gamma_w) \quad \text{for} \quad j > \bar{J} \end{cases} \tag{2}$$

Budget constraint Working-age household of age j in period t working in sector h with individual productivity component $\eta_{j,h,t}$ earns labor income $\eta_{j,h,t} w_{h,t}$, where $w_{h,t}$ denotes the sector-specific marginal product of labor. Labor income 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. Retired households receive pension benefits $b_{j,h,t}$, which are exempt from income taxation. In addition to salary, the 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).
In each period, households decide how much income to spend on the consumption of manufacturing goods $c_{m,j,h,t}$ and services $c_{s,j,h,t}$, which are subject to consumption tax $\tau_{c,t}$, and how much assets $a_{j+1,t+1}$ to accumulate. We denote the price of services as $p_{s,t}$ and manufacturing as $p_{m,t}$, with the latter normalized to one. Asset markets are incomplete; only assets with the risk-free interest rate r_t are available. Summarizing, households face the following budget constraint:

$$\begin{aligned} (1+\tau_{c,t})(c_{m,j,h,t} + p_{s,t} c_{s,j,h,t}) + a_{j+1,h,t+1} \quad &= \\ = (1-\tau_{\ell,t})(1-\tau) w_{j,h,t} \quad &+ \quad b_{j,h,t} + (1+(1-\tau_{k,t}) r_t) a_{j,h,t} \end{aligned} \tag{3}$$

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

Consumer problem The state of the world $s_{j,h,t}$ for an individual of age j at time t is given by the level of private assets $a_{j,h,t}$ and individual productivity determined by $\eta_{j,h,t}$, $s_{j,h,t} = (a_{j,h,t}, \eta_{j,h,t}) \in \Omega_h$. At each state $s_{j,h,t}$, the household maximizes the expected value of the remaining lifetime utility

$$\begin{aligned} V_{j,h,t}(s_{j,h,t}) \quad &= \max_{(c_{m,j,h,t}, c_{s,j,h,t}, a_{j+1,h,t+1})} u(c_{m,j,h,t}, c_{s,j,h,t}) + \\ &+ \quad \delta_h \mathbf{E}_t \big(V_{j,h,t+1}(s_{j+1,h,t+1}) \mid s_{j,h,t} \big), \end{aligned} \tag{4}$$

subject to the budget constraint given by equation (3), formulas for pensions given by (2), and the productivity process given by equation (1). 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 $\mathbb{P}_{j,h,t}$. Moreover, the instantaneous utility function is given by

$$u(c_{m,j,h,t}, c_{s,j,h,t}) = (1-\vartheta_t)\ln c_{m,j,h,t} + \vartheta_t \ln c_{s,j,h,t} \tag{5}$$

It is convenient to define aggregate consumption of manufacturing $C_{m,t}$, services $C_{s,t}$, and aggregate asset holdings A_t as follows

$$C_{m,t} = \sum_{j=1}^{J} \sum_{h\in\{m,s\}} \left(\int_{\Omega_h} c_{m,j,h,t}(s_{j,h,t}) d\mathbb{P}_{j,h,t} \right) \chi_{j,h,t} N_{j,t} \tag{6}$$

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

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

Reallocation A newborn household enters the economy with no assets ($a_{1,h,t} = 0$) and is assigned to sector h with probability given by the share of last period employment in this sector $\chi_{h,t-1}$. Only newborn households can move from sector h to the other sector denoted as $\neg h$ after incurring the cost ϱ_t, expressed in real units. This measure involves utility loss rather than a reduction in resources. Households change sector from the initial allocation when the consumption equivalent gain from changing the sector $CE_{h,t}$ is higher than the cost, i.e.

$$\mu_{h,t} = 1 + CE_{h,t} \geqslant 1 + \varrho_t \tag{9}$$

where the following formula gives the consumption equivalent

$$E_t[\sum_{j=1}^{J} u(\mu_{h,t} c_{m,j,h,t+j-1}, \mu_{h,t} c_{s,j,h,t+j-1})] = E_t[\sum_{j=1}^{J} u(c_{m,j,\neg h,t+j-1}, c_{s,j,\neg h,t+j-1})]. \tag{10}$$

The trade-offs involve the relative level of aggregate wages ($w_{h,t}$) as well as properties of the income processes ($\eta_{j,h,t}$). The trade-offs involve the working and retirement periods, as pension benefits are derived from earned income. Note that the household has perfect foresight concerning the macroeconomic aggregates in the model, whereas the properties of the income processes reproduce through the transition. Consequently, the choice established at $j = 1$ in a given time t is optimal for a given individual until J at time $t + J$. As we discuss in the introduction section, the assumption that only young workers can change sectors is supported by the data as reported by Tyrowicz and Van der Velde (2018).

