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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 earnings risk improves welfare by up to 3.5 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 increases mobility away from low-productivity occupations, but does not improve average welfare. A progressive tax-and-transfer scheme decreases mobility, but improves welfare through redistribution.

JEL: D31, D52, E21, J24
Keywords: occupational mobility, financial frictions, incomplete markets, self-insurance, welfare costs, training subsidies, income taxes

Occupation-level earnings risk represents an important source of uncertainty for U.S. workers. In the absence of complete insurance markets, workers can self-insure against such risk through precautionary savings, and it is well known that this matters for consumption, capital accumulation, and welfare. However, another means of self-insurance is available for a worker whose occupational match turns bad: he or she can switch occupations. In this paper we study how these two self-insurance mechanisms interact with each other. Market incompleteness reduces workers' ability to move away from occupations hit by negative productivity shocks. In our benchmark model the monthly occupational mobility rate is half a percentage point lower than in a comparable complete-markets framework. This has aggregate consequences: labor supply, measured in efficiency units, is 1.4 percent lower than 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 3.5 percent of lifetime consumption.

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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. Unlike most 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 at best, 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 allow for both voluntary and involuntary occupational moves; doing so allows us to match not only the overall frequency of occupational mobility and the average wage gain from switching, but also how these moments vary over the wage distribution. In particular, we match the empirical observation that the frequency and gains to mobility fall as wages in the current occupation rise. Viewed through the lens of our model, this suggests that the bulk of mobility at the lower end of the wage distribution is voluntary, while most mobility is involuntary at the higher end.

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: 2.7 percent of workers switch occupations each month, an increase from the 2.2 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 4.9 percent under incomplete markets to 8.2 percent when markets are complete, despite the fact that conditional on a worker's position in the wage distribution, the average wage gain associated with an occupational switch is almost the same in the two settings. This 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. (This effect is, however, partially offset by the fact that the increased mobility slightly lowers the average occupational experience level of the workforce.) On net, effective labor supply increases around 1.4 percent under complete markets.

The welfare cost of market incompleteness is quantitatively significant. A randomly chosen agent drawn from the incomplete-markets economy would on average value access to complete insurance markets, holding prices constant, at 3.5 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 2.4 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 3.2 percent of lifetime consumption (holding prices constant) or 2.1 percent (general equilibrium). That is, the reduction in occupational mobility arising from market incompleteness is associated with a welfare cost of around 0.3 percent of lifetime consumption.

We also investigate whether, in an incomplete-markets setting, policies which either encourage occupational mobility or reduce income inequality can capture a significant part of the potential gains. We first consider subsidizing the retraining cost associated with voluntary moves. The policy is financed by a tax on labor income. Perhaps not surprisingly, the subsidy does indeed raise the rate of occupational switches from 2.2 percent (in the benchmark economy) to 2.9 percent, and because average occupational match quality improves, effective labor supply rises by nearly 2 percent. Inexperienced individuals in low-productivity occupations benefit from the subsidy, but average welfare gains are slightly negative since the gains from individuals leaving the least productive occupations are offset by losses for individuals on more productive islands.

We also consider the effects of a simple progressive tax-and-transfer scheme, specifically, a proportional tax on labor income redistributed in lump-sum fashion to all agents. Such a policy seeks to insulate agents from labor income risk directly. We find that occupational mobility decreases: the policy reduces the benefit from switching occupations, as well as the consumption risk 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 improves welfare: a randomly chosen agent would forgo around 0.5 percent of lifetime consumption to switch to a world with the tax.

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 understanding the cross-sectional distribution of occupational tenure, occupation-specific human capital, wages, and wage growth.[1] A recent strand of this literature allows for a richer structure of occupations than we do, either by modeling the task content of occupations and thereby allowing for skills to be (partially) transferrable across occupations or by accounting for the hierarchical relations of occupations to each other.[2] 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.

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 this framework and has incorporated progressively more realistic exogenous earnings processes and policy features.[3] 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 agents can access in financial markets.

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.[4] 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.[5] 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 to investigate.

Last, workers' accumulation of other types of human capital beyond the occupation-specific also provides a mechanism by which earnings might be endogenous to the market structure. While

[1] 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.

