INTERNATIONAL ECONOMIC REVIEW
Vol. 61, No. 1, February 2020 DOI: 10.1111/iere.1

SOCIAL INSURANCE AND OCCUPATIONAL MOBILITY*

BY GERMAN CUBAS AND PEDRO SILOS[1]

University of Houston, U.S.A.; Temple University, U.S.A.

This article studies how insurance from progressive taxation improves the matching of workers to occupations. We propose an equilibrium dynamic assignment model to illustrate how social insurance encourages mobility. Workers experiment to find their best occupational fit in a process filled with uncertainty. Risk aversion and limited earnings insurance induce workers to remain in unfitting occupations. We estimate the model using microdata from the United States and Germany. Higher earnings uncertainty explains the U.S. higher mobility rate. When workers in the United States enjoy Germany's higher progressivity, mobility rises. Output and welfare gains are large.

1. INTRODUCTION

Can redistributive taxation increase aggregate output by encouraging occupational mobility? According to conventional wisdom, the answer is no. Continental Europe, with its high levels of redistribution and low job and occupational mobility rates, is presented as a case in point. In this article, we argue instead that redistributive taxation can encourage occupational mobility. The better sorting of workers into occupations follows results in higher productivity and output. To arrive at that answer, we link two seemingly unrelated areas of work. One highlights the role of job and occupational mobility in producing better matches, and, as a result, higher productivity and earnings.[2] The other studies the welfare effects of social insurance policies, particularly, progressive taxation. These policies are designed to shield workers from adverse earnings shocks and reduce inequality. It is the insurance provided to risk-averse workers by the tax system that leads to a higher occupational mobility rate when redistribution rises. We also demonstrate that the source of the low occupational mobility rate in Germany—representative of Continental Europe—is the much lower frequency of large shocks to earnings experienced by German workers.

The central argument of this article is as follows: The process of finding the best occupation requires experimentation by workers. Few ever have perfect information about their abilities and, as a result, about the likelihood of success in every available occupation. To overcome this obstacle, they try alternative professions, settling for one when the gain in a prospective

*Manuscript received July 2017; revised June 2019.

[1] We thank Jesús Fernández-Villaverde (Editor) and three anonymous referees for providing detailed comments that have greatly improved the article. We have also received useful comments from L. Ales, A. Bick, M. Bils, Y. Chang, S. Chatterjee, M. De Nardi, A. Drenik, M. Dvorkin, L. Hendricks, R. Hosseini, G. Kambourov, G. Kaplan, A. Michaud, S. Pashchenko, B. Ravikumar, A. Seshadri, B. Sorensen, V. Ríos-Rull, R. Rogerson, R. Serrano-Padial, Y. Shin, G. Ventura, and G. Vereshchagina. Seminar participants at Arizona State University, Central Bank of Uruguay, Center for Research and Teaching in Economics (CIDE), Federal Reserve Bank of Kansas City, George Washington University, Iecon-Udelar, SAIS-John Hopkins University, Society for Economic Dynamics Meeting in Edinburgh, University of Chile, University of Cincinnati, University of Georgia, University of Iowa, and Virginia Commonwealth University provided useful feedback. This research includes calculations carried out on Temple University's HPC resources and thus was supported in part by the National Science Foundation through major research instrumentation grant number 1625061 and by the US Army Research Laboratory under contract number W911NF-16-2-0189. Earlier versions of this article circulated under the name "Risk Taking to Succeed: Progressive Taxation and Risky Career Choices." Please address correspondence to: Pedro Silos, Department of Economics, Temple University, Ritter Annex 879, 1301 Cecil B. Moore Ave, Philadelphia, PA 19122. E-mail: *pedro.silos@temple.edu*.

[2] Early references for this line of work are Jovanovic (1979), Miller (1984), and Topel and Ward (1992).

occupation is not worth the risk. Even when workers know their abilities, they may change occupations in response to shifts in earnings prospects in alternative occupations, a common aspect of labor markets. If opportunities to insure earnings risk are limited and workers are risk-averse, they may settle for an unfit occupation, forgoing opportunities that the labor market offers. Therefore, lack of insurance is a source of worker misallocation. By partially filling in for missing private insurance markets, social insurance programs— for example, progressive or redistributive taxation—favor risk-taking and encourage mobility. As a result, such programs improve the sorting of workers into occupations, thus raising output and welfare.

The mechanism we highlight has not been explored, let alone quantified, in a large literature on macroeconomics that examines the effects of alternative tax schemes on hours worked, output, and savings. We fill this gap by linking the two areas of the literature described earlier. In doing so, we make empirical, theoretical, and quantitative contributions. On the empirical side, we uncover new features of the U.S. and German labor markets. On the theoretical side, we build an equilibrium ability-to-occupation assignment model (Roy, 1951) with missing insurance markets. Our framework allows analysis of the interaction of occupational choice, earnings risk, and social insurance. On the quantitative side, we take our theoretical framework to the data and analyze, from a positive angle, the effects of changing the degree of progressivity on output and welfare.

Our theoretical contribution is to develop a life-cycle model incorporating the interaction between earnings risk, social insurance, and occupational mobility. Every period, a worker's decision is to pick between two options: remaining in the current occupation or switching to a more uncertain alternative. A worker's human capital comes in two varieties. The first variety is an occupation-specific innate ability that is discovered sequentially. The second variety is a general—transferable across occupations—level of human capital. As workers' careers progress, more information is revealed about their innate abilities; experience reduces labor market uncertainty. However, workers experience occupation-specific permanent shocks to their general human capital. For workers, a prospective occupation is always more uncertain than their current occupation. The insurance provided by progressive taxes decreases the cost of earnings uncertainty. The reason is that workers dislike risk, and progressive taxes redistribute from high to low earnings realizations. As a result, under a more progressive tax, a worker sees a lower probability of a low-earnings outcome. Of course, he also sees a lower probability of a high outcome, but that is the purpose of insurance. Because he is risk-averse, the worker accepts the trade-off: the lower likelihood of low earnings more than compensates, in utility terms, the lower likelihood of high earnings. This effect is larger, the riskier an occupation is. In other words, the increase in the relative value of a risky occupation is greater than that of a safe occupation. Risky occupations become relatively more attractive.

In the model, labor markets—one for each occupation—are competitive. The price of a unit of efficiency clears the market for a given occupation. The demand for that occupation is driven by a technology employing all occupations and used to produce a general consumption good. The supply is driven by the selection of workers into that occupation based on their individual job histories. Despite the higher relative value of risky occupations, it is not inevitable that the size of risky occupations increases after a more progressive tax is introduced. The result is a combination of two effects. First, a more progressive tax function increases the number of inflows to riskier occupations. But because those occupations are risky—earnings shocks are large—the number of outflows also increases. Second, as workers flow into risky occupations, the equilibrium price of an efficiency unit falls, making that occupation relatively less attractive.

This article takes a positive approach when quantifying the impact of our proposed channel on output and welfare. Margins that for tractability are left out of our analysis can be important in any study concerned with calculating the optimal amount of progressivity. Incorporating some of these margins would strengthen the effects on welfare and output, whereas incorporating others would dampen the effects. For example, by not modeling savings or an intensive margin of labor supply, we exclude some of the negative consequences of progressive taxation. But we also abstract from any human capital accumulation prior to entering the labor market. Because that accumulation process is costly, providing insurance against labor market shocks could result in larger welfare gains.

To link the model and the data, we document new facts about earnings risk and occupational mobility for the United States and Germany. We focus our analysis on these two countries because of the substantial differences in their tax systems (see Holter et al., 2015). The German tax system is more progressive than that of the United States.[3] We find that, first, the U.S. labor market is much riskier—earnings are more uncertain—than the German labor market. We estimate the standard deviation of permanent shocks to earnings in both countries and find that on average it is 40% higher in the United States.[4] Second, occupational mobility—the rate at which workers change occupations—is substantially lower in Germany. The 2-year mobility rate in the United States is about 20%, but it is only 2.4% in Germany. At face value, this fact may seem to invalidate our hypothesis: that Germany's more generous social insurance programs encourage mobility. Yet, it is possible that differences in risk across the two economies partly explain the disparity in occupational mobility.

To isolate the importance of earnings risk for occupational mobility, we use a logit model to estimate the likelihood of a worker switching occupations when faced with an unpredictable drop in earnings. That likelihood, which we label the *propensity to switch*, is similar for German and U.S. workers. This finding suggests that U.S. workers change occupations more frequently as a natural response to the larger shocks they face compared with German workers. The differences in risk observed likely reflect differences in labor market institutions across the two economies. According to our results, these differences are of first-order importance when explaining the lower mobility of German workers. Although some of these features that affect earnings risk are policies chosen by society, we take them as exogenous. Moreover, we assume that policymakers set the degree of progressivity of the earnings tax function independently of other institutional features that may affect workers' earnings risk.[5]

We calibrate the model to the United States and Germany using our estimates of permanent earnings risk as well as data on occupational mobility. We then ask, how much does social insurance matter for output and welfare? To answer that question, we assign the more progressive German tax system to the United States and find that occupation mobility increases as workers are willing to assume more risk. The higher rate of mobility increases output by 3.3%.[6] To understand our results, note that the rule for deciding whether to switch occupations always takes the form of a productivity cutoff below which the worker stays in the current occupation. Productivity is the result of abilities and general human capital, so realizations of the first or shocks to the second (or both), may prompt a switch. By making switches more attractive, progressivity raises the productivity cutoff. As a result, a marginal worker—who is indifferent between switching or staying—is more productive. Productivity per worker rises and so does aggregate output. To investigate the welfare effects of such a policy change, we compute the consumption equivalent variation (CEV). Welfare rises by 4.0% of annual consumption. Both the higher output and the smoother earnings—consequences of the extra insurance—underlie the rise in welfare. The calibrated model also allows us to isolate the effect of the extra insurance on workers' mobility decisions. To that end, we calculate workers' propensity to switch occupations using simulated data from the baseline and the counterfactual economies. The propensity to switch increases when U.S. workers enjoy the insurance of the German tax system.

