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## Abstract

We study the effects of market incompleteness on occupational mobility. Under incomplete markets, low-asset workers remain in low-productivity occupations even when the expected value of switching is positive. In a calibrated model, completing markets against wage risk improves welfare by up to 2.5 percent of lifetime consumption, in part because workers move into better occupations, but also thanks to improved consumption smoothing. We also investigate policies affecting mobility. Subsidizing retraining with additional taxes increases mobility away from low-productivity occupations and is welfare improving. In contrast, an equivalent tax increase redistributed in lump-sum fashion decreases mobility and barely changes welfare.

JEL: D31, D52, E21, J24

Keywords: occupational mobility, financial frictions, incomplete markets, self-insurance, welfare costs, training subsidies, income taxes

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Changes in occupation-level average wages are important in accounting both for wage growth and for earnings risk for U.S. workers. Switching occupation is, on average, associated with an increase in wages: for the 1996-1999 period, prime-age workers who changed (3-digit) occupations saw, on average, wage gains of 6.3 percent. But occupation switchers also experience more volatile earnings than do occupation stayers: the variance of wage changes, for comparable workers, rises from 0.07 for stayers to 0.16 for switchers. In this paper we study the interaction between market incompleteness, occupational earnings risk, and occupational mobility. We find that incomplete financial markets significantly reduce workers' ability to move away from occupations hit by negative productivity shocks: completing markets raises the occupational mobility rate by 22 percent. This has aggregate consequences: labor supply, measured in efficiency units, is 1.5 percent higher under complete markets. Last, the welfare costs of market incompleteness are non-trivial: the average gain from moving to complete markets can be as high as 2.5 percent of lifetime consumption.

We model occupational choice using an equilibrium search model in the style of Lucas and Prescott (1974), Alvarez and Veracierto (1999), and Kambourov and Manovskii (2009a). The returns to working in an occupation are stochastic. Occupational mobility is costly for several reasons: first, because of the opportunity cost of wages forgone while moving; second, because a worker who switches occupations loses occupation-specific human capital; third, because of retraining costs; and fourth, because the randomness of the occupational mobility process exposes the worker to additional risk. We allow both for voluntary and involuntary occupational mobility; the possibility of the latter type of occupational switch represents an additional source of risk. Unlike much of the existing literature on occupational mobility, we do not assume that financial markets are complete. Instead, we follow the tradition of Bewley (1986), Huggett (1993), and Aiyagari (1994) and allow agents to self-insure using a risk-free bond. This kind of insurance is partial, because of the persistence of the shocks and because occupational mobility is most valuable precisely for those workers who have experienced negative shocks to

their occupation and, hence, their earnings and assets.

We calibrate the model to match information on occupational mobility from the Survey of Income and Program Participation (SIPP). We match not only the overall frequency of occupational mobility and the associated wage gain, but also how these moments vary over the wage distribution. In particular, both in the data and model, the frequency of occupational mobility and the wage gain for switchers fall as wages in the current occupation rise. Individuals with below-median wages, both in the data and model, are twice as likely to move as individuals with above-median wages. We also match the facts that, conditional on switching, individuals with below-median wages in their current occupation experience average wage gains 10 percentage points in excess of those for similar occupational stayers, while individuals with above-median wages experience wage losses which exceed those experienced by occupational stayers by a similar amount.

Given that the model does a good job of accounting for the empirical patterns of occupational mobility, we next seek to understand the importance of financial market incompleteness. We compare the equilibrium of our benchmark model to a setting with complete markets against occupational and other risk. Overall occupational mobility is higher when markets are complete: 2.0 percent of workers switch occupations each month, an increase from the 1.6 percent per month in the benchmark. This difference is accounted for by increased mobility by individuals at the lower end of the wage distribution. The average wage gain for workers who switch occupations rises from 6 percent under incomplete markets to 10 percent when markets are complete. Individuals at the lower end of the wage distribution benefit the most, as their average annual wage gain increases from 16 to 20 percent. This result is intuitive: under incomplete markets, wealth-constrained individuals remain in low-productivity occupations even when the expected gain of switching is positive. As a result, the increased occupational mobility under complete markets enhances aggregate productivity by allowing more individuals to work in more productive occupations.<sup>1</sup> Effective labor supply increases around 1.5 percent.

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<sup>1</sup>This effect is partially offset by the fact that the increased mobility slightly lowers the

The welfare cost of market incompleteness is quantitatively significant. A randomly chosen agent drawn from the incomplete-markets economy would value access to complete insurance markets, holding prices constant, at 2.5 percent of lifetime consumption. General-equilibrium effects offset this somewhat: the average gain if complete markets are unexpectedly ‘switched on’ for the whole economy is 1.9 percent, lower but still substantial. While the majority of this gain is associated with better consumption smoothing, a non-trivial amount arises from an improvement in the income process. To quantify this, we compute the welfare gains associated with completing markets holding constant the frequency of occupational mobility conditional on occupational match quality. These gains are 1.5 percent of lifetime consumption (holding prices constant) or 1.4 percent (general equilibrium). That is, the reduction in occupational mobility arising from market incompleteness is associated with a welfare cost ranging between 0.5 and 1.0 percent of lifetime consumption, depending on whether prices are allowed to adjust or are held constant.

Returning to an incomplete-markets setting, we also investigate whether policies aimed at either encouraging occupational mobility or reducing individuals’ exposure to after-tax income inequality can capture a substantial part of the potential gains associated with completing markets. As an example of the first type of policy, we allow the government to subsidize the retraining cost associated with occupational mobility. The subsidy is financed by increasing the tax on labor income. Perhaps not surprisingly, this does indeed raise the rate of occupational switches from 1.6 percent (in the benchmark economy) to 2.4 percent; also, because average occupational match quality improves, effective labor supply rises by 2.4 percent. Welfare gains are significant, averaging 0.7 percent of lifetime consumption, with inexperienced individuals gaining slightly more and the experienced slightly less.

Second, we also consider the effects of increasing taxes on their own. We suppose that the government raises labor income taxes as in the first policy experiment, but, rather than subsidizing occupational mobility, instead simply redistributes the proceeds lump-sum to all agents regardless of mobility

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average occupational experience level of the workforce.

status. This reduces after-tax income inequality. We find that occupational mobility decreases: the policy reduces the benefit from switching occupations, as well as the consumption impact associated with working in the least productive occupations. Effective labor supply falls relative to the benchmark model because more people work in the least productive occupations. However, because of the reduction in after-tax earnings risk, the tax still slightly improves welfare: a randomly chosen agent would forgo less than 0.1 percent of lifetime consumption to switch to a world with the higher tax rate.

The structure of the remainder of the paper is as follows. [Section 1](#) describes related literature. In [Section 2](#), we present the model. We describe our calibration strategy in [Section 3](#). [Section 4](#) presents the comparison between complete- and incomplete-markets economies, [Section 5](#) discusses our policy experiments, and [Section 6](#) concludes.

## 1 Related Literature

Our paper contributes to several parts of macroeconomics and labor economics. First, there is a large literature establishing the importance of occupational mobility, in particular for job mobility (Miller, 1984; McCall, 1990) and for wages (Neal, 1995; Parent, 2000; Kambourov and Manovskii, 2009b; Sullivan, 2010). Relative to this literature, our contribution is to show that market incompleteness is quantitatively relevant for understanding occupational mobility, and therefore also for the cross-sectional distribution of occupational tenure, occupation-specific human capital, wages, and wage growth.<sup>2</sup>

Our paper also relates to the literature on self-insurance when financial markets are incomplete. The first generation of models seeking to understand the effect of labor income risk on workers' consumption and welfare in this setting took the income process faced by workers as exogenous (Bewley, 1986; Huggett, 1993; Aiyagari, 1994). By now, a very large literature builds on

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<sup>2</sup>Manovskii (2002) was the first to argue that there was a significant interaction between market incompleteness and occupational mobility, but he does not allow for savings. He sketches a model along the lines of ours, but does not analyze it quantitatively.

this framework and has incorporated progressively more realistic exogenous earnings processes and policy features.<sup>3</sup> The framework has been used to understand the welfare cost of market incompleteness at least since İmrohoroğlu (1989). Our paper differs in focus from this work since we highlight the endogeneity of observed wages themselves to the amount of insurance through financial markets agents can access.

A second strand of the literature partially endogenizes the earnings process by allowing workers to choose labor supply each period in response to exogenous changes in their wages and employment opportunities. Most closely related to the current paper are Pijoan-Mas (2006) and Heathcote, Storesletten, and Violante (2008, 2014), who emphasize that incomplete markets affect the correlation between workers' labor supply and productivity, so that improvements in the cross-sectional allocation of labor supply are an important source of the welfare gains from completing markets.<sup>4</sup> This approach differs from ours in that the labor supply decision of workers is static, in the sense that working more today does not affect the determination of labor income tomorrow.

A third line of work emphasizes that when markets are incomplete, workers' ability to finance spells of unemployment will affect their future wages. Danforth (1979) focused on the effects of assets on workers' reservation wages when unemployed; other authors have emphasized search effort.<sup>5</sup> This line of research is related to ours in that the effect of market incompleteness on workers' wages has a dynamic aspect; however, the mechanism is complementary. In fact, since occupation switches frequently occur along with unemployment spells (Carrillo-Tudela and Visschers, 2014), allowing for incomplete markets in an environment with both search frictions and occupational mobility seems a promising area of future research.