[2] On the task content of occupations, see Guvenen et al. (2015) and the references therein, as well as the survey by Sanders and Taber (2012). On the vertical structure of occupations, see Groes, Kircher, and Manovskii (2015).

[3] 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.

[4] See also Low (2005), Flodén (2006), Marcet, Obiols-Homs, and Weil (2007), and Heathcote, Storesletten, and Violante (2010).

[5] 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.

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.[6] 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.[7] Our paper is complementary to this work in focusing on human capital accumulation after formal educational decisions have been made.

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 $\mathbf{E} \sum_{t=\tau}^{\infty} \beta^t u(c_t)$.

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 $\pi(x' \mid x)$ 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.[8]

Each worker's productivity is also subject to a transitory 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 $h^z(z)$. This shock captures dispersion in wages not attributable to occupation-level shocks. Alternatively, it allows the model to account for classical measurement error in wages.

[6] See Sanders and Taber (2012) for a recent survey.
[7] See Lochner and Monge-Naranjo (2012) for a recent survey.
[8] This simple way of modeling the return to occupational tenure follows Kambourov and Manovskii (2009a).

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, and an experienced worker 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 $m = n$ has no ability to move islands. She works on the current island during the 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. A worker undertaking an im does not work during the period of the move. She begins the next period located on a different island, ready to supply labor there but 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 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 on a new island, ready to supply labor but inexperienced. A vm differs from an im in two respects. First, the worker must pay a training cost of $\kappa \geq 0$ units of goods.[9] Second, the productivity of the new island, x', is drawn from a different distribution, which has pdf $\psi_{vm}(x' \,|\, x)$. Conditional on the worker undertaking a vm and on x, the realization of x' is iid across workers and over time. 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

[9] As well as the monetary cost of retraining, κ may also capture lower wages during an 'apprenticeship' period or forgone due to job search.

$e \in \mathcal{E}$ 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 $\eta_n(1 \,|\, 1) = 1$.

Finally, write $\psi_n(x' \,|\, x) \equiv \pi(x' \,|\, x)$ for all $x, x' \in \mathcal{X}$. We then have that 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 μ, can be denoted $\psi_\mu(x'| \, x)$.

We 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 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 μ, is

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

2.3 Production

There is a single representative firm which rents capital and labor and produces output using a neoclassical production function $Y(K, L)$.[10] The firm is a price-taker in the rental market for capital. Capital is owned by workers, and rented each period to the firm. It depreciates at rate $\delta \in (0, 1)$. The firm is also a price-taker in the rental market for labor. Labor supply to the firm 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.[11] Finally, the firm is also a price-taker in the market for the final good. We normalize the price of the final good to 1.

2.4 Incomplete markets model

In our benchmark model, we assume that there are incomplete markets, following Huggett (1993) and Aiyagari (1994). There are no state-contingent securities which insure against shocks to a worker's occupation productivity, experience, idiosyncratic labor productivity, or mobility. A worker holds assets a which may take value in the finite set $\mathcal{A} \subset [\underline{a}, +\infty)$, where the lower bound $\underline{a}$ can either be the natural borrowing limit or a strictly greater exogenous limit.[12]

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 $V(s, m, a)$

[10] 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.

[11] 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 substantially enhances the tractability of the model. We also conjecture that the effect of market incompleteness would be qualitatively similar if we allowed for empirically plausible values of the 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).

[12] 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.

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 μ. Because agents may only choose the mobility action allowed to them according to their mobility status, we have that for any (s,a),

$$V(s,m,a) = \begin{cases} W(s,m,a) & \text{if } m \in \{n, im\}; \\ \max\left\{W(s,n,a), W(s,vm,a)\right\} & \text{if } m = vm. \end{cases} \tag{2}$$