[3] A second reason is that we have comparable longitudinal microdata available.

[4] As we make clear below, these moments are estimated using earnings of nonoccupational switchers and thus are inputs we use when we estimate the model. Also, note that these are permanent shocks, so even small differences in the standard deviation of earnings can translate into large changes in utility.

[5] There are other aspects of these countries that surely affect the mobility of workers. An example is the vocational education system in Germany. Our model does not incorporate many of the institutional differences. We opt instead to have an age-dependent mobility cost function whose role in the model is to capture these institutional differences.

[6] In this counterfactual, we ensure that the average level of earnings taxes—measured by the ratio of tax revenues to output—remains the same. In other words, the effects we find are only due to higher progressivity and not to changes in the average level of taxes, which differ between Germany and the United States.

1.1. *Related Literature.* The article connects several strands of the literature in macroeconomics and public finance. First, it relates to works studying the welfare effects of the social insurance from progressive income taxation. Important studies are Conesa and Krueger (2006) and Seshadri and Yuki (2004) who follow the work of Mirrlees (1974), Eaton and Rosen (1980a), Eaton and Rosen (1980b), and Varian (1980). It is also related to studies of optimal taxation using task-to-talent assignment models. Examples are Rothschild and Scheuer (2013) and Ales et al. (2015). We incorporate the ideas of this literature, but take a quantitative approach like Conesa et al. (2009) in their positive analysis of tax reforms. We also incorporate the dynamic nature of career progressions. There are important questions in public economics and macroeconomics that are inherently dynamic. For example, workers' skills change stochastically and have a life-cycle component. Along the same lines, Acemoglu and Shimer (1999) and Acemoglu and Shimer (2000) study the positive effect of unemployment insurance policies on the willingness of unemployed workers to accept low-productivity job offers.

Our article documents patterns of occupational mobility and analyzes them in the context of an aggregate environment. For these reasons, we see our work as complementing the work of Kambourov and Manovskii (2008, 2009). In addition, we incorporate the mechanisms present in Jovanovic (1979), Miller (1984), Papageorgiou (2014), and Lopes de Melo and Papageorgiou (2016). We complement their findings as well as the ones present in Cubas and Silos (2017), Silos and Smith (2015), Hawkins and Mustre del Rio (2012), Dillon (2017), and Neumuller (2015) by linking risk and abilities to the experimentation process. It also relates to previous work that studies how prevailing economic conditions affect the quality of matches between workers and jobs (see, e.g., McLaughlin and Bils, 2001; Oreopoulos et al., 2012; Wee, 2016).

Our focus on occupational mobility and its relationship to earnings is based on an extensive literature highlighting the importance of occupation-specific human capital. Neal (1999) posits that workers first match with a career, and once it is chosen, they search for the best job match. Sullivan (2010) estimates the returns to occupation- versus industry-specific human capital using U.S. data. Although he finds variation across occupations on the relative magnitudes, the contribution to earnings of occupation or industry-specific human capital is larger than the contribution of the firm-specific human capital. The results in Kambourov and Manovskii (2009) are in line with those of Sullivan (2010). For the case of Germany specifically, Busch (2017) finds that the most important source of earnings changes are occupational changes; changes due to firm mobility are second order.

2. MODEL

The model combines elements from Cubas and Silos (2017) with elements from the learning literature (e.g., Papageorgiou, 2014 or Lopes de Melo and Papageorgiou, 2016). Cubas and Silos (2017) employ a framework in which risk-averse workers with different abilities to perform different occupations choose an occupation in which to offer their labor. The model we present below adds occupational mobility to that environment as well as imperfect information about workers' abilities. Specifically, workers sequentially learn about their abilities by trying occupations, as in Papageorgiou (2014).

2.1. *Households.* The economy is populated by a continuum of workers who value the consumption of a final good. Every period they are endowed with a unit of time. They live for S periods, financing consumption using labor earnings. Workers rank levels of consumption c of the final good according to a utility function $u(c)$. This function is concave, and, as a result, workers dislike risk. Finally, workers do not value leisure, supplying all of their time in a labor market described in detail below.

2.2. *The Labor Market.* The labor market is divided into submarkets, one for each occupation. There are J occupations available labeled by an index j from 1 to J. Occupations are mutually exclusive; workers can work in only one occupation during any given period. However, they may switch occupations between periods. During their tenure in occupation j, workers receive a wage w_j per unit of their human capital. Human capital comes in two varieties. The first variety is an occupation-specific ability. At birth, each worker is characterized by a vector $\{\theta_j\}_{j=1}^J$. Each θ_j is drawn from a distribution $G_j(\theta_j)$ with variance $\sigma_{\theta,j}^2$, but prior to entering the labor market, the elements of the vector $\{\theta_j\}_{j=1}^J$ are unknown. Its values are discovered sequentially as workers experiment and sample different occupations. For a given occupation j, the value of θ_j is revealed to the worker the first time occupation j is tried. Once discovered, the worker retains that specific θ_j, even if he eventually switches to other occupations. In what follows, it is convenient to define the set $J(s)$ as the set of occupations tried by (the beginning of) age s, and $\{\tilde{\theta}\}_{j\in J(s)}$ as the set of abilities for those occupations already tried.

The second type of human capital is general and therefore transferable across occupations. The stock of this type of human capital, denoted by z, evolves over a worker's career. Despite its generality, the evolution of this type of human capital depends on the worker's current occupation. To be more specific, while working in a given occupation, z changes randomly, and the shocks that affect it are occupation-specific. Shocks to z are an additional source of occupational mobility and are denoted by ϵ.[7] Formally, although an individual works in occupation j, his general human capital evolves according to $z' = z + \epsilon_j$, where ϵ_j is drawn from a distribution $F_j(\epsilon_j)$ with variance σ_j^2. When workers make an occupational choice, they know the value ϵ_j in their current occupation. They do not know that value in a prospective occupation. We are agnostic about the exact nature of these shocks. They capture, for example, the interaction between a worker's skills and an occupation's response to technological innovation. In other words, occupations react differently to changes in technology, and given such a reaction, a worker's human capital may suffer more or less depending on his portfolio of skills. At any rate, as the evidence in Subsection 3.2 shows, occupation-specific shocks to earnings are a feature of the data.

2.3. *Technology.* There is a set of J intermediate service producers indexed by j. We associate such services with occupations. The quantity of intermediate service j each produces is X_j using a linear technology in labor N_j, that is, $X_j = N_j$. The producer faces prices for her service p_j and wages w_j. Both intermediate services and labor markets are competitive.

The producer of intermediate service j solves the following maximization problem:

$$\max_{N_j} p_j X_j - N_j w_j, \tag{1}$$

subject to $X_j = N_j$. Intermediate service producers sell to a final goods producer. To produce Y units of the final good, a Cobb–Douglas technology aggregates intermediate services $\{X_1, \dots, X_J\}$,[8]

$$Y = \prod_{j=1}^{J} \left\{ X_j^{\alpha_j} \right\}. \tag{2}$$

The final goods producer faces purchase prices $\{p_j\}_{j=1}^J$ for the different occupations. The final good is the numeraire and its price is 1. Formally, its producer solves,

$$\max_{\{X_1,\dots,X_J\}} \prod_{j=1}^{J} \left\{ X_j^{\alpha_j} \right\} - p_j X_j. \tag{3}$$

[7] Occupation-specific earnings shocks are a feature of the models in Carroll and Samwick (1997) and Neumuller (2015).

[8] We assume no capital in this version but it is an easy-to-add feature. To check the robustness of the results to the assumption of a unitary elasticity of substitution across intermediate inputs, in the Online Appendix, we present results with alternative values for the elasticity of substitution. Our results are robust to assuming an elasticity of substitution equal to 1.5 or equal to 0.5.

Note that in equilibrium, $X_j = N_j$ and $p_j = w_j$, so the solution to this maximization problem implicitly defines labor demand functions $\{N_j = N_j^d(w_j, N_{-j})\}_{j=1}^J$.

2.4. *Worker Optimization.* At the beginning of the period, the worker faces an occupational choice decision. The worker knows her current level of general human capital z and the shock in the current occupation ϵ_j. She can remain in her current occupation with total general human capital equal to $z + \epsilon_j$ and known ability θ_j. Alternatively, she can try another occupation. Some of the alternatives have never been tried before and for those, the ability θ is unknown. Define by $W_s(\Omega_s, z, \epsilon, j)$ the maximum value an age s agent obtains by choosing among J mutually exclusive occupations. This choice depends on the set of occupations the worker has visited before $J(s-1)$, as well as her associated abilities $\{\tilde{\theta}_j\}_{j\in J(s-1)}$. These two elements make up Ω_s. The choice also depends on the current stock of general human capital z, its current innovation ϵ, and the current occupation j.

The following expression formally describes the choice between a known occupation j and a set of alternative occupations j':

$$W_s(\Omega_s, z, \epsilon, j) = \max\left\{V_s(\Omega_s, z, \epsilon, j), \{M_s(\Omega_s, z, j')\}_{j'\neq j}\right\}. \tag{4}$$

where $V_s(.)$ represents the value of staying in the current occupation and $M_s(.)$ the value of an alternative occupation. We describe them in detail in what follows.