Last, workers' accumulation of other types of human capital beyond the

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<sup>3</sup>For example, see Gourinchas and Parker (2002) and Storesletten, Telmer, and Yaron (2004) for quantitatively realistic life-cycle models, and Heathcote, Storesletten, and Violante (2009) for a useful review.

<sup>4</sup>See also Low (2005), Flodén (2006), Marcet, Obiols-Homs, and Weil (2007), and Heathcote, Storesletten, and Violante (2010).

<sup>5</sup>See Low, Meghir, and Pistaferri (2010) and Lise (2013) for important recent contributions in this area, and the references in these papers for earlier work.

occupation-specific also provides a mechanism by which earnings might be endogenous to the market structure. While there has been a large amount of research on human capital accumulation over the life cycle, much of it implicitly assumes that financial markets are complete.<sup>6</sup> One exception is Huggett, Ventura, and Yaron (2011), who investigate the importance of heterogeneous human capital, learning ability, and wealth for understanding U.S. inequality. The focus of their paper differs from ours in that they do not investigate the importance of the market incompleteness for their results and they do not undertake policy experiments. There has also been a very large amount of research on the importance of credit constraints for education.<sup>7</sup> Our paper is complementary to this work in focusing on human capital accumulation after formal educational decisions have been made.

While the key contribution of our paper is to show in a quantitatively reasonable setting that the two-way interaction between market incompleteness and occupational mobility is significant, we have deliberately kept our model parsimonious so as to keep the key mechanisms at work transparent. This does come at a cost. First, we cast our model in an infinite-horizon setting, so abstracting from life-cycle dynamics. Second, we abstract from some features of occupation-specific human capital and earnings dynamics that may also be quantitatively important. For example, we do not model the task content of occupations and so do not allow for skills to be (partially) transferrable across occupations as in Guvenen et al. (2015); nor do we account for the hierarchical relations of occupations to each other as in Groes, Kircher, and Manovskii (2015).<sup>8</sup> Likewise, we do not allow for a risk-return tradeoff across industries as in Cubas and Silos (2017) or Dillon (2016). It would be very interesting to understand how our results would be enriched by allowing for such features. However, we leave this for future research.

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<sup>6</sup>See Sanders and Taber (2012) for a recent survey.

<sup>7</sup>See Lochner and Monge-Naranjo (2012) for a recent survey.

<sup>8</sup>On the task content of occupations, see also the survey by Sanders and Taber (2012).



## 2 Model

### 2.1 Preferences

Time is discrete. There is a continuum of workers of fixed measure, normalized to one. Workers are infinitely lived. They discount the future with discount factor  $\beta \in (0, 1)$ . Workers derive utility from consumption. The expected utility function is given by  $\mathbf{E} \sum_{t=\tau}^{\infty} \beta^t \log c_t$ .<sup>9</sup>

### 2.2 Occupations and Occupational Mobility

There is a continuum of islands of unit measure. At the beginning of a period, each island has a non-negative measure of workers located on it.

On each island, a single occupation is conducted. Its productivity, denoted  $x$ , takes values in a finite set  $\mathcal{X}$  and follows a first-order Markov process. Write  $\pi(x' | x)$  for the probability that the value of the shock next period is  $x'$  conditional on the current-period value  $x$ . The Markov processes for  $x$  on each island have the same functional form but are independent across islands.

Each worker can be either experienced or inexperienced in the occupation that is undertaken on the island on which they are located. We denote a worker's experience level by  $e \in \{0, 1\} \equiv \mathcal{E}$ , with  $e = 0$  corresponding to being inexperienced and  $e = 1$  to being experienced. Experienced workers are more productive than inexperienced workers by a factor  $1 + \chi > 1$ . Due to learning-by-doing, an inexperienced worker becomes experienced with probability  $q \in [0, 1]$  each period that she remains on a specific island; this process is iid across workers, across islands, and over time. Experience is occupation-specific, so that a worker who moves to a different island loses her experience.<sup>10</sup>

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<sup>9</sup>The assumption of logarithmic utility is conservative: with a coefficient of relative risk aversion in excess of 1, we might expect to find larger effects than in our current specification, analogously to Heathcote, Storesletten, and Violante (2008).

<sup>10</sup>This simple way of modeling the return to occupational tenure follows Kambourov and Manovskii (2009a) and is chosen for tractability given the size of the baseline model's state space. While this assumption allows us to match the average slope of the wage-occupational tenure profile, the resulting one-shot process for gaining occupational experience does generate a non-negligible source of labor income risk. In Appendix G we investigate whether

Each worker's productivity is also subject to a transitory idiosyncratic shock, denoted  $z$ , which takes values in a finite set  $\mathcal{Z}$ . This shock is iid across workers, across islands, and over time. Its pdf is denoted  $h^z(\cdot)$ , so that the probability that the realized value is some particular  $z \in \mathcal{Z}$  is  $h^z(z)$ .

The occupation- and individual-level productivity shocks, as well as the productivity gain from being experienced, are labor-augmenting. On an island with productivity  $x$ , an inexperienced worker with individual productivity  $z$  supplies  $xz$  efficiency units of labor; if experienced, she supplies  $xz(1 + \chi)$  efficiency units. A unified expression for this is that a worker with experience  $e$  supplies  $xz(1 + \chi)^e$  efficiency units of labor.

Each period, a worker either works on the island on which she begins the period, or moves to a new island. What action she takes is in part determined by a random variable, her mobility status, which we denote by  $m \in \{n, im, vm\} \equiv \mathcal{M}$ . Mobility status is iid across workers, across islands, and over time. Its pdf is denoted  $h^m(\cdot)$ , so that the probability that its realized value is some particular  $m \in \mathcal{M}$  is  $h^m(m)$ . We now describe the actions available under each realization of  $m$ .

A worker with  $m = n$  cannot move islands. She works on her existing island during the current period and remains there at the beginning of the next period.

A worker with  $m = im$  must undertake an involuntary move. The involuntary nature of an  $im$  is intended to capture occupational mobility which does not involve retraining and may not lead to a wage increase.<sup>11</sup> A worker undertaking an  $im$  does not work during the period of the move. She begins the next period located on a different island; she is inexperienced in that island's occupation. The productivity of the new island,  $x'$ , is drawn from a distribution which depends on the productivity of the current island,  $x$ . We denote the pdf by  $\psi_{im}(x' | x)$ . Conditional on the worker undertaking an  $im$

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our results are much affected by this; we do so by studying a version of our model without occupational experience (that is,  $\chi = 0$ ). We show that our results are largely unchanged. Intuitively, this is because workers face other, larger, sources of income risk than this one.

<sup>11</sup>For example, this may occur if the worker loses her job or if she moves to a new geographic location where her previous occupation is not available.

and on  $x$ , the realization of  $x'$  is iid across workers and over time.

Finally, a worker with  $m = vm$  receives an offer to undertake a voluntary move. Such an occupational move requires the worker to obtain training in the skills needed to perform the new occupation. If the worker rejects the offer to undertake a  $vm$ , she works on her current island and remains there at the beginning of the next period, just as if she had drawn  $m = n$ . If she instead takes up the offer, then, similarly to an  $im$ , she does not work in the current period, and she begins the next period inexperienced and on a new island. A  $vm$  differs from an  $im$  in two respects. First, the worker must pay a training cost of  $\kappa \geq 0$  units of goods.<sup>12</sup> Second, the productivity of the new island,  $x'$ , is drawn from a different distribution with pdf  $\psi_{vm}(x' | x)$ . Conditional on undertaking a  $vm$  and on  $x$ , the realization of  $x'$  is iid across workers and over time. Thus, in deciding whether to undertake a  $vm$ , the worker only knows the distribution  $\psi_{vm}(\cdot | x)$  and not the realization of  $x'$ .

Since several objects in our model depend on the agent's mobility action, it is convenient to introduce notation for it. Denote by  $\mu \in \mathcal{M}$  the mobility action the worker actually undertakes. (Of course, the agent's mobility status and mobility action are closely related: for  $m = n$  and  $m = im$ , the worker has no option but to set  $\mu = m$ , while if  $m = vm$  then the worker can set either  $\mu = n$  or  $\mu = vm$ .) This allows us to denote by  $\eta_\mu(e' | e)$  the probability that the agent's experience level on the island where she begins the next period will be  $e' \in \mathcal{E}$ , conditional on today's experience  $e \in \mathcal{E}$  and mobility action  $\mu \in \mathcal{M}$ . We have that  $\eta_\mu(0 | e) = 1$  and  $\eta_\mu(1 | e) = 0$  for  $e \in \mathcal{E}$  and  $\mu \in \{im, vm\}$ , while  $\eta_n(0 | 0) = 1 - q$ ,  $\eta_n(1 | 0) = q$ ,  $\eta_n(0 | 1) = 0$ , and  $\eta_n(1 | 1) = 1$ .

Write  $\psi_n(x' | x) \equiv \pi(x' | x)$  for all  $x, x' \in \mathcal{X}$ . The probability distribution over the island-specific shock for the island on which the agent will begin the following period, conditional on today's shock  $x$  and mobility action  $\mu$ , is then always denoted  $\psi_\mu(x' | x)$ . We also can summarize the stochastic process for productivity, experience, and mobility status in a compact fashion as follows. First, define  $\mathcal{S} = \mathcal{X} \times \mathcal{E} \times \mathcal{Z}$ , with typical element  $s = (x, e, z)$ . Then the

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<sup>12</sup>As well as the monetary cost of retraining,  $\kappa$  may also capture lower wages during an 'apprenticeship' period or forgone due to job search.

probability of the realization  $s' = (x', e', z')$  and mobility status  $m'$  next period, conditional on the current state  $s$  and the current mobility action  $\mu$ , is

$$\Gamma_\mu(s', m' | s) = \psi_\mu(x' | x)\eta_\mu(e' | e)h^z(z')h^m(m'). \quad (1)$$

## 2.3 Production

There is a competitive representative firm which rents capital and labor and produces output  $Y(K, L) = AK^\alpha L^{1-\alpha}$ .<sup>13</sup> We normalize  $A = 1$ . Capital is owned by workers and rented each period to the firm. It depreciates at rate  $\delta \in (0, 1)$ . Labor supply from a given island comes from aggregating the efficiency units of labor supplied by workers located on that island. The total labor supply to the firm then comes from integrating island-level labor supply over the measure 1 of islands.<sup>14</sup> We normalize the price of the final good to 1.