Firms We assume firms operate in a perfectly competitive environment. In both manufacturing and services, $h \in \{m, s\}$ firms produce their output $Y_{h,t}$ by combining capital $K_{m,t}$ and labor $L_{m,t}$ with the Cobb-Douglas technology

$$\forall_h : Y_{h,t} = K_{h,t}^{\alpha_h}(z_{h,t}L_{h,t})^{(1-\alpha_h)} \tag{11}$$

where $z_{h,t}$ denotes exogenous sectoral labor-augmenting technological progress, consistent with Smeets Kristkova et al. (2017). Recall we denote prices of manufacturing and services, with the former normalized to one, as $p_{m,t}$ and $p_{s,t}$, respectively. Firms maximize profits

$$\forall_h : \max_{Y_{h,t},L_{h,t},K_{h,t}} p_{h,t}Y_{h,t} - w_{h,t}L_{h,t} - (r_t + d)K_{h,t} \tag{12}$$

subject to the production function (11). We use the price of manufacturing goods as numeraire, $p_{m,t} = 1$. Note that since capital is perfectly mobile across sectors, the return on capital is equal across sectors, and the real interest rate r_t is given by

$$r_t = \alpha_m K_{m,t}^{(\alpha_m-1)}(z_{m,t}L_{m,t})^{1-\alpha_m} - d = p_{s,t}\alpha_s K_{s,t}^{(\alpha_s-1)}(z_{s,t}L_{s,t})^{1-\alpha_s} - d \tag{13}$$

However, labor is not perfectly mobile across sectors, so, in principle, the marginal product of labor $w_{h,t}$ can differ across sectors and is given by:

$$w_{h,t} = (1-\alpha_h)K_{h,t}^{\alpha_h}(z_{h,t}L_{h,t})^{1-\alpha_h}L_{h,t}^{-1} \tag{14}$$

It is convenient to define the average wage in each sector by $\bar{w}_{h,t} = w_{h,t}L_{h,t}/\sum_{j=1}^{j=\bar{J}-1} N_{j,h,t}$, the average wage in the economy $\bar{w}_t = \bar{w}_{m,t}\chi_{m.t} + \bar{w}_{s,t}\chi_{s.t}$. Finally, the payroll growth is given by $\gamma_w = \sum_h w_{h,t}L_{h,t}/\sum_h w_{h,t-1}L_{h,t-1} - 1$.

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

$$G_t + subsidy_t + r_t D_t = \tau_{c,t}\sum_h C_{h,t} + \tau_\ell(1-\tau)\sum_h w_{h,t}L_{h,t} + \tau_k r_t A_t + (D_{t+1} - D_t) \tag{15}$$

where the social security of pay-as-you-go character has the following budget constraint:

$$\sum_{j=\bar{J}}^{J}\sum_{h\in H} b_{j,h,t}N_{j,h,t} = \tau_t \sum_h w_{h,t}L_{h,t} + subsidy_t, \tag{16}$$

Throughout the path, we keep tax rates fixed at their initial steady state levels, calibrated to data. We use the government expenditure to satisfy the government budget imposed by (15).

Market clearing Finally, we have market clearing conditions. The labor market clearing in sector h requires

$$L_{h,t} = \sum_{j=1}^{\bar{J}} \left(\int_{\Omega_h} \xi_{h,t} \eta_{j,h,t} d\mathbb{P}_{j,h,t} \right) \chi_{j,h,t} N_{j,t}. \tag{17}$$

We assume that the government purchases manufacturing goods and services in the same proportion as the private sector. Hence, in each sector, market clearing requires

$$C_{m,t} + X_t + \frac{Y_{m,t}}{Y_{m,t} + p_{s,t} Y_{s,t}} G_t = Y_{m,t} \tag{18}$$

$$C_{s,t} + \frac{p_{s,t} Y_{s,t}}{Y_{m,t} + p_{s,t} Y_{s,t}} G_t = Y_{s,t} \tag{19}$$

where X_t denotes the investment in capital,

$$K_{m,t+1} + K_{s,t+1} = X_t + (1-d)(K_{m,t} + K_{s,t}) \tag{20}$$

Finally, asset market clearing requires

$$K_{m,t+1} + K_{s,t+1} + D_{t+1} = A_{t+1} \tag{21}$$

2.1 Equilibrium and model solving

Next, we define a competitive equilibrium for our economy. For this definition, recall that households make two types of decisions. First, after they enter the labor market, they decide whether to stay in the same sector to which they are assigned or to change it. Once they settle on the sector and in later periods of their life, they make standard decisions on how much to save and consume. 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*

$$\{(((c_{m,j,h,t}(s_{j,h,t}), c_{s,j,h,t}(s_{j,h,t}), a_{j+1,h,t+1}(s_{j,h,t}))_{h\in H})_{j=1}^{J}\}_{t=0}^{\infty},$$

prices $\{p_{s,t}, r_t, w_{m,t}, w_{s,t}\}_{t=0}^{\infty}$*, government policies* $\{\tau_{c,t}, \tau_k, \tau_\ell, D_{t+1}\}_{t=0}^{\infty}$*, social security parameters* $\{\tau, subsidy_t, \rho_t\}_{t=1}^{\infty}$*, consumption equivalents for newborn agents* $\{(CE_{h,t})_{h\in H}\}_{t=0}^{\infty}$*, aggregate quantities* $\{(Y_{h,t}, L_{h,t}, K_{h,t}, C_{h,t})_{h\in H}, A_t, X_t\}_{t=0}^{\infty}$*, and a measure of households* $\{(\mathbb{P}_{j,h,t})_{h\in H}\}_{t=0}^{\infty}$ *such that:*

i) ***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 consumer problem* (4) *given prices and government policies;*