The value of remaining in the current occupation j, $V_s(\Omega_s, z, \epsilon, j)$, is conditional on a particular value of the random variable ϵ (the shock to general human capital z). In other words, workers know the contemporaneous productivity shock in their current occupation, but take expectations over possible values of productivity in prospective occupations, hence the dependence on ϵ_j of the value of staying in the current occupation. This assumption reflects workers' better information about their performance in their current job. Alternative occupations—those labeled j'—never depend on $\epsilon_{j'}$ and depend on $\theta_{j'}$ only if it is already known—that is, if the worker has worked in j' at some point in his past.

The value of staying is given by the maximum value attained by working in occupation j:

$$V_s(\Omega_s, z, \epsilon, j) = \left\{u(c) + \beta \int W_{s+1}(\Omega_{s+1}, z', \epsilon', j) dF_j(\epsilon')\right\}, s.to, \tag{5}$$

$$c = T\left(w_j e^{\theta_j} e^z e^\epsilon\right), \tag{6}$$

$$z' = z + \epsilon, \tag{7}$$

$$\Omega_{s+1} = \Omega_s. \tag{8}$$

The continuation value is the maximum among J occupations, knowing that productivity in occupation j will experience a shock ϵ'. The flow budget constraint (6) equates consumption to total income, which is simply after-tax earnings $T(w_j e^{\theta_j} e^z e^\epsilon)$. Pretax earnings are equal to the product of a wage rate w_j and the amount of efficiency units $e^z e^{\theta_j} e^\epsilon$. A progressive tax function $T(\cdot)$ applied to pretax earnings gives the after-tax amount available to finance expenditures. We work with the following class of tax functions: $y_a = T(y_p) = \phi_0 y_p^{1-\phi_1}$, where y_p and y_a are pre- and after-tax earnings, respectively. Any revenue collected by the government is wasted.

The (log of) general human capital z evolves according to (7). The current shock ϵ is added to the stock z to update it to its new value z'. Finally, remaining in the same occupation adds no new information to Ω_s, and as a result $\Omega_{s+1} = \Omega_s$.

By switching occupations, a worker bets that his performance will improve as a result of the change. If the worker has chosen that occupation for the first time, the outcome is uncertain because both ϵ and θ in that prospective occupation are unknown. The worker takes expectations with respect to both distributions to compute the value of the alternative occupation. If at some point, the worker has tried occupation j', only the value of ϵ is uncertain.

Recall that Ω includes the set $J(s-1)$, the set of inspected occupations. If j' is not an element of $J(s-1)$, the value of the alternative occupation is

$$M_s(\Omega_s, z, j') = \int H_s(\Omega_s, \theta, z, \epsilon, j') dG_{j'}(\theta) dF_{j'}(\epsilon). \tag{9}$$

Conditional on a particular θ and ϵ, the value of the alternative occupation is the maximum attained by adding the utility flow from earnings plus the continuation value:

$$H_s(\Omega_s, \theta_{j'}, z, \epsilon, j') = \left\{ u(c) + \beta \int W_{s+1}(\Omega_{s+1}, z', \epsilon', j') dF_{j'}(\epsilon') \right\}, s.to, \tag{10}$$

$$c = T\left(w_{j'} e^{z} e^{\theta_{j'}} e^{\epsilon_{j'}} e^{-c(s,\kappa)} \right), \tag{11}$$

$$z' = z + \epsilon'_j, \tag{12}$$

$$\Omega_{s+1} = \left\{ \Omega_s, j', \theta_{j'} \right\}. \tag{13}$$

This value is similar to that of remaining in the same occupation. There are two differences. First, according to (13), the set Ω_s grows, because the worker obtains new information about his ability in the new occupation j'. The second difference is the term $e^{-c(s,\kappa)}$, affecting the amount of efficiency units and reflecting a (temporary) human capital loss. This cost is borne by all switchers, regardless of whether the new occupation has been tried before. The function $c(s, \boldsymbol{\kappa})$ reflects mobility costs; it depends on age and on a vector of parameters $\boldsymbol{\kappa}$. This specification permits modeling in a flexible way the mobility costs facing workers as they age.

Evaluating an occupation j' that has been visited before is simpler. The only uncertainty facing the worker is with respect to the shock ϵ in j'. The alternative value for this case—the analog to Equation (9)—can be written as

$$M_s(\Omega_s, z, j') = \int V_s(\Omega_s, z, \epsilon, j') dF_{j'}(\epsilon). \tag{14}$$

Note that the ability parameter $\theta_{j'}$ is an element of Ω_s, because the worker has previously visited that occupation. The calculation of the value of switching is almost identical to (10)–(13). The exception is Equation (13), which now becomes (8): The set Ω_s does not change because no new information is revealed about the worker's innate abilities.

The previous description of the occupational decision problem holds for all periods except the first one. In the first period, a fraction f_j of workers is exogenously assigned to occupation j. These workers learn their comparative advantage in that occupation but experience no ϵ shocks (i.e., their z is 0). In the second and subsequent periods, they optimally choose their occupation as described above.

2.5. *Equilibrium.* Let us denote the policy function that describes the occupational decision of an individual of age s characterized by a realization ϵ, a set Ω_s, and productivity z, who is currently in occupation j' and who switches to occupation j by $I_{j,s}(j', \omega, z, \epsilon)$.

For aggregation purposes, it is necessary to specify the position of individuals across states. Let $\Psi_{j,s}(\Omega_s, z, \epsilon)$ be the mass of individuals of age s in occupation j, with productivity z, and shock ϵ, who have been in other occupations in the past with their respective ability, represented by Ω_s. The measure Ψ is defined for all the possible values of Ω_s, z, and ϵ that belong to sets that are Borel subsets of $\mathbb{R}$.

The dynamic evolution of the mass of individuals reads as follows: As described above, the mass of newborns in occupation j is exogenously determined and given by f_j. Thus, for $s = 0$,

$$\Psi_{j,0}(\Omega_0, z, \epsilon) = \frac{1}{S} f_j \quad \forall \quad j \in \{1, \dots, J\}. \tag{15}$$

In addition, since individuals live S number of years, we have that for $S + 1$,

$$\Psi_{j,S+1}(\Omega_{S+1}, z, \epsilon) = 0 \quad \forall \quad j \in \{1, \dots, J\}. \tag{16}$$

For $0 < s < S$, Ψ obeys the following recursion:

$$\Psi_{j,s+1}(\Omega_{s+1}, z, \epsilon) = \sum_{j'} \Psi_{j',s}(\Omega_s, z, \epsilon) I_{j,s}(j', \omega_s, \epsilon, z) \quad \forall \quad j' \in \{1, \dots, J\}. \tag{17}$$

The[9] aggregate mass of efficiency units in each occupation is thus given by

$$N_j = \frac{1}{S} \sum_{s \in S} \int e^z e^{\theta_{j'}} e^{\epsilon_{j'}} d\Psi_{j,s}(\Omega_s, z, \epsilon) + \frac{1}{S} \sum_{s \in S} \sum_{j \neq j'} \int e^{-c(s,\kappa)} d\Psi_{j',s-1}(\Omega_{s-1}, z, \epsilon). \tag{18}$$

We can now define a stationary competitive equilibrium that consists of (i) a set of occupation-level wages $\{w_j\}_{j=1}^J$, (ii) occupation populations (or masses) $\{\Psi_j\}_{j=1}^J$, (iii) a set of intermediate goods prices $\{p_j\}_{j=1}^J$, (iv) occupation-level efficiency-weighted employment levels $\{N_j\}_{j=1}^J$, and (v) occupation-specific decision rules $\{I_{j,s}\}_{j=1}^J$ and associated value functions $\{V_s\}_{s=1}^S$ that satisfy the following conditions:

1. The occupation decision rules solve the optimization problems described in Subsection 2.4.
2. The labor inputs N_j are the solution to the intermediate producer optimization problem.
3. The intermediate goods quantities X_j solve the final goods producer's problem.
4. Prices p_j equate supply and demand of intermediate goods.
5. The wage in occupation j is the marginal product of a unit of efficiency in that occupation:

$$w_j = \alpha_j N_j^{\alpha_j - 1} \prod_{j' \neq j} \left\{ N_j'^{\alpha_j'} \right\}. \tag{19}$$

6. Labor markets clear at the occupational level.
7. In a given occupation j, Ψ_j is the stationary distribution.

By Walras's law, the market for the final good also clears.

3. CALIBRATION

In this section, we separately calibrate our model economy to German and U.S. data; the calibration strategy is identical for the two economies. There is a set of parameters common

[9] Note that j' can take the value j since there is a mass of individuals who were in j and stay in j.

to the two countries and a set of parameters that differ. Due to the computational burden, we group occupations into three groups based on the level of risk: safe (S), medium (M), and risky (R). We first describe the data set and the moments used, and then proceed to report the calibration procedure and the parameter values we obtain.

3.1. *Data.* We use comparable cross-country longitudinal household surveys provided by the Cross-National Equivalent File (CNEF) at Ohio State University. The file contains consistently defined variables for a set of developed countries. Included in that data set are the U.S. Panel Study of Income Dynamics (PSID) and the German Socio-Economic Panel (SOEP).