## 2.4 Government

There is a government that taxes labor income at a rate  $\tau$  and uses the proceeds to finance government purchases  $G$  and lump-sum transfers to households  $T$ .<sup>15</sup> Government purchases are exogenous and not valued by households.<sup>16</sup> The government balances its budget each period, so that

$$G + T = \tau wL. \quad (2)$$

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<sup>13</sup>An alternative, equivalent, formulation would allow for a representative firm on each island, each producing the same final good. Provided capital is freely mobile across islands, each island's representative firm would set the same capital-efficiency units of labor ratio, so that aggregate output would be the same under this formulation.

<sup>14</sup>Note that efficiency units of labor supplied on different islands are perfect substitutes. This assumption differs from that made by Kambourov and Manovskii (2009a). Our assumption enhances the tractability of the model. We conjecture that the effect of market incompleteness would be qualitatively similar if we allowed for an empirically plausible elasticity of substitution across the output of different occupations, for example, around 3, as suggested by Kambourov and Manovskii (2009b) or by Alvarez and Shimer (2011). We leave formal investigation of this for future research.

<sup>15</sup>This type of tax function follows, for example, Krusell et al. (2008).

<sup>16</sup>Since we do not model how the level of  $G$  is chosen, we hold it constant throughout so as to avoid any welfare consequences or effects on occupational mobility arising from changes in  $G$  or in how the government finances it.

## 2.5 Incomplete markets model

In our benchmark model, markets are incomplete. There are no state-contingent securities which insure against shocks to a worker's occupation productivity, experience, idiosyncratic labor productivity, or mobility. Workers can save by holding capital, which is risk-free in the absence of aggregate shocks. A worker's holdings of capital may take any value in the finite set  $\mathcal{A} \subset [\underline{a}, +\infty)$ . We assume that  $\underline{a} = 0$ , so that workers cannot borrow.<sup>17</sup>

The state variables for an individual worker in the incomplete-markets economy are of three types. First, summarized in  $s = (x, e, z)$  are the productivity of the island on which she is located,  $x$ , her transitory shock,  $z$ , and whether or not she is experienced in her island's occupation,  $e$ . Her state variables also include her assets,  $a$ , and her mobility status  $m$ . We denote by  $V(s, m, a)$  the (Bellman) value of an agent in this state. Also write  $W(s, \mu, a)$  for the value of such an agent conditional on deciding to undertake mobility action  $\mu$ . Because agents may only choose the mobility action allowed to them according to their mobility status, we have that for any  $(s, a)$ ,

$$V(s, m, a) = \begin{cases} W(s, m, a) & \text{if } m \in \{n, im\}; \\ \max \{W(s, n, a), W(s, vm, a)\} & \text{if } m = vm. \end{cases} \quad (3)$$

We also have that

$$W(s, \mu, a) = \max_{c > 0, a' \in \mathcal{A}} u(c) + \beta \mathbf{E}_\mu [V(s', m', a') | s] \quad (4)$$

$$\text{s.t.} \quad c + a' = (1 + r)a + \mathbb{I}_{\mu=n}wxz(1 + \chi)^e(1 - \tau) - \mathbb{I}_{\mu=vm}\kappa + T \quad \text{and} \quad a' \geq 0,$$

where  $\mathbb{I}_\Xi$  takes the value 1 if the condition  $\Xi$  is satisfied and 0 otherwise, and where

$$\mathbf{E}_\mu [V(s', m', a') | s] = \sum_{s' \in \mathcal{S}, m' \in \mathcal{M}} V(s', m', a') \Gamma_\mu(s', m' | s) \quad (5)$$

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<sup>17</sup>It would be straightforward to allow for alternative choices of  $a$ , not less than the natural borrowing limit; however, we leave investigating this for future research. In our numerical work,  $\mathcal{A}$  contains 2000 elements, and its maximal element is large enough that no agent is constrained by the desire to save more than this in any state.

denotes the agent's expectation for her next-period value, conditional both on the current state  $s$  (and specifically on the persistent components  $x$  and  $e$ ) and on her mobility action  $\mu$ . This last choice affects the agent's consumption-savings problem in four ways: the agent receives labor income only if she works, she pays the mobility cost only if she undertakes a  $vm$ , and in addition the mobility action affects the probability distributions over both  $x'$  and  $e'$ .

The worker takes as given the interest rate  $r$ , the wage per efficiency unit of labor  $w$ , labor income taxes  $\tau$ , lump-sum transfers  $T$ , and government expenditures  $G$ . We write  $g^\mu(s, m, a)$  for the optimal mobility action  $\mu$  undertaken in state  $(s, m, a)$ , and  $g^c(s, m, a)$  and  $g^a(s, m, a)$  for the corresponding consumption and savings choices  $c$  and  $a'$ .<sup>18</sup>

Denote by  $\nu(s, m, a)$  the mass of agents with productivity state  $s \in \mathcal{S}$ , mobility status  $m \in \mathcal{M}$ , and assets  $a \in \mathcal{A}$ . Given the policies  $g^\mu(\cdot)$  and  $g^a(\cdot)$ , the distribution of agents evolves so that, for any  $s' \in \mathcal{S}$ ,  $m' \in \mathcal{M}$ , and  $a' \in \mathcal{A}$ ,

$$\nu'(s', m', a') = \sum_{s \in \mathcal{S}, m \in \mathcal{M}, a \in \mathcal{A}} \Gamma_{g^\mu(s, m, a)}(s', m' | s) \mathbb{I}_{g^a(s, m, a) = a'} \nu(s, m, a). \quad (6)$$

A *steady-state equilibrium under incomplete markets* is a set of functions  $\mathcal{F} = \{V(\cdot), W(\cdot), g^\mu(\cdot), g^c(\cdot), g^a(\cdot)\}$ , a probability measure  $\nu$ , aggregate capital  $K$  and labor  $L$ , prices  $w$  and  $r$ , taxes and transfers  $\tau$  and  $T$ , and government expenditures  $G$  such that

1. given prices  $w$  and  $r$ , taxes  $\tau$ , and transfers  $T$  the functions  $\mathcal{F}$  solve the household's decision problem (3)-(4);
2. prices equal marginal productivities,  $r = Y_K(K, L) - \delta$  and  $w = Y_L(K, L)$ ;
3. factor markets clear,

$$K = \sum_{s \in \mathcal{S}, m \in \mathcal{M}, a \in \mathcal{A}} a \nu(s, m, a) \text{ and } L = \sum_{s \in \mathcal{S}, m \in \mathcal{M}, a \in \mathcal{A}} \mathbb{I}_{g^\mu(s, m, a) = n} x z (1 + \chi)^e \nu(s, m, a);$$

4. the government satisfies its balanced budget constraint (2);

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<sup>18</sup>To be sure, the only nontrivial mobility decision pertains to mobility status  $m = vm$ , but this general notation allows for a unified treatment across mobility statuses.

5. and the distribution  $\nu(\cdot)$  is invariant, in the sense that  $\nu' = \nu$  in (6).

Market clearing for the produced good follows from Walras' law. We postpone a detailed description of the nature of equilibrium and of agents' policies for savings and mobility to [Section 4](#) below, where we study a calibrated version of our model. For now, we observe that, when markets are incomplete, an agent's mobility choices depend on her assets. An agent with the opportunity to undertake a  $vm$  will be unable to do so if she does not have enough assets to pay the mobility cost  $\kappa$ . Moreover, even if her assets exceed this lower bound, she may still elect not to switch occupations to avoid depleting her precautionary savings and exposing herself to large falls in consumption should she experience negative earnings shocks in the future.

## 2.6 Complete markets model

We also study an alternative setting in which financial markets are complete. This allows us to evaluate the welfare cost of market incompleteness and the effects of policies aimed at ameliorating them. Under complete markets, the economic environment is largely unchanged from that described above. Importantly, we still assume the existence of a government that levies labor income taxes to finance government expenditures and lump-sum transfers to households; the existence of the government and its behavior are treated as primitives of the environment. However, financial markets are notably different as we allow agents to trade a full set of state-contingent (Arrow) securities.

Like before, agents face four sources of risk: occupational productivity  $x'$  and experience  $e'$ , the transitory component of income  $z'$ , and mobility status  $m'$ . We assume that during a period agents can trade contracts which pay off in the following period contingent on the realizations of  $s' = (x', e', z')$  and  $m'$  in that period. These contracts are supplied by competitive risk-neutral insurance companies, and are thus priced in an actuarially fair manner.