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ii) ***sector choice:*** *each newborn agent with reallocation cost* ϱ_t *assigned to sector* h *switches sector if* (9) *is satisfied;*

iii) ***firm problem:*** *for each* t *and* h*,* $(Y_{h,t}, K_{h,t}, L_{h,t})$ *solves the firm problem* (12) *given prices;*

iv) ***government sector:*** *the government budget and the PAYG pension system constraints are satisfied, i.e., equations* (15) *and* (16) *are satisfied;*

v) ***markets clear****, i.e.* (17) - (21) *together with* (6) - (8) *are satisfied.*

vi) ***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.*

In order to solve our model, first, we solve the consumer problem with value function iterations with the endogenous grid method. 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 use piece-wise linear interpolation for both policy and value functions. Once we find the policy functions from the consumer problem, we move on to the newborn agent's problem. We determine which direction agents want to reallocate (from services to manufacturing or vice versa) and allow a fraction of agents to reallocate. First, we solve the initial and final steady state. We obtain a larger share of workers in manufacturing in the final steady state. In order to avoid cycles on the transition path, we allow workers only to move from manufacturing to services. Next, we can compute the distribution of agents over the state space given the initial distribution $\hat{\mathbb{P}}_{1,h,t}$ at age $j = 1$ in time t, the transition matrix $\Pi(\eta_{j,t}|\eta_{j-1,t-1})$, and the policy functions $\{a_{j+1,t+1}(\hat{s}_{j,t})_{j=1}^{J}\}_{t=1}^{\infty}$.
Finally, we compute aggregate quantities using the Gaussian quadrature method and apply the Gauss-Seidel algorithm to iterate over the general equilibrium quantities. In each iteration, the value of aggregate capital is updated until the difference between the aggregate capital from subsequent iterations is negligible, i.e., l_1-norm of the difference between a capital vector in subsequent iterations falls below 10^{-12}.

3 Calibration

The model is calibrated to replicate the structural change in the Polish economy that took place between 1990 and 2020. For the purposes of the simulation, we ignore changes to the social security and tax systems during the transition path. While there was some evolution in the tax rates, these changes affected workers in both sectors in the same way. Likewise, we ignore changes in the social security system (the literature focusing on the reform was covered by Stroinski 1998, Hausner 2002, Góra 2014, Makarski et al. 2017). The initial steady state is based on the data for 1990-2000.

3.1 Main model parameters

Idiosyncratic productivity shocks, η No panel data is available for Poland. We thus rely on idiosyncratic shocks using the Socio-Economic Panel (SOEP) for Germany, following the approach of Fehr et al. (2013). The idiosyncratic component is specified as a first-order autoregressive process. We estimate the stochastic process separately for services and manufacturing. We obtain autoregression $\varrho_{s,\eta} = 0.9447$ for the individuals working in services and $\varrho_{m,\eta} = 0.9819$ in manufacturing. Likewise, we obtain the variance for those in services at $\sigma_{s,\eta} = 0.0125$ and in manufacturing $\sigma_{m,\eta} = 0.0065$. The productivity shocks are constant over time and birth cohorts.

Production function We use the National Accounts to establish capital share (α) in manufacturing and service sectors. We obtain the values of 0.42 and 0.51, respectively.

Preferences and depreciation We set the discount factor δ at 0.999 and the depreciation rate d at 2.1% to match jointly the interest rate of approximately 6%. and the investment rate of approximately 21%. Unfortunately, we cannot match the latter, which equals 26.6%. Since this variable is not key to our study, we keep it at that level.

Social security parameters Retirement age eligibility occurs at 60, 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 set the parameters driving the share of expenditure on pensions in GDP, $\rho = 0.215$, so that initial steady state subsidies to the pension system equal zero.

Taxes Taxes are calibrated using Mendoza et al. (1994) approach. The capital income tax is set to 11.5% to match 4.0% ratio of the capital income tax revenues to GDP in the 1990s. The marginal tax rate consumption is set to 19.3% to match 10.7% ratio of consumption income tax revenues to GDP in the initial steady state. The labor tax rate is set to 16% 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 1. We set the government expenditure to GDP ratio in the initial steady state to 0.27 to close the budget and match the debt to GDP ratio at 50%. On the transition path and in the final steady state, the government expenditure is adjusted to satisfy the government budget constraint given by equation (15).
The calibration details are summarized in Table 1.

Table 1: Calibrated parameters

Model parameters		Calibration		Target	Value (source)	Model outcome
Income shocks		services	mfg.			
$\varrho_{h,\eta}$	shock persistence	0.9447	0.9819		estimation	
$\sigma_{h,\eta}$	shock variance	0.0125	0.0065		estimation	
Calibrated for $t \in < 0, 2 >$ using the targets from 1990s						
τ_ℓ	labor tax	16%		revenue (% GDP)	7.3% OECD	7.2%
τ_c	consumption tax	19.3%		revenue (% GDP)	10.7% OECD	11.2%
τ_k	capital tax	11.5%		revenue (% GDP)	4.0% OECD	4.5%
$\bar{J}$	retirement age	40		OECD		
τ	social security contr.	14.2%		benefits (% GDP)	7.5% OECD	7.4%
ρ	replacement rate	21.5%		$subsidy_{t=0}/Y_{t=0}$	0	0
δ	discounting rate	0.999		int. rate	-	6.6%
d	depreciation rate	2.1%		inv. rate	-	26.6%
$\gamma_{h,t}$	productivity growth	0.2%	3%		Growiec et al. (2015)	
α	capital share	0.42	0.51		NA data	
ϑ	preference	0.61		empl. share in manuf.	55% (data)	55%