3.1.1. *The panel study of income dynamics.* In 1968, the PSID started collecting information on a sample of roughly 5,000 households. Of these, about 3,000 were representative of the U.S. population (the core sample) and about 2,000 were low-income families (the Census Bureau's Survey of Economic Opportunity [SEO] sample). Thereafter, both the original families and their descendants (children of the original family forming a family of their own) have been followed. The panel is annual until 1997; it has since become biennial. In the empirical analysis, we use the entire sample from 1980 through 2007 and adapt the estimation methodology to the change in the sampling frequency.[10]

3.1.2. *The socioeconomic panel.* The SOEP data are drawn from the SOEP-CNEF files. The SOEP is a wide-ranging representative longitudinal study of private households, located at the German Institute for Economic Research, DIW Berlin. Every year nearly 15,000 households and about 25,000 persons are sampled. The data provide information on all household members, consisting of Germans living in the old and new German states, foreigners, and recent immigrants to Germany. The panel started in 1984 and we use data up to 2012.

For both countries, we restrict our sample to working-age individuals 26–60 years of age. We omit those who are not employed or who are self-employed, those who do not report earnings, education, or hours worked; as well as individuals with fewer than 8 years of consecutive data. In the PSID-CNEF, individuals are classified into occupations according to ISCO-68 and industries according to a 34-industry classification provided by the CNEF.[11] The SOEP occupations are provided by using the ISCO-88 (an update of ISCO-68) classification, so we convert them to the ISCO-68 by following the cross-walk provided by the International Labor Organization (ILO). After grouping the data into 12 occupations (see the Online Appendix), the resulting data set is a panel of individuals' labor earnings per hour, employment status, age, education level, industry, occupation, gender, and location.[12]

3.2. *Labor Income Shocks.* Calibrating the model requires parameter values for the variance of the shocks to earnings. There is a standard literature that uses a regression approach (see, e.g., Carroll and Samwick, 1997) to compute earnings variability at the individual level. We proceed to estimate a fixed effects model for each occupation, for a sample of individual data in 12 different occupations.[13] Thus, we obtain estimates for the variance of the shocks to earnings for each of the 12 occupations. We then aggregate them into three groups grouped by risk. We rank the 12 occupations by the variance of the permanent shock. The S group of occupations is defined as those with the lowest level of risk and include around 25% of workers. Analogously,

[10] The reason to start in 1980 is to have an approximately comparable sample period for Germany and the United States.

[11] ISCO-68 refers to the first International Standard Classification of Occupations issued by the ILO.

[12] The location measure is the State for the United States and the Bundesland for Germany.

[13] The more disaggregated ISCO-68 classification contains 286 occupations but due to sample size, we aggregate them into 12 by following the ISCO-68 criteria; we include the details in the Online Appendix.

the R group is the set of occupations with the highest permanent risk that include around 25% of workers. We report the groups of occupations in the Online Appendix.[14]

Note that this standard estimation procedure does not consistently identify the true structural variance parameters (σ_j^2) in the model. The reason is precisely that the estimation procedure does not take into account the occupational switches, and thus, the estimated variances are biased (downward) because realized shocks lead nonswitchers to remain in the same occupation. However, this procedure yields moments that we use to obtain the "true" underlying variances of the shocks within the structural model.

To obtain the moments, the first step is to obtain the residuals from an individual-level wage regression. Given a panel of N individuals for whom we measure earnings per hour worked (and other variables) over a period of time T, we assume that (log) earnings per hour for individual i in occupation j at time t, y_{ijt}, can be written as:

$$y_{ijt} = \alpha_{ij} + \boldsymbol{\beta}_j \boldsymbol{X}_{ijt} + u_{ijt}. \tag{20}$$

The vector $\boldsymbol{X}$ includes observables that predict changes in the level of log earnings: age, gender, ethnicity, years of schooling, location, an industry dummy, and time dummies. β_j are the corresponding coefficients, α_{ij} is the individual fixed effect, and u_{ijt} the residual. We estimate Equation (20) for all individuals in a given occupation. Repeating this procedure for all occupations yields estimates $\{\hat{\alpha}_{ij}, \hat{\boldsymbol{\beta}}_j\}_{j=1}^{12}$.

The nature of risk faced by workers is important for assessing the welfare consequences of changing social policies. Temporary shocks should not lead to major changes in workers' careers and are easily overcome by a small amount of savings. For that reason, we focus only on permanent (or very persistent) risk that can be associated with, for instance, a depreciation of occupation-specific human capital and can therefore lead to an occupational change. To decompose risk into a permanent component and a transitory component, we follow Carroll and Samwick (1997) and Low et al. (2010), among others. We assume that

$$u_{ijt} = \eta_{ijt} + \omega_{ijt}, \tag{21}$$

where η_{ijt}, the transitory component, is distributed i.i.d. $N(0, \sigma_{\eta j}^2)$ and ω_{ijt}, the permanent component, follows a random walk,

$$\omega_{ijt} = \omega_{ij,t-1} + \epsilon_{ijt}, \tag{22}$$

with i.i.d. innovations ϵ_{ijt} that are distributed $N(0, \sigma_{\epsilon j}^2)$. By estimating Equation (20), we obtain $\{\{\hat{u}_{ijt}\}_{i=1}^{N_j}\}_{t=1}^{T}$.

Our procedure to estimate the variances of ϵ and η follows the identification procedure of Low et al. (2010); in the Online Appendix, we provide the details. We obtain $\widehat{\sigma_{\epsilon_j}^2}$ and $\widehat{\sigma_{\eta_j}^2}$ for the 12 original occupations. We then obtain our moments of interest, $\widehat{\sigma_{\epsilon_S}^2}$, $\widehat{\sigma_{\epsilon_M}^2}$, $\widehat{\sigma_{\epsilon_R}^2}$, that is, the variance of the permanent shocks for the three occupational groups for both countries, by computing their weighted averages. Table 2 displays these estimates.

3.3. *Income Tax Progressivity.* The United States and Germany differ in the degree of tax progressivity. Holter et al. (2015) estimate parametric functions of the income tax schedule for several countries. The function describes taxation of labor income only; it is therefore consistent with the definition of income in the structural model presented earlier. The estimation of Holter et al. (2015) takes into account certain transfers (but not public pensions, disability insurance,

[14] Besides the variance of permanent shocks, occupations can be grouped according to other criteria. To demonstrate that our results are not driven by the way we group occupations, the Online Appendix includes the entire analysis with occupations grouped by the average level of earnings. There are small quantitative differences across the results using the two groupings, but most results are similar.

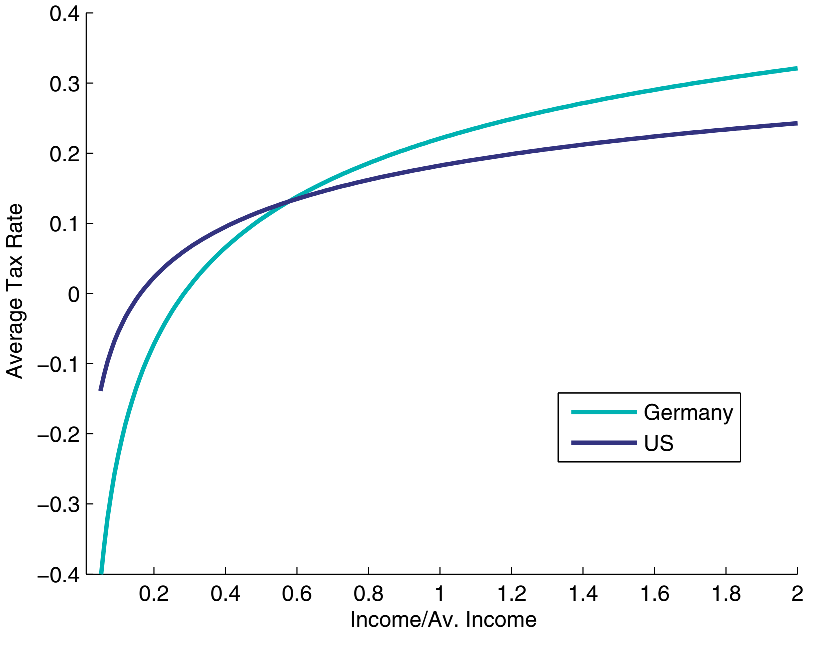


FIGURE 1

THE TAX FUNCTIONS FOR GERMANY AND UNITED STATES ESTIMATED IN HOLTER ET AL. (2015) [COLOR FIGURE CAN BE VIEWED AT WILEYONLINELIBRARY.COM]

etc.) and it fits the actual schedule well except for the lowest income levels. Specifically the tax functions take the following form:

$$y_a = \phi_0 y_p^{1-\phi_1}, \tag{23}$$

with $1 > \phi_1 \geq 0$ and where y_a and y_p are after- and pretax earnings, respectively.[15] We borrow the estimates from Holter et al. (2015) for the United States and Germany: $\phi_{0,GER} = 0.779$, $\phi_{1,GER} = 0.198$, $\phi_{0,USA} = 0.818$, and $\phi_{1,USA} = 0.111$.[16] Figure 1 show the two functions. Germany's income tax is much more progressive than that of the United States. In our quantitative study that follows, we take these tax functions as exogenous.

3.4. *Risk and Occupational Mobility.* With estimates of earnings risk in hand, we now examine occupational mobility rates. Due to restrictions in the frequency of the U.S. data, we compute 2-year mobility rates for both countries. We define those as the proportion of workers who change occupations between two consecutive periods (being the period 2 years and conditional on being present in the sample in both periods). Occupational mobility in the United States is much higher than in Germany. We find that on average 20% of U.S. workers change occupations, but only 2.5% of German workers do.[17]

[15] We rule out the uninteresting case of $\phi_1 = 1$. When $\phi_1 = 1$, the after-tax earnings are always equal to ϕ_0, all occupations look identical; their value is independent of productivity. As a result, it is no longer optimal to have a productivity cutoff rule that determines the optimality of a switch.