To avoid problems of asymmetric information, we assume that not only are the agent's current productivity and mobility states  $(s, m)$  observable and contractible, but so too is the actual mobility action  $\mu$  she undertakes. This is

important in the case of an agent with  $m = vm$ , when the agent can choose  $\mu \in \{w, vm\}$ ; the actual action chosen affects the distribution over future states. We also assume that the agent is not permitted to hold nonzero quantities of securities corresponding to mobility actions  $\mu$  she does not actually take.<sup>19</sup>

We provide a formal description of the complete-markets model in Appendix A. It suffices to observe here that the key qualitative difference from the incomplete-markets benchmark is that when markets are complete, the mobility decision is decoupled from wealth. Instead all agents choose their mobility actions in such a way as to maximize the expected present discounted value of future labor earnings net of mobility costs. Additional wealth is annuitized.

### 3 Model Parameterization

To assess whether the effects of market incompleteness on the economy are quantitatively important requires studying a parameterized version of our environment. We now describe how we calibrate our model.

#### 3.1 Stochastic Processes for Productivity

An important feature to specify in our environment is the pair of distributions from which agents who move, voluntarily or involuntarily, draw the productivity of their new island. One possibility would be for occupational mobility to be completely random, as in Alvarez and Veracierto (1999). This would be appropriate if workers knew nothing about their new island prior to making a switch, or if a worker's productivity in an occupation were an experience good. This seems possible if occupational productivity largely arises from the quality of the match between a worker and an occupation, rather than from the characteristics of the occupation itself, and if this match quality is unobservable ex ante. An alternative modeling approach would allow for occupational mobility to be fully directed, as in Lucas and Prescott (1974). In this case

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<sup>19</sup>In the absence of this restriction, the agent would want to hold unboundedly large negative quantities of Arrow securities corresponding to actions  $\mu$  she does not plan to take.



workers would move only to occupations in which their productivity is high. This would be appropriate if a worker’s occupational productivity could be anticipated before the move takes place, perhaps because characteristics of the occupation and the worker’s match quality were known in advance.

Instead of imposing one or the other of these two polar assumptions a priori, we instead allow for search to be partially directed. To model this, we allow for the productivity  $x'$  of the destination island found through search to depend on that of the current island  $x$ , as follows:

$$\log(\tilde{x}') = \phi_j + \gamma_j \log(x) + \epsilon_j \quad s.t. \quad \epsilon_j \sim N(0, \sigma_j^2) \quad \text{for } j \in \{vm, im\}.$$

This formulation nests the two extreme cases discussed above. If  $\gamma_j = 0$  and  $\phi_j = 0$ , then occupational mobility of type  $j$  is completely random (because of  $\epsilon_j$ ) and independent of the current island. If  $\gamma_j = 0$  and  $\sigma_j = 0$ , then mobility is fully directed at islands of productivity level  $\phi_j$ . As  $\phi_j$  increases, mobility is directed toward the best occupations. A more interesting case arises when  $\phi_j$ ,  $\gamma_j$ , and  $\sigma_j$  are all non-zero. In this case, mobility is partially directed (governed by  $\phi_j$ ) and also correlated with the current occupation. As discussed below, we will use information about wage changes for occupational movers to inform us about these parameters.

When individuals remain in the same occupation we assume that  $x$  follows a discrete approximation to an AR(1) process in logs:<sup>20</sup>

$$\log(x') = \rho_x \log(x) + \epsilon_x \quad s.t. \quad \epsilon_x \sim N(0, \sigma_x^2).$$

The iid idiosyncratic productivity shock  $z$  is lognormal,  $\log(z) \sim N(0, \sigma_z^2)$ .

## 3.2 Calibration

We set the model time period to be a month. This implies that occupational switches (voluntary and involuntary) involve one month of not working.<sup>21</sup>

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<sup>20</sup>For details, see Appendix C.1.

<sup>21</sup>This is consistent with the median duration of non-employment for occupational switchers we find in the Survey of Income and Program Participation (SIPP).

We set a few parameters following standard practice. We calibrate the capital income share  $\alpha$  to 0.36 and set  $\delta$  to imply a quarterly depreciation rate of 2.5 percent. We set  $\beta$  so that in equilibrium the implied quarterly real interest rate is 1 percent. Following Krusell et al. (2008), we set the tax rate at  $\tau = 0.30$ . Government transfers  $T$  and expenditures  $G$  are chosen to match a transfer to output ratio of 10.6 percent as in Krusell and Ríos-Rull (1999).

The more distinctive structural parameters of our model are those governing the returns to occupational experience ( $q$  and  $\chi$ ); the standard deviation of idiosyncratic shocks ( $\sigma_z$ ); the productivity shock process for occupations ( $\rho_x$  and  $\sigma_x$ ); the financial cost of voluntarily moving ( $\kappa$ ); the parameters governing the iid likelihood of each type of mobility ( $p_{vm}$  and  $p_{im}$ ); and the parameters governing the distribution of islands an individual lands on given the type of mobility ( $\phi_{vm}$ ,  $\gamma_{vm}$ ,  $\sigma_{vm}$ ,  $\phi_{im}$ ,  $\gamma_{im}$ , and  $\sigma_{im}$ ).

Similar to Kambourov and Manovskii (2009a), we set  $q$  and  $\chi$  so that in the model it takes in expectation 10 years of occupational tenure to become experienced and earn a permanent wage increase of 20 percent, relative to inexperienced individuals. To calibrate the financial cost of moving,  $\kappa$ , we follow evidence from Heckman, Lalonde, and Smith (1999). They report the average vocational training program in the U.S. takes about three months of study and has a direct cost of \$2,000 to \$3,000 in 1997 U.S. dollars. Kambourov and Manovskii (2009a) argue that this monetary cost is close to two months of wages for the median worker in 1997. We set  $\kappa$  equal to two months of pre-tax wages for the mean employed worker in our model.<sup>22</sup>

The remaining 11 parameters ( $\sigma_z$ ,  $\rho_x$ ,  $\sigma_x$ ,  $p_{vm}$ ,  $p_{im}$ ,  $\phi_{vm}$ ,  $\gamma_{vm}$ ,  $\sigma_{vm}$ ,  $\phi_{im}$ ,  $\gamma_{im}$ ,  $\sigma_{im}$ ) are jointly calibrated so that the model matches salient features of occupational mobility and (residual) wages measured in the 1996 panel of the SIPP. We restrict our attention to males aged 30-54 who work in the private sector. Our measure of labor income is hourly wages. Occupational switches are measured at the three-digit level.<sup>23</sup> The wage gain conditional on

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<sup>22</sup>Our results would be little changed if we used the median rather than the mean.

<sup>23</sup>Defining mobility at one- or two-digit level would tend to bias our results toward greater voluntary mobility as switches at these levels of detail are more likely to involve re-training. Intuitively, this would bias us towards finding larger effects of market incompleteness.

switching occupations is measured as the log difference between the last wage in the previous occupation and the wage 12 months after the switch occurs.<sup>24</sup> This measure is intended to capture the benefit from switching free of any initial effects (for example, probationary periods) either not captured by our model or incorporated in  $\kappa$ .<sup>25</sup> Additional details of our sample construction appear in Appendix B.

Our empirical targets can be divided into mobility and wage moments. We match the overall rate of monthly occupational mobility, both unconditionally and separately for workers with wages below or above the median. We also match the level of repeat mobility, defined as the expected number of occupational moves over four years conditional on having switched occupations at least once.<sup>26</sup> Intuitively, the overall level of mobility in the data identifies  $p_{vm} + p_{im}$ . Greater repeat mobility in the data is indicative of less directedness of the voluntary mobility process and is thus related to  $\phi_{vm}$ ,  $\rho_{vm}$ , and  $\sigma_{vm}$ . The split between voluntary and involuntary mobility is closely related to the relationship between mobility and current-island productivity. Our model suggests that mobility—and in particular, voluntary mobility—is more likely to occur on low-productivity islands and less likely to occur on high-productivity islands. The difference in mobility rates between workers with above-median wages and those with below-median wages is therefore informative.<sup>27</sup>

Turning to wage moments, we target the autocorrelation and cross-sectional variance of wages both for all workers and for occupational stayers alone. These moments help identify the island productivity process  $(\rho_x, \sigma_x)$  and the standard deviation of the iid idiosyncratic productivity shock  $(\sigma_z)$ .

We also seek to capture the returns to occupational switching versus stay-

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<sup>24</sup>In model-simulated data we follow essentially the same procedure, but define the last wage in the previous occupation as the wage that would have prevailed had the agent worked at the time the switch occurs.

<sup>25</sup>Note that, both in the data and in the model, the wage 12 months following the switch may not be earned in the occupation to which the individual first transitioned.

<sup>26</sup>The measure of repeat mobility is similar to that in Kambourov and Manovskii (2009a).

<sup>27</sup>We choose to split the current wage distribution at the median, for two reasons: first, it is more parsimonious, and second, it makes identification more transparent given that we allow for two types of occupational mobility.

ing, which are related to the parameters  $(\phi_{vm}, \gamma_{vm}, \sigma_{vm})$  and  $(\phi_{im}, \gamma_{im}, \sigma_{im})$ . We target the mean and variance of the 12 month wage gain for occupational switchers and stayers separately. Differences in the processes for voluntary and involuntary moves are captured by targeting the mean and variance of the wage gain from switching (relative to staying) separately for workers whose wages in their original occupation are below or above the median. Because the model predicts that voluntary mobility mostly occurs on low-productivity islands, the dynamics of wage growth for workers with below-median wages help identify  $(\phi_{vm}, \gamma_{vm}, \sigma_{vm})$ , while the dynamics of wage growth for workers with above-median wages help identify  $(\phi_{im}, \gamma_{im}, \sigma_{im})$ .