4 Structural change

To build intuition, it is convenient to strip the model to basics, simplifying the setup to have no capital and no social security. Then, with our preferences, assuming constant ϑ, each agent spends a constant share of income on both types of goods. Substituting this finding into the market clearing conditions (18)-(19) and denoting GDP as Y_t we get

$$Y_{m,t} = z_{m,t} L_{m,t} = (1-\vartheta) Y_t = (1-\vartheta)(Y_{m,t} + p_{s,t} Y_{s,t}) \tag{22}$$

$$p_{s,t} Y_{s,t} = p_{s,t} z_{s,t} L_{s,t} = \vartheta Y_t = \vartheta (Y_{m,t} + p_{s,t} Y_{s,t}) \tag{23}$$

Intuition absent labor mobility frictions Absent labor mobility frictions, wages in both sectors are equalized, and given that wages are equal to the value of marginal product (14), we get the following formula which determines the relative price of services:

$$w_{m,t} = z_{m,t} = p_{s,t} z_{s,t} = w_{s,t} \tag{24}$$

Summarizing, higher productivity growth in manufacturing translates into higher production in manufacturing.
Note that with constant shares of expenditure on both goods by consumers, higher growth of productivity in manufacturing would necessitate the reduction of the labor force in manufacturing. How would it happen? The wage equalization condition shows that the relative price of services goes up, or, in other words, the relative price of manufacturing has to go down. This mitigates the increase in production of manufacturing driven by productivity growth.
A rise in the relative price of services raises the demand for labor in this sector. In order to respond with higher supply to an increasing relative price, labor has to reallocate from manufacturing to services. This shift enables an increase in the production of services, limits the growth of production of manufacturing, and is crucial for adjustments.

Intuition with labor mobility frictions In parallel to the frictionless scenario, the supply-induced decline in the relative price of manufacturing is reinforced by a demand-induced increase in the relative price of services. The main difference to the frictionless scenario is that the wage equalization condition no longer holds. Since workers cannot reallocate freely, the change in relative prices cannot be mitigated. Thus the relative price of services increases even more than in the case of free labor mobility. It lowers wages in manufacturing below the level in services due to excess labor supply in manufacturing.

Further mechanisms in the model Note that changes in (relative) productivity can drive structural change, but changes in tastes can also drive it. The tastes are

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operationalized by the preference parameter ϑ. It can vary over time, reflecting the shift of consumer preferences away from goods and towards services. Shifts in ϑ may either be the sole driver of the reallocation of workers or reinforce the reallocation induced by changes in relative productivity $\gamma_{h,t}$.

4.1 Productivity growth, γ

The model specifies labor augmenting technological progress in each sector with the growth rate given by $\gamma_{h,t+1} = z_{h,t+1}/z_{h,t} - 1$. Following, Growiec et al. (2015) we assume that the growth in manufacturing sector equals $\gamma_{m,t} = 3\%$ and $\gamma_{s,t} = 0.2\%$ in services. Furthermore, we assume that the productivity growth in both sectors remained constant over the transition period and was the same in both the initial and final steady state.

4.2 Reallocation of workers

Our primary focus in this paper is structural change. We match the rate of change to the observational data. To this end, we rely on individual-level data from the Polish Labor Force Survey (PLFS) and obtain shares of youth employed in manufacturing and services each year since 1993. Youth entry is defined as an individual aged 18-25 who was in education the previous year and is currently employed in one of two sectors. We drop employment in agriculture and non-market services. We report this evolution in Figure 1.

Our model replicates the flows of young workers as observed in the data. We use between the earliest available year, 1993 and 2020, to obtain the shares of salaried workers employed in the manufacturing sector and services. We obtain these shares for all workers and the labor market entrants. In the initial steady state, we calibrate the preference parameter ϑ_t to replicate the share workers employed in manufacturing equal to 55% and 45% in services, $\chi_{m,t}, \chi_{s,t}$ respectively. This value is set to 0.61. However, it does not have a clear economic interpretation. Note that the relative wage ratio equals one in the initial steady state.

We operationalize the reallocation of workers as changes in the shares of individuals entering the labor force $\chi_{1,m,t}, \chi_{1,s,t}$, as per Figure 1. We match these targets by varying the value of the preference parameter ϑ_t. In our model, setting $\chi_{1,m,t}, \chi_{1,s,t}$ determines merely the share of labor market entrants. Relative wages for all age groups across both sectors are determined endogenously, given the stock of all economically active households employed in both sectors, as well as macroeconomic parameters. Thus, labor income inequality (and thus consumption and wealth inequality) emerge endogenously in the model.