[16] These parameters are for singles, since our quantitative framework does not model the household explicitly. The parameters are reported in the last column of table 4 in Holter et al. (2015).

[17] Kambourov and Manovskii (2009) report that 1-year mobility rates in the United States in the 1990s are roughly 21%. Our estimate is not directly comparable. On the one hand, we use at mobility across three occupations (which lowers our estimate). On the other hand, we look at 2-year mobility rates (which increases our estimate).

We additionally compute 2-year mobility rates for three age groups: the average mobility rate for the 28-to-38-year-olds (young), the 39-to-49-year-olds (middle-aged), and those 50 years or older (old). Mobility is much higher in the United States than in Germany and the difference is largest for young workers. In the United States, about 22.36% of young workers switch occupations in 2 years. This fraction drops to only 19.74% for the middle-aged and to 17.97% for the older group. The corresponding figures for Germany are 4.1%, 2.1%, and 1.0%.

Despite the extra insurance provided by a more progressive tax system, Germany's mobility rate is lower. However, because the level of earnings uncertainty is so much lower in Germany than in the United States, we are rather interested in the following question: Given a shock to earnings of the same size, is a U.S. worker more or less likely to switch occupations? To find an answer, we move beyond raw mobility rates and estimate a logit model that relates occupational mobility to the earnings shocks experienced and to several other controls.

For the estimation of the two statistical models below, we restrict the analysis to pre-1997 data.[18] We estimate the following panel earnings regression:

$$y_{it} = \alpha_i + \eta \boldsymbol{H}_{it} + \nu_{it}. \tag{24}$$

The notation is similar to that of Equation (20): y_{it} is log earnings per hour of individual i at time t, α_i is an individual fixed effect, and the vector $\boldsymbol{H}$ includes several variables that help predict changes in the level of log earnings. Specifically, we include age, sex, ethnicity, education, occupation, industry, and time dummies. The only difference between Equations (24) and (20) is that the former includes switchers and nonswitchers—hence the lack of an occupational subscript j. We estimate this regression for each country to obtain $\hat{\nu}$. These estimated residuals represent the realized shocks to earnings that individuals experience. Some of the shocks occur while working in an occupation, but some other shocks precede an occupational switch.

We assume that the probability of switching occupations is a function of realized (lagged) earnings shocks (and possibly additional variables):

$$P_{i,t} \equiv \Pr\left(y_{i,t} = 1 \mid \hat{\nu}^-_{i,t-1}\right) = E\left(y_{i,t} \mid \hat{\nu}^-_{i,t-1}\right) = \psi\left(\hat{\nu}^-_{i,t-1}; \beta\right). \tag{25}$$

In this specification, P_i is the probability that individual i switches occupations and ψ is the logit function. The variable P_i is a binary variable that takes the value 1 if worker i switches the occupation between period t and $t+1$. The variable $\hat{\nu}^-$ represents the negative values of $\hat{\nu}$; if $\hat{\nu}$ is positive, $\hat{\nu}^-$ is set to 0.[19]

We label the absolute value of the coefficient associated with $\hat{\nu}^-$ the *propensity to switch*.[20] The sign is negative when a negative shock is associated with a higher likelihood of an occupational switch. The value of the propensity to switch allows us to compare occupational mobility between the United States and Germany for a shock of equal value. Table 1 reports the result of the estimation for both countries. The value of the coefficient estimated for Germany is −0.028 and for the United States is −0.016. These numbers imply that the propensity to switch is larger in Germany than in the United States. However, the coefficients cannot be interpreted in a structural way. In the model described in Section 2, large negative shocks cause individuals to choose a different occupation. We cannot readily attach the same causal interpretation to the coefficients, as shown in Table 1. Nevertheless, the logit estimation results illustrate the

[18] The reason for using data up to 1997 is that the PSID became biennial that year. Using earnings shocks lagged two periods introduces noise. To see why, consider a worker who receives a positive earnings shock on year t, a negative shock at $t+1$, and who switches occupations at $t+2$ as a reaction to that negative shock. Relating the shock at t and the occupational change at $t+2$ pushes the true negative relationship between shocks and switches toward zero.

[19] The reason for not using the raw residuals is the pattern studied by Groes, Kircher and Manovskii (2015). They find that when sorted by earnings, workers at both ends of the distribution are more likely to switch occupations. The quantitative model we use below ignores occupational switches that result from large positive earnings shocks and relates only to negative ones. For this reason, we focus on the negative values of the residual, setting other values to 0.

[20] The coefficient represents the marginal effect evaluated at the mean value of the independent variables.

TABLE 1
LOGIT REGRESSION: UNITED STATES VERSUS GERMANY

	United States	Germany
$\hat{\nu}^-$	−0.016	−0.028
	(0.009)	(0.004)

NOTE: The table displays the results of running a logit regression of the occupation-switching decision on the negative of the earnings residuals ($u^{-1} = \min\{u, 0\}$) (second and third columns). The second column shows the result for the PSID and the third column shows the result for the SOEP. The coefficients represent the marginal effects evaluated at the mean value of the independent variable.

pitfalls of concluding that the likelihood of an occupational switch given a negative shock is vastly higher for U.S. workers just because the mobility rate in the United States dwarfs that of Germany.

3.5. *The Model's Parameter Values.* There is a set of parameters common to the two countries and a set of parameters that differ. The common set of parameters includes the period frequency, the number of occupations J, the discount factor β, the coefficient of relative risk aversion γ,[21] and the life span S.

The model period is set equal to 1 year and a worker's lifetime S is 35 years. We set the relative risk-aversion coefficient γ equal to 3, and the discount factor β equal to 0.96. The value for γ is well within the range of typically used figures. The value for β is consistent with a real interest rate of 4% in an infinite-horizon economy with complete markets when the period is 1 year.

The values for the remaining parameters are country-specific. We choose values so that our model economy replicates features of the actual economy. We assume that the distribution of shocks to human capital z and the distribution of abilities θ are normal:

$$\epsilon_j \sim N\left(-0.5\sigma_j^2, \sigma_j^2\right), \tag{26}$$

$$\theta_j \sim N\left(-0.5\sigma_{\theta,j}^2, \sigma_{\theta,j}^2\right), \tag{27}$$

for j in $\{S, M, R\}$. We also assume a quadratic mobility cost function $c(s, \kappa)$:

$$c(s, \kappa) = \kappa_0 + \kappa_1 s + \kappa_2 s^2. \tag{28}$$

The set of parameters that are country-specific is

$$\Lambda = \left\{\kappa_0, \kappa_1, \kappa_2, \left\{\sigma_j^2, f_j, \sigma_{\theta,j}^2, \alpha_j\right\}_{j\in S,M,R}\right\}. \tag{29}$$

The value of some of these parameters can be calculated directly from the data. First, the parameters f_S, f_M, and f_R correspond to the fractions of the youngest group of workers in each of the three occupations. Of the 26 years old, 32.5% work in the safe occupation in the United States and 29.4% in Germany. For the medium and the risky occupations, there is more disparity across the two economies. For the medium-risk occupation, the fraction is about a half for Germany (52.30%), whereas it is less than 40% for the United States (38.2%). The

[21] The utility function $u(c)$ is of the constant relative risk-aversion class:

$$u(c) = \frac{c^{1-\gamma}}{1-\gamma}.$$

TABLE 2
TARGETED MOMENTS: UNITED STATES AND GERMANY

	United States	Germany
Mob. rate young	0.224	0.041
Mob. rate mid-age	0.197	0.021
Mob. rate old	0.180	0.010
Var. log earnings S	0.191	0.052
Var log earnings M	0.159	0.063
Var. log earnings R	0.165	0.089
SD risk S	0.102	0.063
SD risk M	0.146	0.075
SD risk R	0.216	0.101

NOTE: The table displays the moments and the values targeted in the estimation of the model for the United States and Germany. Mob, mobility; M, medium; R, risky; S, safe; SD, standard deviation; Var., variance.

labor share parameters α_j for $j \in \{S, M, R\}$ can be computed outside the model as well. Because the final good employs occupation services, and the amount of those services equals the total amount of efficient units of labor provided by workers in that occupation, α_j, represents the wage bill in occupation j as a share of the total wage bill. Therefore, one can calculate α_j as total earnings in occupation j as a fraction of total earnings across all occupations.[22] The values for the U.S. labor shares are: $\alpha_S = 0.21$, $\alpha_M = 0.43$, and $\alpha_R = 0.36$. For Germany, the values are: $\alpha_S = 0.23$, $\alpha_M = 0.40$, and $\alpha_R = 0.37$.

We choose the values for the remaining country-specific parameters so that the model matches a set of moments from the data. Table 2 displays the values of these moments for the United States (first column) and for Germany (second column).