We also have that

$$\begin{aligned} W(s,\mu,a) &= \max_{c>0,a'} u(c) + \beta \mathbf{E}_\mu \left[V(s',m',a') \,|\, s\right] \\ \text{s.t.} \qquad c + a' &= (1+r)a + \mathbb{I}_{\mu=n} wxz(1+\chi)^e - \mathbb{I}_{\mu=vm}\kappa \qquad \text{and} \qquad a' \geq \underline{a}, \end{aligned} \tag{3}$$

where $\mathbb{I}_\chi$ denotes an indicator function which takes the value 1 if the condition χ is satisfied and 0 otherwise, and where

$$\mathbf{E}_\mu \left[V(s',m',a') \,|\, s\right] = \sum_{s'\in\mathcal{S}, m'\in\mathcal{M}} V(s',m',a')\Gamma_\mu(s',m' \,|\, s) \tag{4}$$

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 chosen mobility action μ. 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 and the wage per efficiency unit of labor w. We write $g^\mu(s,m,a)$ for the optimal mobility action μ 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'.[13]

Steady-state equilibrium requires that the distribution ν of agents be constant over time. To write this formally, let Σ be the σ-algebra on $\mathcal{S}\times\mathcal{M}\times\mathcal{A}$ generated by the product of the discrete σ-algebras on the $\mathcal{S}\times\mathcal{M}$ with the Lebesgue σ-algebra on $\mathcal{A}$. The measure ν of agents over states and assets evolves such that for all (s,m) and all Lebesgue-measurable $A \subseteq \mathcal{A}$,

$$\nu'\left(\{(s',m')\}\times A\right) = \int_{\mathcal{S}\times\mathcal{M}\times\mathcal{A}} \Gamma_{g^\mu(s,m,a)}\left(s',m' \,|\, s\right) \mathbb{I}_{g^{a'}(s,m,a)\in A} \,\mathrm{d}\nu(s,m,a); \tag{5}$$

the measure ν' is the unique measure on Σ satisfying this requirement.

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 measure ν, aggregate capital K and labor L, and prices w and r such that

1. given prices w and r, the functions $\mathcal{F}$ solve the household's decision problem (2)-(3);
2. prices equal marginal productivities, $r = Y_K(K,L) - \delta$ and $w = Y_L(K,L)$;

[13] 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.

3. factor markets clear,

$$K = \int_{\mathcal{S}\times\mathcal{M}\times\mathcal{A}} a \, \mathrm{d}\nu \quad \text{and} \quad L = \int_{\mathcal{S}\times\mathcal{M}\times\mathcal{A}} \mathbb{I}_{g^{\mu}(s,m,a)=n} xz(1+\chi)^{e} \, \mathrm{d}\nu;$$

4. and the measure ν is invariant, in the sense that $\nu' = \nu$ in (5).

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 consumption, 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 κ. 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. This is in contrast with the mobility choices that apply under complete markets, to be described next.

2.5 Complete markets model

We also study an alternative setting in which financial markets are complete. This serves as a yardstick against which to evaluate the welfare cost of market incompleteness and the effects of policies aimed at ameliorating them.

Under complete markets, the economic environment is unchanged from that described above, except that we allow agents to trade a full set of state-contingent (Arrow) securities. 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 μ 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 μ she does not actually take.[14]

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

[14] In the absence of this restriction, the agent would want to hold unboundedly large negative quantities of Arrow securities corresponding to actions μ she was not planning to take.

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 Functional Forms

Utility is logarithmic, $u(c) = \log(c)$.[15] No borrowing is allowed, $\underline{a} = 0$.[16] The production function of the representative firm is Cobb-Douglas, $Y(K, L) = AK^{\alpha}L^{1-\alpha}$, and we normalize $A = 1$.

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 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 itself, as well as how well the worker is matched to it, 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:

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

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 ϵ_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 ϕ_j. As ϕ_j increases, mobility is directed toward the best occupations. A more interesting case arises when ϕ_j, γ_j, and σ_j are all non-zero. In this case, mobility is partially directed (governed by ϕ_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.

[15] This assumption 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).

[16] For our policy experiments, the zero borrowing limit implies no borrowing against government transfers.

When individuals remain in the same occupation we assume that the first-order Markov process for x approximates an AR(1) process in logs:

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

Last, we assume that 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) necessarily involve one month of not working. This is consistent with the median duration of occupational switches from our Survey of Income and Program Participation (SIPP) sample discussed below.