The preference parameter ϑ_t evolves gradually, reflecting the gradual change in employment shares, as reported in Figure 1. This friction changes slowly to prevent immediate adjustment in employment shares. However, due to perfect foresight, the shift from the initial steady state to the transition path generates a large-scale reaction

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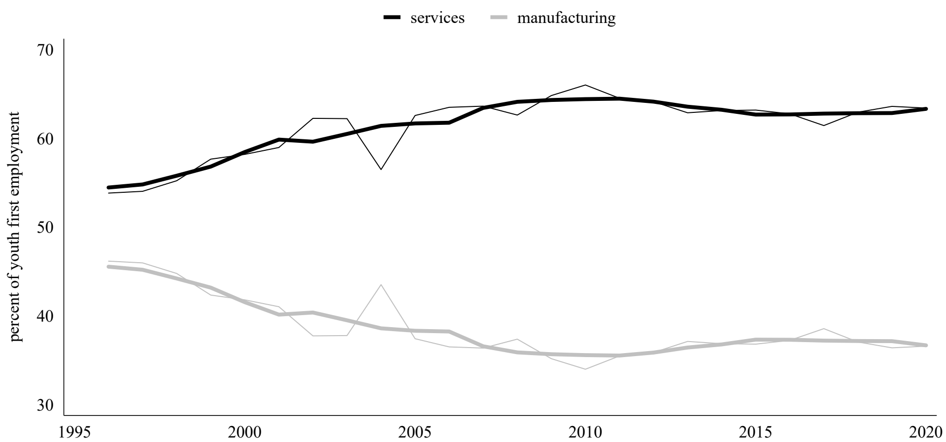
Figure 1: Youth labor market entry to manufacturing and services



Note: PLFS was first fielded in 1992, but sectors, according to NACE, are only available as of 1993, which we use as our initial employment shares. We drop employment in agriculture and non-market services. The manufacturing sector comprises the following sections: mining and quarrying, construction, industrial production, and utilities. The service sector comprises all market services: wholesale and retail trade, repairs, transporting and storage, accommodation and food service activities, information and communication, financial and insurance activities, real estate activities, and professional activities. Smoothed data were obtained with the use of a four-year moving average filter.

by households. In other words, while the share of young entrants starting in the service sector increases slowly, and the analogous share for the manufacturing sector declines slowly – the real wages may adjust rapidly, reinforcing or dampening the incentives to reallocate.

5 Results

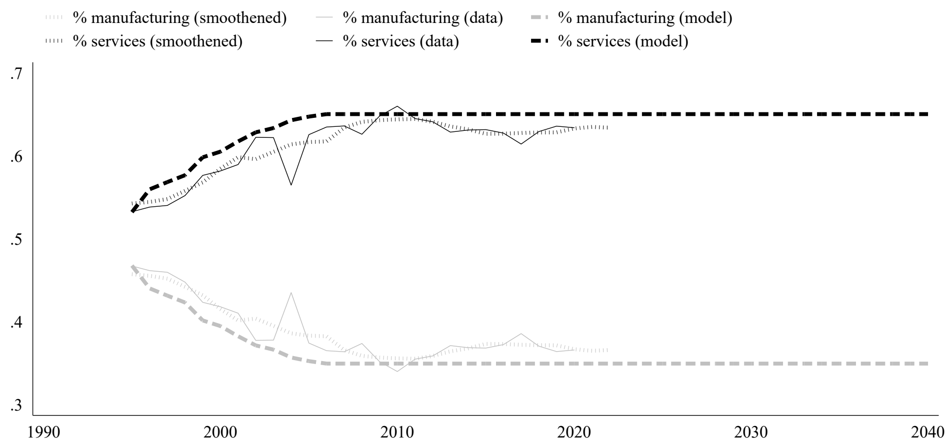
We study structural change for the baseline scenario, where all parameters of the structural change are marked to the data. We assume that two processes drive structural change. First, the TFP growth in the manufacturing sector, which amounts to 3% per annum, is higher than in services, which is 0.2% per annum, following the evidence by Growiec et al. (2015). Second, there is a shift in consumer tastes toward services. We use the preference parameter (ϑ_t) to match the shares of services and manufacturing in GDP and employment in the initial steady state, as described in section 3. We assume that over the next three decades, the employment shares gradually change from 45% in services (55% in manufacturing) to 65% in services

(and 35% in manufacturing). This implies a change in the preference parameter ϑ_t from 0.61 to 0.92.
We model both processes as gradual linear changes of ϑ_t that spread over almost thirty years, after which we assume that consumer preferences remain constant, i.e., the changes are assumed permanent. To match the transition of employment shares to the data, we also use labor mobility frictions. In our baseline calibration, the threshold for labor mobility cost ϱ_t was set to 1.09% of lifetime consumption in the first period of labor market transition to match the share of youth entry into manufacturing (see Figure 3). It slowly declines to reach 0% in 2020.
Frictions are calibrated to match the rate of change in youth employment matched to the data. It is portrayed by the change in youth employment shares in Figure 2. Since individuals choose an employment sector once in their lifetimes, total employment shares converge to youth employment shares. The share of youth employment in manufacturing and services was taken from Labor Force Survey for Poland, published quarterly by Statistics Poland. We take a technical assumption that currently, observed employment shares continue to the final steady state. The implied original level of friction to match the shares in the initial steady state equals 0.014. It gradually declines to zero over the next thirty years and remains zero henceforth.
We also present results for two counterfactual scenarios. In the first counterfactual, we assume that the labor mobility friction, ϱ, is 25% higher than the baseline portrayed in Figure 2. In the second counterfactual, we assume that the labor mobility friction, ϱ, is 25% lower than the baseline. These two scenarios inform about the potential range of implied labor income and wealth inequality.
We present the results in three substantive parts. First, we discuss the labor market flows with endogenous structural change. We show the flow of young workers and the implied rate of change in the total employment structure. Second, we demonstrate how it affects labor income and wealth inequality. Note that income shocks and structural change drive income inequality: our households do not choose labor supply *per se*, whereas wages are determined in general equilibrium. Admittedly, capital income is driven by endogenous choices. Structural change drives changes in the manufacturing-to-services wage wage ratio and employment choices, thus affecting the scope of differences in earnings between households. Income inequality in our model translates to wealth inequality. The households accumulate wealth due to precautionary motive and because they want to save for old age.