Besides targeting the mobility rate by age groups, we also target the standard deviation of the permanent shocks to labor earnings, also by occupation. The variances of permanent shocks to earnings estimated in Subsection 3.2 are moments for the model to match. Recall that in the data, these are estimated for a panel of workers using spells of work in the same occupation. The model counterparts to those moments are computed in an identical way. To be specific, recall that he reduced-form model estimated in Subsection 3.2 takes the form:

$$\tilde{y}_{ijt} = \alpha_{ij} + u_{ijt}, \tag{30}$$

where $\tilde{y}_{ijt}$ represents log-earnings net of the effect of observables (age, marital status, etc.). The term α_{ij} is a fixed effect of individual i who works for her entire career in occupation j. The term u_{ijt} is a sequence of shocks (transitory and permanent) for a worker who does not switch occupations. Log-earnings in the model for workers who never change occupations follow:

$$y_{ijt} = w_j + \theta_{ij} + z_{ijt}. \tag{31}$$

The fixed effect $w_j + \theta_{ij}$ is the analog of the reduced-form fixed effect α_{ij}. General human capital z_{ijt} follows a random walk, which implies that the evolution of log-earnings in the model (for nonswitchers) follows the same dynamics as those implied by the reduced-form model. The only exception is that transitory shocks are assumed to be of zero variance.

In addition, we target the variance of the log earnings for the 26-year-olds (by occupation). The middle three rows of Table 2 show the variances of log earnings for the youngest age group in our sample for both Germany and the United States. The variances in Germany are lower than those in the United States by a factor of about 4 for the safest occupation (0.191 vs. 0.052) and a factor of roughly 2 for the riskiest (0.165 vs. 0.089).

[22] Because production of the final good does not require capital, total output is equal to the total wage bill.

TABLE 3
PARAMETER VALUES

	United States	Germany
κ_0	1.174	1.625
$\kappa_1(10^{-3})$	1.273	0.240
$\kappa_2(10^{-3})$	−0.942	−0.808
σ_S	0.109	0.063
σ_M	0.158	0.076
σ_R	0.271	0.101
$\sigma^2_{\theta,S}$	0.191	0.052
$\sigma^2_{\theta,M}$	0.159	0.063
$\sigma^2_{\theta,R}$	0.165	0.089

NOTE: The table displays the value of the estimated parameters of the model for United States and Germany.

Table 3 displays the values of the parameters for the U.S. and German economies. There are substantial differences in earnings uncertainty across occupations. The variability of permanent shocks to earnings is higher for U.S. workers—so much so that the variance of the riskiest occupation in Germany is roughly equal to that of the safest occupation in the United States (0.101 vs. 0.102). As expected, the calibrated variances of the permanent shocks to earnings (the "true" variances of permanent shocks facing workers) are larger than those estimated from spells in the same occupation in Subsection 3.2 (the targeted moments). Although in our quantitative analysis, we take these cross-country differences in risk as exogenous, they may reflect differences in the labor markets of these two countries.[23] What is relevant for our analysis is how workers react to uncertain earnings and by how much this reaction is affected by social insurance policies.

Mobility costs are higher in Germany than in the United States. Given the estimated parameters, overall mobility costs paid are 2.5% of output in Germany and 9.5% in the United States. Although mobility costs (per occupational switch) are higher in Germany, mobility is so much higher in the United States, that the U.S. economy ends up spending more as a result of mobility. The difference in mobility costs may also reflect differences in the labor market between these two countries; distinct labor market characteristics that affect occupational sorting but that are left out of our analysis. The differences in these labor market characteristics show up in the estimated values of the parameters of the cost function: it is more costly to change occupations in Germany than in the United States and that explains some of the lower mobility of Germany. Potentially, mobility costs could be key in explaining the differences in occupational mobility between these two countries. However, below, we show that they matter little for explaining the differences in mobility rates. The main factor is actually the cross-country differences in the variability of shocks to θ and to ϵ.

Table 4 shows the targeted moments and the model-simulated moments for the two economies using the parameter values in Table 3. The two sets of numbers are virtually indistinguishable. The only exception is perhaps mobility for the young in Germany, for which the model delivers too high a rate.

Solving the model for the set of parameter values just described delivers an equilibrium distribution of earnings within and across occupations. In equilibrium, individuals' earnings depend on the occupation wage, and on the realizations of the occupation-specific abilities and the shocks to general human capital. Average earnings within an occupation depend on the wage rate for that occupation and the efficiency units of the workers who selected into that occupation. However, insofar as the variances of the shocks affect the sorting of risk-averse workers, they influence the equilibrium distribution of earnings across occupations as well.

[23] For example, the Kurzarbeit scheme in Germany implemented during the Great Recession shares risk across workers. Employers reduce the average hours worked by all employees instead of laying off some employees. A lower variance of earnings in Germany reflects to some extent such practices.

TABLE 4
MODEL FIT: UNITED STATES AND GERMANY

	United States		Germany	
	Data	Model	Data	Model
Mob. rate young	0.224	0.227	0.041	0.046
Mob. rate mid-age	0.197	0.171	0.021	0.019
Mob. rate old	0.180	0.168	0.010	0.011
Var. log earnings S	0.191	0.190	0.052	0.051
Var log earnings M	0.159	0.157	0.063	0.063
Var. log earnings R	0.165	0.164	0.089	0.089
SD risk S	0.102	0.102	0.063	0.062
SD risk M	0.146	0.143	0.075	0.075
SD risk R	0.216	0.212	0.101	0.101

NOTE: The table displays the fit of the model by presenting the values of the targeted moments in the data and their model counterparts. Mob, mobility; M, medium; R, risky; S, safe; SD, standard deviation; Var., variance.

4. THE EFFECT OF SOCIAL INSURANCE: TAX REFORMS

In this section, we use the calibrated version of the model to conduct quantitative experiments. In addition to the baseline model economy of each country, we consider the case of each country with the taxes of the other. In particular, we study how changes in taxation affect prices and allocations.

4.1. *Main Results.* We first analyze the U.S. economy with the more progressive German income tax (and vice versa). All other parameters remain the same. This is a revenue-neutral experiment. We adjust the parameter ϕ_0 in the tax function, so that the revenue-to-GDP ratios are the same in the U.S. baseline economy and in the U.S. economy with German progressivity. The third column of Table 5 presents the results. Giving U.S. workers more social insurance raises occupational mobility. Workers now switch on average 4.3 times over their lifetimes (8.2% higher than in the baseline). The average mobility rate over the life cycle is now 20% (1.3 percentage points higher than in the baseline). More insurance encourages experimentation. The discovery of one's innate abilities happens sooner. Also, risky occupations become more attractive, but because they are risky, a large number of workers leave those occupations as well.

The higher mobility rate leads to a better assignment of workers to occupations.[24] That better assignment leads to sizable increases in output: It rises from 0.728 to 0.752 (an increase of 3.3%). Inequality, measured by the variance of log earnings, rises from 0.703 to 0.719 (third line). Note, however, that earnings here refer to pretax earnings. More social insurance leads to a lower volatility of after-tax earnings. To summarize, more social insurance, everything else constant, raises aggregate output and increases mobility.

The fourth column of Table 6 shows the shares of workers and mean earnings in each occupation. Both in the baseline economy and in the counterfactual, the medium-risk occupation is the largest. The smallest is also the riskiest, which also happens to have the highest level of mean earnings. In both cases, there is a positive correlation between the level of risk and mean earnings, confirming the results of Cubas and Silos (2017). The higher the risk workers face, the higher the mean earnings. This result is a consequence of the selection of the highest productivity workers. Compared with the baseline economy, the economy with German taxes exhibits a larger risky occupation, a similar-in-size safe occupation, and a smaller medium-risk occupation. With more insurance, the risky occupation becomes more attractive, and so in equilibrium, more workers select into it. The ones with the highest productivity remain, contributing to the higher mean earnings.

[24] The term "better assignment" means that the average productivity of workers is higher. The reason is that through experimentation—a consequence of the higher mobility rate—workers are more likely to find their best occupational fit.

TABLE 5
MODEL SUMMARY: BASELINE VERSUS COUNTERFACTUALS

	United States		Germany	
	Baseline	Taxes GER	Baseline	Taxes USA
Avg. occ. changes	3.968	4.293	0.452	0.345
Avg. mob. rate	0.187	0.199	0.026	0.020
Var. log earnings	0.703	0.719	0.179	0.178
Aggregate output	0.728	0.752	0.381	0.372
Relative to Baseline				
Avg. occ. changes (Δ)	0.324		−0.108	
Avg. mob. rate (Δ)	0.012		−0.006	
Var. log earnings (Δ)	0.016		−0.001	
Aggregate output (Δ%)	3.28%		−2.26%	

NOTE: The table presents the results of the quantitative model. It shows the value of the average number of occupational changes, the mobility rate, the variances of log earnings, and aggregate output for the United States (columns 2 and 3) and Germany (columns 4 and 5). The values of columns 2 and 4 refer to the baseline case. Columns 3 and 5 refer to the counterfactual exercise in which each country has the tax policy of the other: Taxes GER is the case of the United States with the tax code of Germany, and Taxes USA is the case of Germany with the tax code of the United States. The first panel presents the levels and the second the change with respect to the baseline case. Avg., average; mob., mobility; occ., occupational; Var., variance.

The increase in mobility and experimentation resulting from higher progressivity does not mean that all these additional occupational switches are ex post optimal. There is more trial, but also more error. Higher progressivity increases the value of a more uncertain option. As a result, there is more experimentation and on average workers are more likely to settle in the "right" occupation. This effect is illustrated by the higher aggregate (average) productivity—in fact, productivity is higher in all occupations after progressivity rises.

To investigate the welfare effects of such a policy change, we compute the CEV. This measure is the uniform percentage change in consumption, at each date and in each event, needed to make a household indifferent between being born into the baseline economy (the U.S. tax system) and being born into the counterfactual economy (the United States with the German tax system). A positive CEV reflects a welfare increase caused by the policy change. Table 7 shows the results. The second column shows that when U.S. workers enjoy Germany's insurance, their welfare rises by 4.15%. There are two reasons for this increase. First, it is a result of the standard consumption smoothing because of the extra insurance. Second, the higher output, a consequence of the higher productivity of workers because each worker is (on average) better matched to an occupation.