A comparison of Columns (1) and (2) in [Table 1](#) shows the model matches the proposed targets well.<sup>28</sup> The first two panels of this table show the model replicates the overall mobility rate and the cross-sectional dispersion of wages. The next two panels show the model replicates both the average and dispersion of wage gains for occupational switchers. Importantly, it captures that switchers on average gain more than stayers, but also face greater dispersion. Beyond these facts, the model also matches the cross-sectional patterns for switchers and stayers. As in the data, occupational mobility rates are lower for workers with higher wages in their original occupations, as is average wage growth conditional on switching. In fact, average wage growth is positive for those with wages below the median and negative for those above it.<sup>29</sup> To match these facts jointly, the model requires an involuntary move rate of roughly 1 percent as seen by the implied value of  $p_{im}$  in [Table 2](#). This implies that essentially all occupational mobility above the median wage is involuntary. Meanwhile, around half of all mobility below the median wage is voluntary.<sup>30</sup>

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<sup>28</sup> We describe how we solve and calibrate the model in [Appendices C.1](#) and [C.2](#). Columns (3), (4), and (5) of [Table 1](#) show the same moments respectively under complete markets (see [Section 4](#)) and under the subsidy and tax policy experiments ([Section 5](#)).

<sup>29</sup> Measurement error—which is allowed for in the model via the idiosyncratic shock  $z$ —could also explain this pattern for wages, but not the cross-sectional pattern of mobility.

<sup>30</sup> It may seem surprising that there are few voluntary occupational switches for high-wage workers. This is partly a result of our terminology: we could also phrase our conclusion as that there are few moves which are large enough to cross 3-digit occupational boundaries for high-wage workers. To the extent that we miss more ‘local’ occupational switches for high-wage workers, our results may understate the effects of market incompleteness.

Statistic	Target (1)	Incomplete markets (2)	Complete markets (3)	Mobility subsidy (4)	Income tax (5)
Mobility rates					
Mob. rate: all workers	0.0159	0.0161	0.0196	0.0235	0.0158
Mob. rate: below median of wages	0.0213	0.0213	0.0276	0.0359	0.0209
Mob. rate: above median of wages	0.0106	0.0107	0.0107	0.0107	0.0107
Repeat mob. rate	1.5466	1.6595	1.8907	2.1081	1.6448
Wages					
Variance: all workers	0.1332	0.1352	0.1318	0.1336	0.1355
Autocorrelation (annual): all workers	0.7404	0.7650	0.7504	0.7434	0.7673
Variance: stayers	0.1318	0.1325	0.1283	0.1295	0.1329
Autocorrelation (annual): stayers	0.7432	0.7686	0.7538	0.7471	0.7708
Wage gain 12 months from switching (in logs)					
Mean: all switchers	0.0625	0.0611	0.1004	0.1116	0.0575
Mean: below median of wages	0.1623	0.1636	0.1987	0.1949	0.1736
Mean: above median of wages	-0.1759	-0.1724	-0.1807	-0.1767	-0.1721
Variance: all switchers	0.1623	0.1637	0.1648	0.1614	0.1638
Variance: below median of wages	0.1387	0.1426	0.1417	0.1410	0.0639
Variance: above median of wages	0.1310	0.1267	0.1260	0.1276	0.0590
Wage gain 12 months from staying (in logs)					
Mean: all stayers	-0.0008	-0.0010	-0.0020	-0.0028	-0.0009
Mean: below median of wages	0.0702	0.0665	0.0642	0.0678	0.0664
Mean: above median of wages	-0.0687	-0.0694	-0.0746	-0.0745	-0.0693
Variance: all stayers	0.0665	0.0660	0.0680	0.0706	0.0656
Variance: below median of wages	0.0687	0.0641	0.0678	0.0728	0.1224
Variance: above median of wages	0.0549	0.0590	0.0590	0.0591	0.0734

**Table 1.** Calibration targets and corresponding moments in the steady states of the incomplete-markets benchmark model, the complete-markets model, and the two policy experiments under incomplete markets, as described in [Section 5](#).

To understand the mechanism of our model better, Appendix E presents the results of two alternative specifications, one without involuntary occupational moves, and one without the idiosyncratic wage shock  $z$ . The results suggest that without involuntary mobility, the model is unable to account simultaneously for the average level of mobility, for how mobility varies across the wage distribution, and for how the wage gains associated with switching vary across the wage distribution.

Description	Symbol	Value	Description	Symbol	Value
Capital share	$\alpha$	0.36	Std. dev. of occ. shock	$\sigma_x$	0.0592
Depreciation rate	$\delta$	0.0084	Autocorr. of occ. shock	$\rho_x$	0.9844
Tax rate	$\tau$	0.30	Std. dev. of iid shock	$\sigma_z$	0.0478
Transfer to output ratio	$T/Y$	0.1060	Distribution of islands	$\gamma_{vm}$	0.6686
Return to exp.	$\chi$	0.2000	given voluntary move	$\sigma_{vm}$	0.2659
Prob. of gaining exp.	$q$	0.0083		$\phi_{vm}$	-0.0532
Discount factor	$\beta$	0.9964	Distribution of islands	$\gamma_{im}$	0.9961
Mobility cost	$\kappa$	10.4647	given involuntary move	$\sigma_{im}$	0.3141
<i>vm</i> offer rate	$p_{vm}$	0.1155		$\phi_{im}$	-0.0402
<i>im</i> rate	$p_{im}$	0.0107			

**Table 2.** Parameter values.

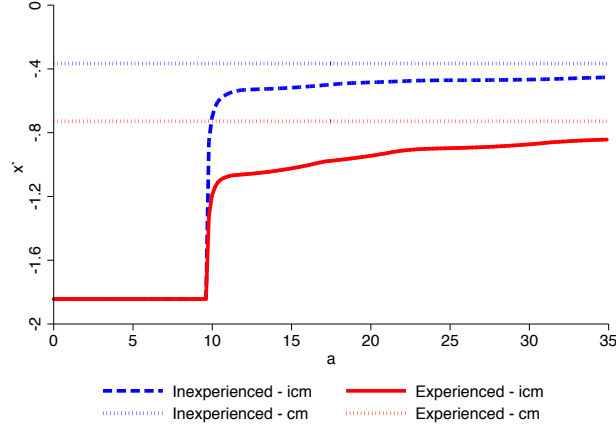
## 4 Results

In this section we present our results on how market incompleteness affects occupational mobility, occupational experience, and welfare. We do this by presenting comparisons between complete and incomplete markets economies.<sup>31</sup>

### 4.1 Policy functions

We begin by describing the policy functions for occupational mobility under the two market environments. First, observe that, conditional on the other state variables  $(e, z, a)$  of the agent's problem, all agents strictly prefer islands with higher productivity  $x$ . These islands deliver higher current wages for agents who work, have higher expected productivity in the future for agents who remain, and are associated with better distributions of productivity (in the sense of first-order stochastic dominance) on the destination island for agents who undertake either voluntary or involuntary moves. However, a higher  $x$  is more valuable to a worker who remains and works on the current island than to one who moves. This is because an agent who works earns the associated wage for some time while one who moves does not, and because the future productivity of the worker's current island is more strongly correlated with the current  $x$  for stayers than for movers. We can thus calculate a reservation

<sup>31</sup>Appendix C.3 describes how we compute the complete-markets steady state.



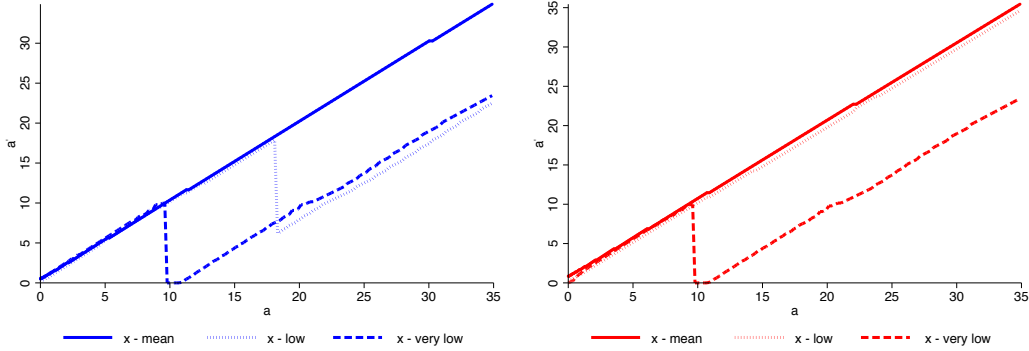
**Figure 1.** Reservation island productivities by assets, shown separately for inexperienced and experienced agents and separately under incomplete markets (icm) and complete markets (cm).

productivity  $x^*(e, z, a)$  below which an agent chooses to move rather than work when given the opportunity to undertake a  $vm$ . This reservation productivity is implicitly defined as the unique solution to

$$W\left((x^*(e, z, a), e, z), n, a\right) = W\left((x^*(e, z, a), e, z), vm, a\right).$$

Figure 1 depicts the reservation productivity level (in logs) for each experience level as a function of the asset level (shown on the horizontal axis) assuming the idiosyncratic shock  $z$  is at its mean.<sup>32</sup> The graph shows two important stylized features of mobility in our model. First, experienced agents, who have higher wages in their current occupation for any  $x$ , have a lower reservation productivity and therefore move less than inexperienced agents, all else equal. Second, conditional on experience, agents with lower assets have a lower reservation productivity. The lower an agent's assets, the worse her current island has to be to justify paying the mobility cost and forgoing income for one period, in order to gain the possibility of higher future pro-

<sup>32</sup>To put the units used in this graph in context, note that the unconditional mean of the distribution of  $x$  across islands is 0, and the cross-sectional standard deviation is  $\sigma_x/\sqrt{1-\rho_x^2} = 0.336$ . The average wage of employed workers is 5.23 units of goods.