5.1 Labor market flows

Endogenous change in employment implies that when entering the labor market, individuals in each birth cohort optimize the choice between working in the manufacturing and service sectors. Changing the sector is optimal as long as the wage rise improves welfare enough to cover the switching costs. Note that there are also second-order effects: individual working in sector h with individual productivity $\eta_{j,h,t}$ earns $w_{h,t}\eta_{j,h,t}$. Thus, the choice of the higher-wage sector implies higher income

Figure 2: Change in youth employment shares: model vs data



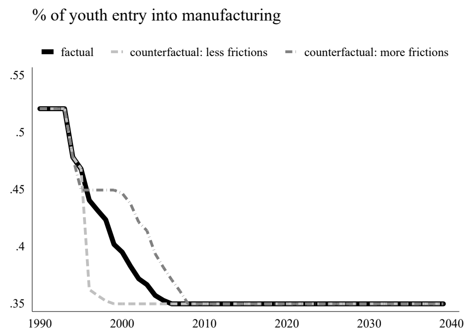
Note: LFS was first fielded in 1992, but sectors, according to NACE, are only available as of 1993, which we use as our initial employment shares. Youth entry is defined as an individual aged 18-25 who was in education in the previous year and is currently employed in one of two sectors. We drop employment in agriculture and non-market services. The manufacturing sector comprises the following sections: mining and quarrying, construction, industrial production, and utilities. The service sector comprises all market services: wholesale and retail trade, repairs, transporting and storage, accommodation and food service activities, information and communication, financial and insurance activities, real estate activities, and professional activities. Smoothed data were obtained with the use of a four-year moving average filter.

uncertainty. In other words, when deciding about the sector, the individuals take into account the *level differences* in wages, the *differences in income risk*, and the *frictions* to labor reallocation in the form of the switching costs.

Figure 3 portrays the effects of structural change on employment structure: among youth and the total working population. Changes in youth employment structure stem from the decisions to change the sector. Changes in total employment structure are implied by youth entry and the elderly exiting to retirement. Suppose the arriving birth cohort enters with the same proportion to the service sector and manufacturing sector as the previous generations. In that case, the employment structure reiterates every period and is stable. If the young birth cohorts deviate from the older birth cohorts, the discrepancy between youth entry and elderly exits amplifies the original effects of youth entry. In other words, the change in total employment is faster than would have been implied by the change in youth employment. Both entries and exits drive it.

The fact that the change happens at the rate of two birth cohorts by period (young entrants and exiting elderly) rather than just one (young entrants) implies that the adjustment is complete in merely forty years. Specifically, given our starting

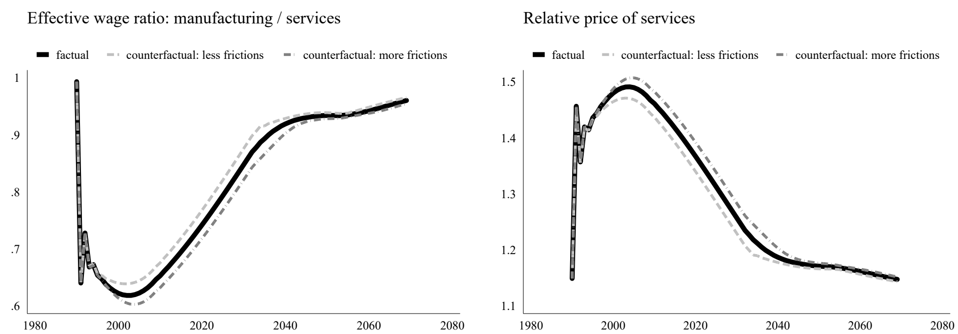
Figure 3: Employment change: youth (left) and the whole labor force (right)



Note: Factual youth entry (the data) is taken from Polish LFS. Youth entry is defined as an individual aged 18-25 who was in education in the previous year and is currently employed in one of two sectors. We drop employment in agriculture and non-market services. The manufacturing sector comprises the following sections: mining and quarrying, construction, industrial production, and utilities. The service sector comprises all market services: wholesale and retail trade, repairs, transporting and storage, accommodation and food service activities, information and communication, financial and insurance activities, real estate activities, and professional activities.