The fifth column of Table 5 shows the results of the alternative experiment: assigning to Germany the less progressive tax system of the United States. Contrary to the previous case, as expected, occupational mobility declines. This is clear by observing the fifth column of Table 5, which shows the decrease of both the average times workers change occupations (from 0.45 in the baseline to 0.35) and the average mobility rate (from 2.6% to 2%). Because U.S. labor taxation discourages risk-taking, workers experiment less. The lower degree of experimentation leads to lower quality matches. Aggregate output suffers as a result, and relative to the baseline German economy, this counterfactual economy yields 2.3% fewer goods and services. Pretax earnings inequality, measured by the variance of log earnings, falls as well. However, because U.S. taxes are less progressive, after-tax earnings inequality rises. The fifth column of Table 6 shows that there is a substantial increase in the proportion of workers in the risky occupation. Compared with the baseline economy, this economy is much less uncertain. Recall that the riskiest occupation in Germany is about as risky as the safest occupation in the United States. As a result, the proportion of workers in the safest and medium-risk occupations decreases. Consequently, mean earnings decrease in all occupations but much more in the risky one due to the inclusion of low-productivity workers.

TABLE 6
OCCUPATIONAL EARNINGS AND SHARES: BASELINE VRESUS COUNTERFACTUALS

	United States		Germany	
	Baseline	Taxes GER	Baseline	Taxes USA
Occ. shares				
Safe (S)	0.321	0.321	0.251	0.259
Medium (M)	0.460	0.455	0.418	0.407
Risky (R)	0.219	0.2224	0.332	0.334
Mean earnings				
Safe (S)	0.476	0.491	0.351	0.336
Medium (M)	0.674	0.708	0.367	0.366
Risky (R)	1.210	1.214	0.421	0.408

NOTE: The table presents the results of the quantitative model for the United States (columns 3 and 4) and Germany (columns 5 and 6). It shows the value of the occupational shares (first panel) and mean earnings (second panel) in each of the three occupations considered (the 12 occupations grouped in three groups according to their level of risk): safe (S), medium (M), and risky (R) groups. The values of columns 3 and 5 refer to the baseline case. Columns 4 and 6 refer to the counterfactual exercise in which each country has the tax policy of the other: Taxes GER is the case of the United States with the tax code of Germany, and Taxes USA is the case of Germany with the tax code of the United States. The first panel presents the levels and the second the change with respect to the baseline case. Occ, occupation.

TABLE 7
WELFARE GAINS RELATIVE TO BASELINE

	United States Taxes GER	Germany Taxes USA
% Welfare from baseline	4.15	−2.97

NOTE: The table presents the welfare calculations using the quantitative model for the United States and Germany. It shows the uniform percentage change in consumption, at each date and in each event, needed to make a household indifferent between being born into the baseline economy and being born into each of counterfactual economies. Taxes USA (second column) is the case of Germany with the tax code of the United States. Taxes GER (third column) is the case of the United States with the tax code of Germany.

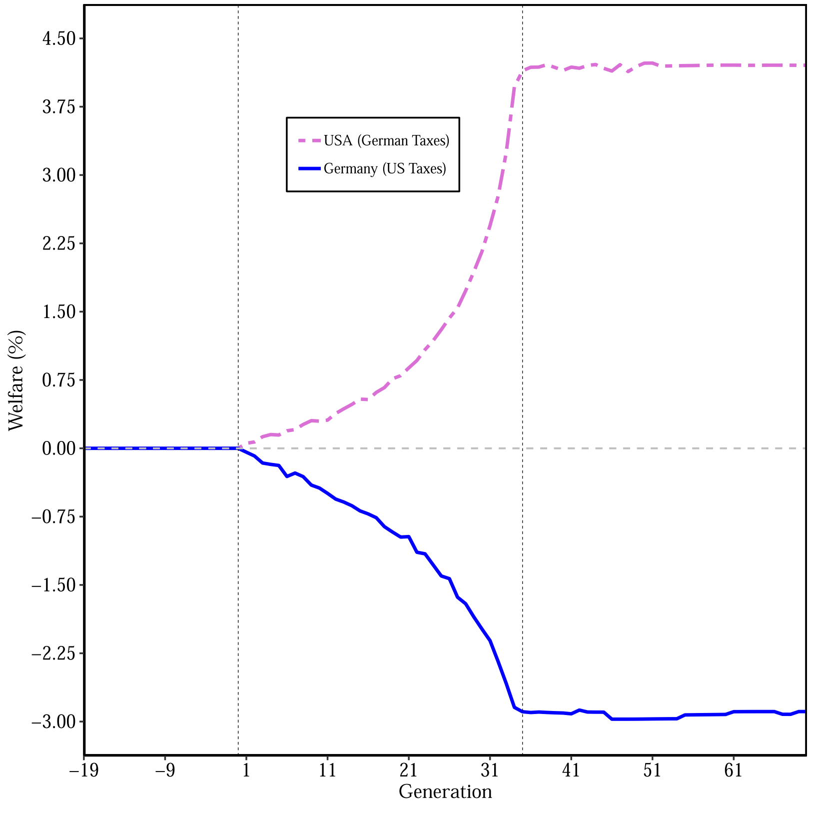
TABLE 8
LOGIT REGRESSION: MODEL-SIMULATED PANEL

	United States		Germany	
	Baseline	Taxes GER	Baseline	Taxes USA
u^-	-0.852	-0.906	-0.255	-0.185
Age	-42.199×10^{-4}	-52.080×10^{-4}	-12.216×10^{-4}	-10.232×10^{-4}
Age^2	0.563×10^{-4}	0.903×10^{-4}	0.041×10^{-4}	0.071×10^{-4}

NOTE: The table displays the results of fitting a logit model to the occupation switching decision on the negative of the earnings residuals ($u^{-1} = \min\{u, 0\}$) (first and third columns), age, age squared, and occupational dummies (coefficients not shown). The first four columns show results for the model economy calibrated to U.S. data and the counterfactuals described in the text. The last four columns show analogous coefficients for the economy calibrated to Germany and its counterfactuals. The coefficients represent the marginal effects evaluated at the mean value of the independent variables.

Regarding the share—measured by the fraction of workers—in each occupation, the results of this counterfactual exercise are qualitatively similar. With less insurance, the fraction of German workers in the risky occupation is almost the same but there are fewer of them in the medium-risk occupation and more in the safe one. Again, as for the United States, there is also compensation for risk in Germany. We also compute CEV for this case and find that there are substantial welfare losses, specifically on the order of 3% compared with the baseline German economy. As shown below, the combination of high earnings (i.e., consumption) volatility and lower output is responsible for large welfare losses from adopting this policy.

It is reasonable to ask whether these results are robust to the introduction of an additional choice for workers: nonemployment. Assuming that the value of nonemployment is



NOTE: Welfare is measured as the consumption equivalent variation relative to the welfare of a generation born with the old tax regime. On the horizontal axis, we identify generations by a number. Generations labeled −19 to 0 are generations not affected by the policy. Generation labeled 1 experiences the tax function change during that generation's last year of life. The solid blue line plots the welfare of German workers under the German progressive tax system and the welfare they experience as they change to the less progressive U.S. tax system. The dash-dotted purple line plots the equivalent for U.S. workers as they experience the change to the more progressive German tax system. The two vertical dotted lines show the generation number 0—the last generation not affected by the policy change—and number 35—the first generation born under the new tax regime.

FIGURE 2

THE WELFARE EXPERIENCED BY DIFFERENT GENERATIONS ALONG THE TRANSITION TO A NEW TAX REGIME
[COLOR FIGURE CAN BE VIEWED AT WILEYONLINELIBRARY.COM]

relatively certain compared to employment—for example, a worker receives a fixed payment while nonemployed—the absence of an extensive margin is not an important shortcoming. When progressivity changes, we ensure that the average tax rate remains the same, so the average tax burden of employment relative to a fixed outside option remains the same. But the extra insurance a more progressive tax system provides increases the value of uncertain alternatives. As a result, being employed when earnings risk is better insured is relatively more valuable. Nonetheless, if we increase the average tax as we increase progressivity or we increase the income received while nonemployed as we increase progressivity, the value of nonemployment may well become more attractive. In that case, output and welfare could fall with a nonemployment option.

4.2. *Transitional Dynamics.* To assess how each generation is affected by the tax policy change, we compute transitional dynamics between the two steady states associated with each of the two tax regimes. We assume that the policy change occurs unexpectedly at some date t. At that point, workers expect the new tax regime to remain unchanged indefinitely. Figure 2 plots the welfare change experienced by each generation along the transition. On the horizontal axis, we identify generations by a number. Generations labeled −19 to 0 are generations not affected by the policy. Generation labeled 1 experiences the tax function change during that generation's last year of life. Analogously, generation numbered 2 is affected by the new policy only during the last 2 years of its life. Members of generations labeled 35 or higher are born with the new policy already in place. In other words, as we move toward the right-hand side of the figure, generations are "surprised" by the policy change at younger ages. The welfare measure is CEV relative to the initial tax regime. The change from the U.S. tax system to the German tax system (dashed-dotted purple line) implies small positive welfare changes for those affected by the policy only at older ages. Young generations at the time of the policy change experience a proportionally larger positive welfare change. The positive change is larger for two reasons. First, younger generations benefit from better insurance during a longer remaining lifetime. Second, experimentation is more valuable at younger ages. As a result, the impact of the policy is increasingly larger as the first generation affected is younger. This is evident by the "convex" shape of the line depicting the welfare change. The logic for understanding the welfare changes for German workers suddenly facing the less progressive U.S. tax system (solid blue line) is the reverse. The negative welfare impact is small when the policy change is implemented when a worker is relatively old. As generations experience the change at younger ages, the welfare drop is proportionally larger.