We set three parameters following standard practice. We calibrate the capital income share α to 0.36 and set δ to imply a quarterly depreciation rate of 2.5 percent. We set β so that in equilibrium the implied quarterly real interest rate is 1 percent.

The more distinctive structural parameters of our model are those governing the returns to occupational experience (q and χ); the standard deviation of idiosyncratic shocks (σ_z); the productivity shock process for the island the individual currently resides on (ρ_x and σ_x); the financial cost of voluntarily moving (κ); the parameters governing the 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 (ϕ_{vm}, γ_{vm}, σ_{vm}, ϕ_{im}, γ_{im}, and σ_{im}).

Similar to Kambourov and Manovskii (2009a), we set q and χ 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, κ, 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 κ equal to two months of wages for the mean worker in our model.[17]

The remaining 11 parameters (σ_z, ρ_x, σ_x, p_{vm}, p_{im}, ϕ_{vm}, γ_{vm}, σ_{vm}, ϕ_{im}, γ_{im}, σ_{im}) are jointly calibrated so that the model matches salient features of occupational mobility and (residual) wages measured in the SIPP. For our purposes, the SIPP has distinct advantages over other standard data sets like the Panel Study of Income Dynamics (PSID) due to its representativeness and frequency. We restrict our attention to males aged 30-54 from the 1996 panel to be consistent with our model, which abstracts from early-life decisions such as schooling as well as from retirement. We restrict our sample to private-sector workers. We use reported hourly wages when available and otherwise impute an hourly wage using information on monthly earnings and hours worked. Occupational mobility is measured at the three-digit level.[18] The wage gain conditional on switching occupations

[17] Our main results would be little changed if we used the median rather than the mean.

[18] Defining mobility at one- or two-digit level would tend to bias our results toward greater voluntary mobility as

is measured as the log difference between the last wage in the previous occupation and the wage 12 months after the switch occurs.[19] This measure is intended to capture the benefit from switching free of any initial effects (e.g. probationary periods) not captured by our model.[20] 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, monthly mobility by wage tercile of the current occupation, and the level of repeat mobility (i.e. the expected number of occupational moves over four years conditional on having switched occupations at least once).[21] 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 ϕ_{vm}, ρ_{vm} and σ_{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. Hence, we target monthly mobility by wage tercile of the current occupation.[22]

Turning to wage moments, we target the autocorrelation and cross-sectional variance of wages both for all workers and for occupational stayers alone. These parameters help identify the island productivity process conditional on staying (ρ_x, σ_x) and the standard deviation for the transitory component of idiosyncratic productivity (σ_z).

We also seek to capture the returns to occupational switching, 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 wage gain from switching (relative to staying). Differences in the processes for voluntary and involuntary moves are captured by targeting the mean and variance of the wage gain from switching by tercile of wages in the old occupation. Because the model predicts that voluntary mobility mostly occurs on low-productivity islands, the dynamics of wage growth for workers who originate on bad islands help identify $(\phi_{vm}, \gamma_{vm}, \sigma_{vm})$, while the dynamics of wage growth for workers who originate on better islands helps identify $(\phi_{im}, \gamma_{im}, \sigma_{im})$.

Column (1) of Table 1 summarizes the target moments, while column (2) displays their counterparts in our calibrated model. (Column (3) of the table shows the associated moments under complete markets, as discussed in Section 4, and columns (4) and (5) show the moments under the policy experiments described in Section 5.) Table 2 displays the implied parameter values.[23]

The model matches the proposed targets well. First, it replicates the overall mobility rate, the overall dispersion of wages, and the average wage gain and the dispersion of wage gains for

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.

[19] 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.

[20] Note that the wage 12 months following the switch may not correspond to the occupation to which the individual first transitions if further switching occurs. Of course, we follow the same procedure in model-simulated data.

[21] The measure of repeat mobility is similar to Kambourov and Manovskii (2009a).

[22] We choose terciles, rather than other quantiles, to keep the calibration parsimonious, as well as due to cell-size concerns.

[23] We describe our procedure for solving and calibrating our benchmark model in Appendix C.1 and Appendix C.2.