parameters, the entrants adjust for roughly fifteen years in the baseline scenario. Then it takes twenty-five more years to conclude the adjustment in the total employment. Regarding the data, Central and Eastern European economies experienced roughly 15-20 years of changes in the employment structure (Aristei and Perugini 2012). Indeed, in the early 1990s, the transition was expected to last about two decades (Aghion and Blanchard 1994). To put these numbers in perspective, if everyone could reallocate between sectors without frictions (an assumption conventional in models with infinitely lived agents), the entire reallocation would occur within one period.
The role of frictions is both quantitatively large and economically meaningful: with frictions lower by 25%, labor reallocation takes nearly a decade shorter (five years for the young). The differences in the transition speed have a noticeable bearing on the wage ratio, Figure 4. The wage adjustment is much swifter and less profound in the scenario with lower frictions. In fact, the wage ratio differs by more than 5 percentage points between the higher and lower friction scenarios. While structural change affects the structure of GDP, frictions (slower labor reallocation and stronger wage adjustment) do not affect the structure of GDP. This is because GDP is driven in both real terms and in nominal terms. The adjustment in relative prices reflects the shortage of services and relative abundance of manufacturing goods.

Figure 4: Wage ratio (left) and relative price of services (right)



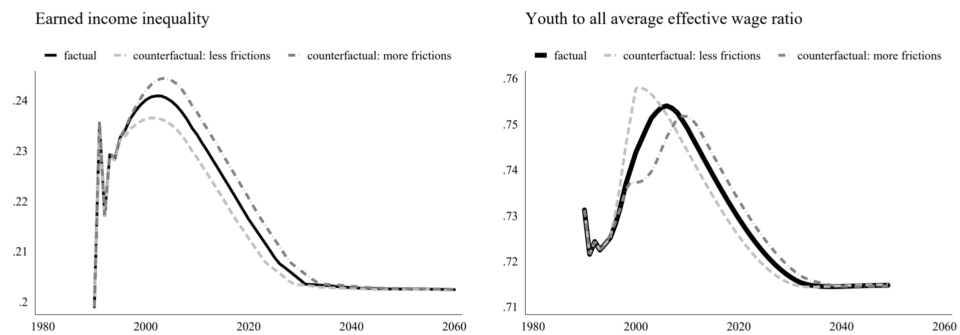
Note: The relative price of services is expressed in terms of manufacturing, i.e. $p_{s,t}/p_{m,t}$

5.2 Income and wealth inequality

Intuitively, structural change amplifies earned income inequality. There are two key mechanisms behind this result in our model. First, wages differ across sectors, reflecting the labor shortage in the growing sector and the abundance of labor in the declining sector. Second, frictions prevent the immediate equalizing of wages. In our setup, there are two types of frictions: (i) workers with experience cannot change the sector of employment; and (ii) not all young workers can immediately change the sector of employment. Note that even if the second type of friction was absent, the fact that only young workers can freely choose a sector of employment is prohibitive implicit friction on all non-young workers. Our setup is, in general, consistent with empirical evidence. While workers with some experience often change jobs, they rarely change the type of employer (be it sector of employment or ownership). Likewise, it takes time for the educational system to adjust to the changes in the labor market needs. There are lags in educational programs, and the choice of education is typically subject to status quo bias.

Our model demonstrates how structural change affects earned income and wealth inequality. They are portrayed in Figure 5. The stark rise in earned income inequality follows from the immediate adjustment in the relative price of services (with the price of manufacturing goods being the *numeraire*). Our model implies that the Gini coefficient on earnings would rise by four points within the first fifteen years of transition. This rise is purely driven by structural change in a sense that no other events – such as unemployment spikes, economic crises, and welfare policies – occur in our model. This is portrayed by the wage ratio between young workers (the youngest five birth cohorts every year) and all the other workers in the right panel of Figure 5. The ratio grows in our baseline specification from roughly 0.72 to roughly 0.76, even though the process of income dynamics (the idiosyncratic component) has not changed. The main reason behind this growth is that a higher fraction of youth opts to work in the service sector, which offers higher wages than the manufacturing sector. Frictions affect both the timing of the shift in ratio and the maximum reached. In our model, structural change eventually ends, which brings earned income inequality down.

Figure 5: Income inequality (left) and wage ratio between youth and other workers (right)

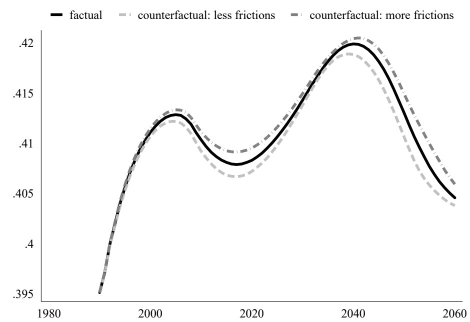


Note: We report the Gini coefficient of inequality, obtained with weights for population distribution and shock distribution. Income inequality is measured on earned labor income among the working-age population. The wage ratio between young workers and all the other workers is computed as a ratio between the average of the effective wage for the youngest five birth cohorts every year $(\sum_h \sum_{j=1}^{5} \int_{\Omega_h} \eta_{j,h,t} w_{h,t} d\mathbb{P}_{j,h,t} / \sum_h \sum_{j=1}^{5} N_{j,h,t})$ and its analog for the rest of the workers $(\sum_h \sum_{j=6}^{\bar{J}} \int_{\Omega_h} \eta_{j,h,t} w_{h,t} d\mathbb{P}_{j,h,t} / \sum_h \sum_{j=1}^{5} N_{j,h,t})$.