4.3. *Logit Regression.* We estimate the logit regressions presented in Subsection 3.4 but now using model-generated data. Specifically, we regress occupational switches on the realization of the negative shocks of the calibrated stochastic process. Table 8 shows the effect of insurance on occupational mobility. For the United States (columns 2 and 3), as workers get more insurance, they tend to switch more. As a result, the coefficient is larger in absolute value than in the baseline case.

The same effect is observed for Germany when we assign their workers the lower level of U.S. insurance: the coefficient drops in absolute value. Note that despite the higher degree of social insurance, the logit coefficient for the German calibration is lower in absolute value than that of the United States (−0.255 vs. −0.852). As our experiments show below, mobility rates in the United States are higher than in Germany mostly because of the higher variance of permanent shocks. But the logit coefficient captures the propensity to switch given a shock realization. As a result, the smaller coefficient estimated for Germany is in large part due to higher mobility costs. In other words, higher mobility costs in Germany dampen the response of workers (relative to the response of U.S. workers) to a negative shock.

5. CONCLUDING REMARKS

This article uncovers a new mechanism through which social insurance policies can improve the matching of workers to occupations. It does so by proposing a dynamic framework in which insurance mitigates the natural uncertainty of career changes. Insurance through redistributive taxation induces workers to bet on career changes, helping them to find their best occupational fit.

We document new facts on earnings risk and its relationship with occupational mobility for Germany and the United States. We find that workers experience substantial earnings uncertainty and that earning shocks are occupation-specific. In addition, cross-country differences in earnings volatility explain the bulk of differences in occupational mobility across countries. Equipped with a quantitative model that describes those data well, we find that better insurance leads to substantial increases in output and welfare, as well as changes in pretax earnings inequality. Our findings appear to support proposals such as Denmark's *Flexicurity* policies. Those policies stress the importance of maintaining a fluid and flexible labor market, while insulating workers from adverse earnings shocks. This article shows that the second aspect of the policy partly determines the first: insurance begets mobility. The model shown here can be the starting point for the evaluation of specific policies in which risk, insurance, and career mobility are fundamental elements.

To focus on our proposed main mechanism, we abstract from many aspects of the labor market. The omissions may also account in part for individuals' occupational choices. For instance, we take earnings volatility as exogenous. Nonetheless, that volatility is key in explaining cross-country differences in mobility. We hope that these and other findings encourage future research on what causes the observed risk across countries and across occupations to vary so widely.

We believe that our article offers a new perspective for understanding labor markets, as well as providing new insights on the welfare effects of missing insurance markets. Other types of extensions can also deliver important results. For example, our work has focused on one policy—income taxation—but other types of policies could have similar effects: the provision of health insurance or transfers targeted at children, among others.

Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table A.1: Occupation Classification
Table A.2: Occupational Grouping
Table C.1: Logit Regression: United States vs. Germany
Table E.2: Model Summary: Baseline vs. Counterfactuals
Table E.3: Model Summary: Baseline vs. Counterfactuals
Table F.1: Occupational Grouping
Table F.2: Parameter Values
Table F.3: Model Fit: United States and Germany
Table F.4: Model Summary : Baseline vs. Counterfactuals
Table F.5: Welfare Gains Relative to Baseline
Table F.6: Logit Regression: Model-Simulated Panel
Table G.1: Model Summary : Baseline vs. Counterfactuals
Table G.2: Welfare Gains Relative to Baseline
Table G.3: Model Summary : Baseline vs. Counterfactuals
Table G.4: Welfare Gains Relative to Baseline
Table G.5: Logit Regression: Model-Simulated Panel
Table G.6: Logit Regression: Model-Simulated Panel

REFERENCES

ACEMOGLU, D., AND R. SHIMER, "Efficient Unemployment Insurance," *Journal of Political Economy* 107 (October 1999), 893–928.

———, "Productivity Gains from Unemployment Insurance," *European Economic Review* 44 (June 2000), 1195–224.

ALES, L., M. KURNAZ, AND C. SLEET, "Technical Change, Wage Inequality, and Taxes," *American Economic Review* 105 (October 2015), 3061–101.

BUSCH, C., "Occupational Switching and Wage Risk," Technical Report, 2017.

CARROLL, C. D., AND A. A. SAMWICK, "The Nature of Precautionary Wealth," *Journal of Monetary Economics* 40 (September 1997), 41–71.

CONESA, J. C., S. KITAO, AND D. KRUEGER, "Taxing Capital? Not a Bad Idea after All!," *American Economic Review* 99 (March 2009), 25–48.

———, AND D. KRUEGER, "On the Optimal Progressivity of the Income Tax Code," *Journal of Monetary Economics* 53 (October 2006), 1425–50.

CUBAS, G., AND P. SILOS, "Career Choice and the Risk Premium in the Labor Market," *Review of Economic Dynamics* 26 (October 2017), 1–18.

DILLON, E. W., "Risk and Return Tradeoffs in Lifetime Earnings," Technical Report, Department of Economics, Arizona State University, 2017.

EATON, J., AND H. S. ROSEN, "Labor Supply, Uncertainty, and Efficient Taxation," *Journal of Public Economics* 14 (December 1980a), 365–74.

———, "Optimal Redistributive Taxation and Uncertainty," *Quarterly Journal of Economics* 95 (1980b), 357–64.

GROES, F., P. KIRCHER, AND I. MANOVSKII, "The U-Shapes of Occupational Mobility," *Review of Economic Studies* 82 (2015), 659–92.

HAWKINS, W. B., AND J. MUSTRE DEL RIO, "Financial Frictions and Occupational Mobility," Technical Report, 2012.

HOLTER, H. A., D. KRUEGER, AND S. STEPANCHUK, "How Does Tax Progressivity and Household Heterogeneity Affect Laffer Curves?," PIER Working Paper Archive 14-039, Penn Institute for Economic Research, Department of Economics, University of Pennsylvania, December 2015.

JOVANOVIC, B., "Job Matching and the Theory of Turnover," *Journal of Political Economy* 87 (October 1979), 972–90.

KAMBOUROV, G., AND I. MANOVSKII, "Rising Occupational and Industry Mobility in the United States: 1968-97," *International Economic Review* 49 (2008), 41–79.

———, "Occupational Mobility and Wage Inequality," *Review of Economic Studies* 76 (2009), 731–59.

LOPES DE MELO, R., AND T. PAPAGEORGIOU, "Occupational Choice and Human Capital, and Learning: A Multi-Armed Bandit Approach," Technical Report, 2016.

LOW, H., C. MEGHIR, AND L. PISTAFERRI, "Wage Risk and Employment Risk over the Life Cycle," *American Economic Review* 100 (September 2010), 1432–67.

MCLAUGHLIN, K., AND M. BILS, "Interindustry Mobility and the Cyclical Upgrading of Labor," *Journal of Labor Economics* 19 (2001), 94–135.

MILLER, R. A., "Job Matching and Occupational Choice," *Journal of Political Economy* 92 (December 1984), 1086–120.

MIRRLEES, J. A., "Notes on Welfare Economics, Information and Uncertainty," in M. Balch, D. McFadden, and S. Wu eds., *Essays on Economic Behavior under Uncertainty*, (North-Holland, Amsterdam: Oxford University Press, 1974).

NEAL, D., "The Complexity of Job Mobility among Young Men," *Journal of Labor Economics* 17 (1999), 237–61.

NEUMULLER, S., "Inter-Industry Wage Differentials Revisited: Wage Volatility and the Option Value of Mobility," *Journal of Monetary Economics* 76 (2015), 38–54.

OREOPOULOS, P., T. VON WACHTER, AND A. HEISZ, "The Short- and Long-Term Career Effects of Graduating in a Recession," *American Economic Journal: Applied Economics* 4 (January 2012), 1–29.

PAPAGEORGIOU, T., "Learning Your Comparative Advantages," *Review of Economic Studies* 81 (2014), 1263–95.

ROTHSCHILD, C., AND F. SCHEUER, "Redistributive Taxation in the Roy Model," *Quarterly Journal of Economics* 128 (2013), 623–68.

ROY, A. D., "Some Thoughts on the Distribution of Earnings," *Oxford Economic Papers* 3 (1951), 135–46.

SESHADRI, A., AND K. YUKI, "Equity and Efficiency Effects of Redistributive Policies," *Journal of Monetary Economics* 51 (October 2004), 1415–47.

SILOS, P., AND E. SMITH, "Human Capital Portfolios," *Review of Economic Dynamics* 18 (July 2015), 635–52.

SULLIVAN, P., "Empirical Evidence on Occupation and Industry Specific Human Capital," *Labour Economics* 17 (2010), 567–580.

TOPEL, R. H., AND M. P. WARD, "Job Mobility and the Careers of Young Men," *The Quarterly Journal of Economics* 107 (1992), 439–79.

VARIAN, H. R., "Redistributive Taxation as Social Insurance," *Journal of Public Economics* 14 (August 1980), 49–68.

WEE, S. L., "Delayed Learning and Human Capital Accumulation: The Cost of Entering the Job Market during a Recession," Technical Report, Carnegie-Mellon University, 2016.