**Figure 2.** Savings policies under incomplete markets for inexperienced (left) and experienced individuals (right) for different values of occupation productivity  $x$ .

ductivity by moving. The fact that the reservation productivity of an agent depends on her assets is entirely because of market incompleteness. When full insurance is available, all agents act to maximize the present discounted value of income, and therefore move away from any island with productivity less than a threshold value which depends only on the agent’s experience level (which affects the value of remaining). This is shown in [Figure 1](#) by the two dotted horizontal lines corresponding to inexperienced and experienced agents. Lastly, note that mobility is muted under incomplete markets even for wealthier individuals: the reservation productivity curves for the benchmark model lie everywhere below their complete-markets analogs.

[Figure 2](#) shows the savings policies in the incomplete-markets model. The left panel of the figure shows savings policies for inexperienced agents who have the option to undertake a voluntary move, assuming the idiosyncratic shock  $z$  is at its mean. The solid line (labeled ‘ $x$  - mean’) represents the savings policy when the occupational productivity shock is at its mean, while the dotted and dashed lines (labeled ‘ $x$  - low’ and ‘ $x$  - very low’) represent the policies when the shock is roughly 2 and 6 standard deviations below the mean, respectively.<sup>33</sup> The right panel shows the corresponding policies for experienced agents.

As expected, future assets,  $a'$ , are increasing in current occupation produc-

<sup>33</sup>More precisely,  $x$ -low equals  $-0.492$ , while  $x$ -very low equals  $-1.843$ .



tivity and in experience (each of which corresponds to higher current labor income). The policy for future assets is in general increasing in current assets, *a*. However, the discrete voluntary mobility choice causes a discontinuity in the savings policy at the asset level at which the agent is indifferent about whether or not to move. For slightly lower asset levels, the agent works, does not pay the mobility cost, and saves. For slightly higher asset levels the agent moves, pays the mobility cost, and expects a future increase in labor productivity in case a better island is drawn; all these reasons lead to lower asset accumulation in the current period. Other smaller discontinuities arise for slightly richer agents who anticipate they might need to move in the near future.

## 4.2 Economic aggregates

A comparison of Columns (1) and (2) in [Table 3](#) highlights how the introduction of complete markets affects economic aggregates by improving mobility.<sup>34</sup> The capital stock is higher in the steady state of our benchmark than under complete markets; this is a standard result in Bewley models, although given that effective labor supply is endogenous to the mobility decisions of agents, it was not guaranteed here (Marcet, Obiols-Homs, and Weil, 2007). However, despite the lower capital stock, output is higher under complete markets because increased occupational mobility improves the allocation of workers across islands and so increases effective labor, which offsets the decline in capital. Consumption is also slightly higher under complete markets because of general equilibrium effects; it actually decreases when holding prices constant at their incomplete-markets levels.

Related to the difference in effective labor are the differences in mobility rates across the two market environments. The monthly mobility rate is 0.35 percentage points higher in the complete-markets steady state, an increase of more than a fifth, as agents move whenever it increases the present discounted value of labor income. Under incomplete markets, instead, agents smooth consumption by remaining in their current occupations, thereby conserving

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<sup>34</sup>Columns (3) and (4) show the effects of the policies discussed in [Section 5](#) below.

Statistic	Incomplete markets (1)	Complete markets (2)	Mobility subsidy (3)	Income tax (4)
Output, $Y$	8.04	8.05 [0.08]	8.23 [2.3]	8.03 [-0.2]
Consumption, $C$	5.22	5.24 [0.4]	5.29 [1.2]	5.22 [-0.1]
Capital, $K$	246.89	241.11 [-2.3]	252.00 [2.1]	246.28 [-0.3]
Effective labor, $L$	1.17	1.19 [1.5]	1.20 [2.4]	1.17 [-0.1]
Experience rate (%)	42.30	41.38 [-2.2]	39.69 [-6.2]	42.56 [0.6]
Overall mobility rate (%)	1.61	1.96 [21.8]	2.35 [46.4]	1.58 [-1.7]
Voluntary mobility rate (%)	0.54	0.89 [64.9]	1.29 [138.0]	0.51 [-4.9]
Wage, $w$	4.39	4.33 [-1.4]	4.39 [-0.1]	4.39 [-0.1]
Real interest rate, $r$	0.33	0.36 [8.8]	0.34 [0.9]	0.33 [0.5]
Labor income tax rate, $\tau$	0.30	0.30 [0.0]	0.32 [7.3]	0.32 [7.3]
Transfers to hh., $T$	0.85	0.85 [0.13]	0.94 [9.7]	0.96 [12.8]

**Table 3.** Aggregates in the benchmark model, under complete markets, and under the two policies considered in Section 5. In columns (2), (3), and (4), the percentage increase from the column (1) benchmark is shown in brackets.

assets by saving the mobility cost and not forgoing labor earnings. Mechanically, higher mobility contributes to a reduction in aggregate labor supply (the mobility rate and the employment rate sum to unity by construction). Additionally, because of greater mobility, agents are less likely to have become experienced in their occupation under complete markets. Overall, though, the distribution of agents across island productivities is improved under complete markets, leading on net to an increase in aggregate labor supply measured in

efficiency units.<sup>35</sup>

### 4.3 Cross-sectional features

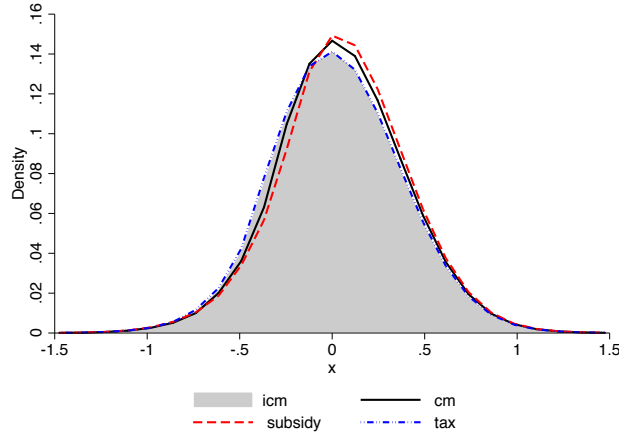
To understand why effective labor increases with the introduction of complete markets, we now focus on how this financial market arrangement changes where agents work. Under complete markets, agents tend to locate on more productive islands. To demonstrate this graphically, [Figure 3](#) displays the overall distributions (pdfs) over occupational productivity for each market arrangement.<sup>36</sup> The pdf associated with the complete-markets steady state (solid black line) lies to the right of that for the incomplete-markets benchmark (shaded area). To gauge the quantitative significance of these differences, [Table 4](#) presents summary statistics both overall and separately by experience level. The first row of this table shows that, under complete markets, individuals are on average located in occupations that are 2.0 log points more productive than under incomplete markets, and this holds true for both inexperienced and experienced agents.

Statistic	Incomplete markets			Complete markets		
	Overall	Inexp.	Exp.	Overall	Inexp.	Exp.
Mean	0.027	0.026	0.029	0.047	0.046	0.049
Variance	0.124	0.134	0.111	0.121	0.132	0.105
1st percentile	-0.865	-0.940	-0.775	-0.856	-0.940	-0.719
5th percentile	-0.596	-0.613	-0.575	-0.580	-0.614	-0.539
50th percentile	-0.043	-0.045	-0.039	-0.021	-0.022	-0.021
95th percentile	0.559	0.580	0.530	0.569	0.588	0.539
99th percentile	0.823	0.853	0.762	0.830	0.857	0.773

**Table 4.** Distributions of workers across islands in the incomplete-markets benchmark and under complete markets, overall and by experience level.

<sup>35</sup>Notice that in our model almost all occupational sorting relates to the allocation of workers across occupations, that is,  $x$ , and not to the idiosyncratic component of income,  $z$ . This is because  $z$  is iid, so the only sorting possible along the  $z$  dimension arises because workers who move do not work for one period; this is quantitatively negligible. We thank an anonymous referee for spurring us to clarify this.

<sup>36</sup>[Figure 3](#) also shows the distributions implied by the policies from [Section 5](#) below.



**Figure 3.** Distributions of workers across islands in the benchmark model (icm), under complete markets (cm), and in the two policy experiments described in [Section 5](#).

The dispersion of occupational productivity is slightly lower under complete markets. As shown in the second row of [Table 4](#), however, this masks subtle differences across experience levels: the variance of occupational productivity for experienced agents falls by a greater amount under complete markets. To investigate this in more detail, the lower panel of [Table 4](#) shows several percentiles of the occupational productivity distribution under both market structures and by experience.<sup>37</sup> For experienced individuals, the greatest distributional improvements are at or below the median, whereas for inexperienced individuals they occur at or above the median. This shows the mechanism that is at work: under complete markets, workers are more able to leave low-productivity islands even when experienced, even though this is associated with a financial cost and also with the possibility that their new occupation will be even worse. Still, the fact that voluntary occupational mobility improves the worker’s occupational productivity in expectation means that both the distributions for experienced and inexperienced workers have higher means when markets are complete.