The rise in income inequality of four Gini points occurs in the world where frictions are calibrated to match the actual youth flows between manufacturing and services. In the counterfactual environment with more frictions, the rise in inequality is as high as five points. This is because, with more frictions, the labor market flows of young workers are slower compared to Figure 3. The rise in inequality reaches three Gini points in a counterfactual setting with lower frictions. The gap of two points between high and low friction environments shows that the frictions themselves play a paramount role during structural change. These two results yield a ballpark for policy purposes: a rise between three to five points in the Gini coefficient is consistent with the estimates for the countries of the CEE (Milanovic 1998, Flemming and Micklewright 2000, Aristei and Perugini 2012). Note that this rise is not easily mitigated by redistribution. For example, if labor taxation were to reduce gains from labor reallocation for the young, this would be akin to raising the frictions, thus creating a higher rise in labor income inequality.

The change in labor income inequality translates into a rise in wealth inequality, as

Figure 6: Wealth inequality



Note: Wealth inequality is measured on end-of-period assets for all individuals in all age cohorts.

portrayed by Figure 6. In our baseline scenario, greater dispersion of wages implies an increase in precautionary savings. Furthermore, greater dispersion of wages implies a greater dispersion in savings for old-age consumption. It is a substantial rise by the literature standards (Davies et al. 2011).

In parallel to the case of earned income inequality, also wealth inequality rises more in a counterfactual scenario with more frictions, and less in a counterfactual scenario with fewer frictions. The difference due to frictions amounts to roughly one Gini point, demonstrating that labor market frictions are not only relevant for the speed of transition but also carry forward to wealth inequality. As income inequality converges to the original levels, wealth inequality follows, but elevated levels continue until the birth cohorts which experienced economic transition finish their lifespans.

6 Conclusions

We study the effects of structural change on income and wealth inequality. The standard models assume perfect labor mobility. Thus, structural change does not affect inequality. However, empirical evidence suggests that there are labor mobility frictions across sectors of production. The data shows that reallocating labor across sectors mainly involves older workers exiting the declining sector and younger workers entering the growing sector. We incorporate this feature into our model.

We find that wages during structural change across sectors are not equalized with labor mobility frictions. With high productivity growth in manufacturing, the demand for labor in this sector declines, leading to lower relative manufacturing wages. At the same time, the demand for labor in services rises. With insufficient labor supply, relative wages in this sector increase. As structural change slows down with time, the wage gap between sectors also declines. Nevertheless, this increase in relative wages in services boosts income inequalities.

As far as wealth inequalities are concerned, the higher wage dispersion should raise wealth dispersion. At the same time, the structural change benefits younger workers with the least assets, so this effect should reduce wealth inequality. However, it turns out that the former effect dominates, and wealth inequality increases. Furthermore, these effects are amplified by the demographic change, i.e., the increase in income and wealth inequalities is larger.

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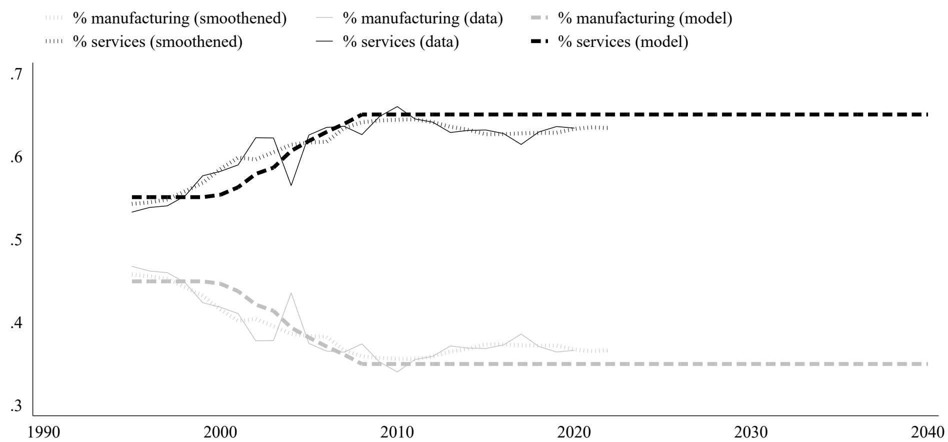
Appendix A Alternative assumptions for labor market frictions

Figure A.1: Change in youth employment shares for more frictions



Note: LFS was first fielded in 1992, but sectors according to NACE are only available as of 1993, which we use as our initial employment shares. Youth entry is defined as an individual aged 18-25 who was in education in the previous year and currently is employed in one of two sectors. We drop employment in agriculture and non-market services. The manufacturing sector comprises the following sections: mining and quarrying, construction, industrial production, and utilities. The service sector comprises all market services: wholesale and retail trade, repairs, transporting and storage, accommodation and food service activities, information and communication, financial and insurance activities, real estate activities, and professional activities. Smoothed data were obtained with the use of a four-years moving average filter.

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Figure A.2: Change in youth employment shares for less frictions