All these differences have important implications for the dispersion of log

<sup>37</sup>We calculate the percentiles using linear interpolation: see [Appendix C.4](#) for details.

wages and for the distribution of wage gains under the two market structures. This can be seen by comparing the moments used for calibrating the benchmark model, reported in column (2) of [Table 1](#), with their counterparts under complete markets, shown in column (3). The first panel of the table reiterates that mobility is higher under complete markets, and shows that this is driven almost entirely by higher mobility for workers with below-median wages. The second panel reports that both the persistence and cross-sectional variance of log wages are fairly similar across models, though this masks the aforementioned differences in the average levels of occupational productivity by experience. The most interesting comparison concerns the returns to occupational mobility, shown in the third panel. Relative to the incomplete-markets benchmark, the wage gain conditional on switching is roughly 4 percentage points higher under complete markets. This difference arises because of the increase in the probability of switching for workers in low-productivity occupations, as can be seen by the fact that the effect is concentrated on workers with previous wage below the median. In fact, workers with above-median wages who move occupations experience slightly larger average wage losses under complete markets: their higher initial wages (due to better sorting and increased experience) mean they have more to lose.

We conclude this section by discussing the wealth distribution implied by our model. We did not target this as part of our calibration strategy, but the model does not do too bad a job of matching the data. As already reported in [Table 3](#), the ratio of average wealth to average (pre-tax) labor income ratio in our incomplete-markets model is 4.02 in annual terms. By comparison, the ratio of the average wealth and average annual wage income for male heads of households between the ages of 30 and 54 in the 1997 Survey of Consumer Finances (SCF) is 4.7. [Table 5](#) shows that the dispersion of wealth is somewhat larger in the data than in the model, however. This is partly a result of our restriction that agents hold positive assets (since  $\underline{a} = 0$ ) and partly due to the well-known difficulty in Bewley models of generating enough wealth accumulation at the top from precautionary saving alone. Since the welfare gains from completing markets are largest at the bottom of the wealth

	1st	2nd	3rd	4th	5th
SCF	-0.16	2.29	6.27	13.91	77.69
Incomplete markets	3.20	9.03	15.74	25.13	46.89

**Table 5.** Shares of wealth by wealth quintile in Survey of Consumer Finances (SCF) and benchmark incomplete-markets model.

	Complete markets				Mobility subsidy	Tax increase	
	Across st. states	Price const.	Mobility const.	Price & mob. const.	Along trans.	Across st. states	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Overall	1.94	2.54	1.40	1.48	1.88	0.72	0.07

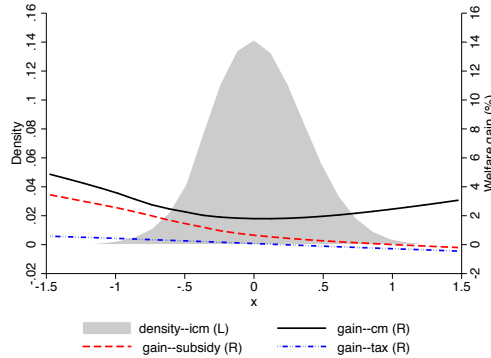
**Table 6.** Consumption equivalent welfare gains (in percent). Columns (1)-(5) show gains associated with completing markets and are described in this section. Columns (6)-(7) show gains associated with the policy experiments described in [Section 5](#).

distribution, this issue seems unlikely to be critical for our results.

More important for our results is the correlation between wealth and wages. Reassuringly, the model’s prediction for the correlation between wealth and income also appears to be in line with comparable data measures. Our model implies a correlation between annual labor income and wealth of 0.31; in the SCF, the correlation between annual wage income and wealth is very similar, at 0.36. Thus, the model’s implication that low-wage workers are also low-wealth workers seems to be quantitatively in line with what the data suggest.

#### 4.4 Welfare cost of incomplete markets

We now investigate the welfare cost of market incompleteness in our model of occupational mobility. Our preferred measure of welfare gains is as equivalent variation: by what percentage would we need to increase an agent’s consumption in every period under incomplete markets so as to make her indifferent to suddenly being transferred, with her current island productivity and assets, into the steady state of the complete markets economy? However, we also report results for several alternative measures, described below. Column (1)



**Figure 4.** Average welfare gains from introducing complete markets (‘cm’) and from the two policy experiments described in [Section 5](#) (‘subsidy’ and ‘tax’). The shaded area represents the distribution of workers across islands in the incomplete-markets benchmark.

of [Table 6](#) reports that the average welfare gains according to our preferred measure are significant, averaging 1.94 percent.<sup>38</sup>

[Figure 4](#) shows how the gains vary by current occupational productivity  $x$ , averaging over the remaining states (i.e. the idiosyncratic shock  $z$ , experience level  $e$ , and assets  $a$ ). The shaded area shows for reference the distribution of workers by occupational productivity in the incomplete-markets steady state.<sup>39</sup> The benefits from accessing complete markets are most pronounced at the tails of the occupational distribution and stem from different sources. Agents in the least productive occupations gain from two sources: they can more rapidly move to more productive islands and so increase the present value of their labor income (net of mobility costs), and they can increase their consumption by borrowing against their future labor income. Inexperienced agents on bad islands benefit especially from the former. In contrast, agents in the most productive occupations gain from general-equilibrium effects. They tend to have higher assets and therefore benefit from the higher interest rate which arises because the capital stock is lower under complete markets.

To gauge the importance of general-equilibrium effects, we calculate welfare

<sup>38</sup>We describe how we compute welfare gains in more detail in [Appendix C.5.1](#).

<sup>39</sup>The figure also shows the gains associated with the experiments discussed in [Section 5](#) below. [Appendix F](#) presents similar figures by experience level.

gains holding prices constant. To do this, we imagine that a single worker is offered access to complete insurance markets, while all other workers continue to trade as in the incomplete-markets benchmark economy. The results of this exercise are shown in column (2) of [Table 6](#). The expected value for the associated welfare gain is 2.54 percent, or 0.6 percentage point higher than in Column (1). In Appendix F we show that agents on less productive islands see their gains increase when holding prices constant, while agents on more productive islands see their gains shrink.

Next, to quantify how much of the measured welfare gains are due to better consumption smoothing rather than improved mobility, we investigate the effect of holding the mobility policy constant while completing markets. To do this, we first compute the average voluntary mobility rate conditional on  $s = (x, e, z)$ , averaging over assets  $a$ , in our incomplete-markets economy. We then impose that in our complete-markets economy, an agent with state  $s$  whose mobility state is  $m = vm$  must switch occupations with this same probability, according to the realization of a random variable that is independent from everything else in the model. The worker must remain in her existing occupation with the complementary probability. We allow agents to insure against the realization of this ‘voluntary’ mobility shock, thereby enriching the set of Arrow securities available for trade.<sup>40</sup> Column (3) of [Table 6](#) reports the results. Average welfare gains under this arrangement are 1.40 percent, suggesting improved mobility accounts for 0.54 percentage points of the headline 1.94 percentage point gain from completing markets.<sup>41</sup>

Column (4) reports welfare gains holding both prices and mobility constant. Under this specification, gains fall to 1.48 percent on average. This implies that improved mobility under complete markets accounts for 1.06 percentage points of the 2.54 percent welfare gain when holding prices constant.<sup>42</sup>

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<sup>40</sup>Appendix C.6 gives more detail on the model with mobility held constant.

<sup>41</sup>The reader might wonder about the effect of applying the complete-markets mobility policy under incomplete-markets rather than, as here, applying the incomplete-markets mobility policy under complete markets. However, we cannot make this comparison since the complete-markets mobility policy is not feasible in the presence of borrowing constraints.

<sup>42</sup>This gain is again quite similar across agents of different experience levels: for inexperienced agents, improved mobility accounts for 1.09 percentage points of their price constant



Finally, a comparison of columns (1) and (5) reveals that accounting for transitional dynamics does not affect our main results.<sup>43</sup> We imagine that the economy begins in the incomplete-markets steady state, and that suddenly and unexpectedly complete markets become available. Solving for the transition to the new steady state and computing the associated welfare gains implies average gains of 1.88 percent rather than 1.94 percent.

## 5 Policy experiments

We have so far studied the effects of market incompleteness by comparing two extreme environments, namely, a benchmark incomplete-markets environment with no borrowing and a complete-markets equivalent. However, an alternative and perhaps more realistic way to understand the effects of market incompleteness is to consider the effects of policies that relax the constraints on occupational mobility while preserving the basic incomplete-markets structure of the benchmark model. We now consider the effects of two such policies. The first experiment targets occupational mobility directly by subsidizing the training cost for voluntary moves. The subsidy is financed by increasing the tax rate on labor income. In the second experiment, we raise the tax rate by the same amount as in the first experiment, but rebate the additional transfers in a lump-sum fashion. The results from these two experiments highlight the importance of conditioning the extra government spending on mobility. We find that the subsidy is effective in raising occupational mobility, effective labor, and welfare, while the tax-and-transfer scheme reduces mobility and effective labor and leaves welfare essentially unchanged.

### 5.1 The Effects of a Training Subsidy

For this experiment, we assume that the government subsidizes mobility by paying half the training cost. This reduces the mobility cost faced by agents

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gain, while the corresponding figure for experienced agents is 1.03 percentage points.

<sup>43</sup>We give details of how we solve for the transition in Appendix C.7 and we describe the transition paths for the key endogenous variables in Appendix D.1.

from  $\kappa$  (which was equal to two months of wages of the mean worker in the benchmark environment) to  $\kappa/2$ . The government finances the subsidy by increasing the tax rate on labor income, which we denote by  $\tau_{subs}$ . These changes alter the worker's budget constraint (4) to the following:

$$c + a' = (1 + r)a + \mathbb{I}_{\mu=n}wxz(1 + \chi)^e(1 - \tau_{subs}) - \mathbb{I}_{\mu=vm}\frac{\kappa}{2} + T_{subs} \quad \text{and} \quad a' \geq 0.$$

The decision problem is otherwise unchanged.<sup>44</sup> We still assume that the government chooses the tax rate  $\tau_{subs}$  to balance the budget given a potentially new level of transfers  $T_{subs}$ , but holding fixed government expenditures  $G$  at their benchmark level. It achieves this using a tax rate of 0.32, only slightly higher than the tax rate in the benchmark model.

The effects on economic aggregates of this policy, in the new steady state which arises once the subsidy and tax have been imposed, are reported in column (3) of [Table 3](#). The effects on the wage and mobility moments used to calibrate the benchmark model are reported in column (4) of [Table 1](#). The improvement in the endogenous distribution of  $x$  can be seen in [Figure 3](#) by comparing the shaded area (benchmark) and the dashed red line (subsidy). Three features of the resulting equilibrium are particularly noteworthy.

First, the subsidy is effective in increasing the occupational mobility rate, which rises from 1.6 percent to 2.4 percent per month. Moreover, the increased mobility is mostly among low-wage agents. This can be seen by comparing columns (2) and (4) in the top panel of [Table 1](#).

Second, the subsidy is also effective in increasing aggregate output, labor, and capital: these all expand by between 1 and 2 percent relative to the no-subsidy benchmark. The increase in labor arises because the subsidy induces agents to move away from low-productivity islands and so improves the average occupational productivity  $x$ . This effect is strong enough to overcome two offsetting forces: first, the mechanical effect that higher mobility implies lower employment (since workers undertaking occupational switches do not work), and second, the fall in the experience rate which occurs because workers leave

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<sup>44</sup>Notice that the zero borrowing limit implies no borrowing against government transfers.

marginal islands despite being experienced there. Capital rises almost proportionally with pre-tax total labor income: the saving rate is not much affected. This is because the need for precautionary savings does not fall much: while the subsidy reduces the cost of undertaking a single occupational switch, this is offset by an increase in the overall and repeat mobility rates.<sup>45</sup>

Last, the subsidy increases welfare. This can be seen in column (6) of [Table 6](#), which reports our preferred measure of average welfare gains, arising from suddenly ‘dropping’ an agent from the benchmark economy into the steady state of the economy with the mobility subsidy. The average welfare gain is equal to 0.72 percent; both inexperienced and experienced agents gain, with inexperienced agents gaining slightly more.<sup>46</sup>

To understand the source of the welfare gains better, we investigate how they vary with occupational productivity. The red dashed line in [Figure 4](#) shows that the gains associated with the policy are uniformly decreasing in occupational productivity. Comparing the distribution of gains with the reservation productivity at which agents prefer to work rather than move occupations ([Figure 1](#)), we see that the largest welfare gains (nearly 4 percent) accrue to workers in less productive occupations, who can more easily move. Even in occupations that are one standard deviation below the unconditional mean gains still average 1.2 percent with the inexperienced benefiting slightly more (1.4 percent). Individuals in more productive occupations lose because of higher taxes, but their welfare losses are modest since the tax rate does not rise much. In summary, the mobility subsidy is successful at increasing mobility, effective labor, and welfare.

## 5.2 Increasing taxes and lump-sum transfers

For this experiment we assume that the government changes the tax on labor income as in the previous experiment but rebates the proceeds equally to all

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<sup>45</sup>As seen in [Table 1](#), the average number of moves over four years, conditional on having moved at least once, rises from 1.66 to 2.11.

<sup>46</sup>The average gain for the inexperienced is 0.82, while the experienced gain 0.58 percent. Allowing for the transition reduces these values to 0.61 and 0.40, respectively, bringing down the overall average gain to 0.52 percent. See Appendix D.2 for more detail.

agents in a lump-sum fashion instead of subsidizing mobility.

As before, we denote the tax rate by  $\tau_{subs}$  and the transfer by  $T_{tax}$ . These changes modify the worker's budget constraint (4) as follows:

$$c + a' = (1 + r)a + \mathbb{I}_{\mu=n}wxz(1 + \chi)^e(1 - \tau_{subs}) - \mathbb{I}_{\mu=vm}\kappa + T_{tax} \text{ and } a' \geq 0.$$

With a tax rate of  $\tau_{subs} = 0.32$  and government expenditures  $G$  held at their benchmark level, the government balances its budget with  $T_{tax} = 0.96$ .

The effects on economic aggregates, in the new steady state which arises once the new tax and transfer scheme has been imposed, are reported in column (7) of [Table 3](#). The effects on the wage and mobility moments used to calibrate the benchmark model are reported in column (5) of [Table 1](#). Last, the endogenous distribution of occupational productivity under this policy is represented by the blue dash-dotted line in [Figure 3](#).

Output, capital, and effective labor are all lower than in the baseline model. Capital falls because the tax redistributes income to individuals with low productivity realizations and during periods of mobility, so that the precautionary motive for savings is weakened. Effective labor falls since the tax-and-transfer scheme reduces the dispersion of non-financial income (that is, transfers plus after-tax labor income) across occupations, and this reduces the returns associated with voluntary mobility. The reduction in mobility has three effects on aggregate labor supply. Most directly, reduced mobility implies that more individuals are working. Second, the share of experienced workers increases: if workers move less frequently, then fewer individuals lose their occupation-specific experience and more inexperienced individuals become experienced. Both of these effects serve to increase aggregate labor supply. However, more than offsetting these effects is that the reduction in mobility implies an increase in the share of workers on low-productivity islands.

Column (7) of [Table 6](#) displays the average welfare gains associated with instituting the higher labor income tax and redistributing the proceeds in a lump-sum fashion. On average, agents are willing to sacrifice only 0.07 percent

of lifetime consumption to move to the steady state with the tax.<sup>47</sup> To gain additional insight, the blue dash-dotted line in [Figure 4](#) presents the average welfare gains by occupational productivity. As expected, individuals on above-average islands lose due to the redistributive nature of the tax. Conversely, individuals on below-average islands benefit from the transfer component of the tax system.<sup>48</sup> Overall, however, gains are very modest. This highlights the importance of conditioning the additional transfers on mobility.

## 6 Conclusion

We have argued that two important methods workers can use to insulate themselves against occupation-level shocks, self-insurance and occupational mobility, are closely intertwined. Wage risk arising from shocks to a worker’s occupational match generates an incentive to undertake precautionary savings, but this does not fully insulate the worker against their occupational match turning bad. Accordingly, workers are less able to undertake the costly and risky process that is occupational mobility, in order to seek out a better match, than they are in a complete-markets setting. In our calibrated model, the welfare costs of market incompleteness are as high as 2.5 percent (with prices held constant) or 1.9 percent (in general equilibrium) of lifetime consumption, and a significant component of this (between 0.5-1.0 percentage points) arises from a worsening of workers’ occupational match quality.

We also investigate whether the gains from completing markets can be captured through the types of policies seen in real-world labor markets. A tax-financed retraining subsidy raises occupational mobility, effective labor, and welfare by 0.7 percent. In contrast, simply raising taxes and transferring them in a lump-sum fashion depresses occupational mobility and effective labor, and has only a modestly positive effect on welfare.

The specification we studied is deliberately parsimonious: we made the

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<sup>47</sup>Allowing for the transition makes almost no difference. Average welfare gains increase to 0.10 percent. See Appendix D.2 for more detail.

<sup>48</sup>Inexperienced individuals benefit slightly more due to their lower average labor income. See Appendix F for details.

minimal alterations to a standard incomplete-markets model in the Bewley tradition in order to be able to study whether the effects of market incompleteness on occupational mobility are likely to be large. There are clear limitations to this approach, in that we abstracted from features that seem likely to matter in a full accounting of the effects of market incompleteness on occupational mobility and welfare. Among these, several stand out. First, there is a strong life-cycle pattern of occupational mobility, perhaps associated with searching for a good occupational match (Neal, 1999). If financial frictions impede such mobility, they can potentially have a severe effect on slowing the life-cycle growth of earnings. Second, as we discussed in [Section 1](#), skills may be to some extent task-specific rather than occupation-specific, so that not all occupational moves will be associated with the same losses in specific human capital or require the same amount of retraining. Third, we assumed that all capital accumulation arises from precautionary savings, which may exaggerate the extent to which agents can insure themselves against risk (Kaplan and Violante, 2010). Fourth, in the baseline model, we abstracted from needs-based social insurance programs, so that we may overstate the degree of consumption risk faced by agents particularly at the low end of the income distribution. And last, we abstracted from cyclical considerations, even though occupational mobility exhibits substantial cyclical volatility (Carrillo-Tudela and Visschers, 2014). Understanding the precise quantitative importance of these, and other, features for our results seems like a promising line of research.

On the other hand, we chose the approach we did for several reasons. First, and most importantly, the parsimony of our model makes transparent the sources of efficiency gains: since workers are ex ante identical, we need consider only the distribution of workers across islands and by experience levels. Second, it facilitates comparison with similar papers in which earnings risk is either fully exogenous, as in Aiyagari (1994), or can be affected by the worker only in a static fashion, as in Pijoan-Mas (2006), Marcet, Obiols-Homs, and Weil (2007), and Heathcote, Storesletten, and Violante (2008, 2014). Last, the fact that we find significant effects of market incompleteness on occupational mobility even in our rather parsimonious model suggests that the result

is likely to be robust to including the features such as those we listed above. Accordingly, we think that the takeaway from our exercise is that market incompleteness is likely to induce a significant reduction in occupational mobility beyond the specific setting of our model.

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