Statistic	Target (1)	Incomplete markets (2)	Complete markets (3)	Mobility subsidy (4)	Income tax (5)
Mobility rates					
Mob. rate: all workers	0.0222	0.0221	0.0268	0.0289	0.0215
Mob. rate: 1st tercile of wages	0.0315	0.0311	0.0423	0.0478	0.0297
Mob. rate: 2nd tercile of wages	0.0191	0.0172	0.0172	0.0172	0.0172
Mob. rate: 3rd tercile of wages	0.0165	0.0172	0.0171	0.0171	0.0172
Repeat mob. rate	1.6415	1.6812	1.9189	2.0011	1.6541
Wages					
Variance: all workers	0.1333	0.1459	0.1477	0.1514	0.1455
Autocorrelation: all workers	0.9764	0.9693	0.9677	0.9677	0.9694
Variance: stayers	0.1319	0.1450	0.1459	0.1494	0.1448
Autocorrelation: stayers	0.9767	0.9720	0.9721	0.9728	0.9719
Wage gain 12 months from switching (in logs)					
Mean: all switchers	0.0481	0.0485	0.0822	0.0855	0.0439
Mean: 1st tercile of wages	0.2022	0.2147	0.2163	0.2079	0.2142
Mean: 2nd tercile of wages	−0.0053	−0.0445	−0.0553	−0.0545	−0.0427
Mean: 3rd tercile of wages	−0.1672	−0.1910	−0.1898	−0.1889	−0.1915
Variance: all switchers	0.1317	0.1285	0.1450	0.1476	0.1267
Variance: 1st tercile of wages	0.1247	0.1241	0.1412	0.1451	0.1224
Variance: 2nd tercile of wages	0.0781	0.0736	0.0752	0.0780	0.0734
Variance: 3rd tercile of wages	0.1165	0.0784	0.0784	0.0792	0.0783
Other moments					
Depreciation rate	0.0084	0.0084	0.0084	0.0084	0.0084
Real interest rate	0.0033	0.0033	0.0038	0.0033	0.0034
Return to occ. experience	0.2	0.2	0.2	0.2	0.2
Mobility cost / average wage	2.0000	2.0000	2.0171	1.9656	2.0128

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.

occupational switchers. However, notably, it also matches the cross-sectional pattern of these variables. Specifically, the model delivers a fall in the frequency of occupational mobility, together with a fall in the average wage gain conditional on switching occupation, for workers with higher wages in their current occupation. In fact, on average, both in the model and in the data, individuals in the lowest tercile of wages see their wages increase conditional on switching, while wage gains are negative in the second and third terciles. To match these facts jointly, the model requires an involuntary move rate of 1.7 percent, which implies that essentially all occupational mobility for workers whose pre-move wage is in the second and third terciles of wage distribution is involuntary, while around half of all mobility for workers whose pre-move wage is in the lowest tercile of wages is voluntary.[24]

[24]It may seem surprising that there are few voluntary occupational switches for high-wage workers. However, this is a result of our terminology. We could also phrase our conclusion as that there are few moves requiring costly retraining for high-wage workers. To the extent that some occupational switches for high-wage workers do require costly retraining, our results are likely to understate the effects of market incompleteness.

Description	Symbol	Value	Description	Symbol	Value
Capital share	α	0.36	Std. dev. of occ. shock	σ_x	0.0803
Depreciation rate	δ	0.0084	Autocorr. of occ. shock	ρ_x	0.9790
Return to exp.	χ	0.2	Std. dev. of iid shock	σ_z	0.0245
Prob. of gaining exp.	q	0.0083	Distribution of islands	γ_{vm}	0.7400
Discount factor	β	0.9962	given voluntary move	σ_{vm}	0.3366
Mobility cost	κ	10.3050		ϕ_{vm}	−0.0615
vm offer rate	p_{vm}	0.0701	Distribution of islands	γ_{im}	0.8840
im rate	p_{im}	0.0171	given involuntary move	σ_{im}	0.0194
				ϕ_{im}	0.3036

Table 2. Parameter values.

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. In particular, we show 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, or the small average wage gains associated with occupational switching which coexist with large gains for workers with low wages before their occupational switch.

4 Results

In this section we present our results on the effects of market incompleteness on occupational mobility, occupational tenure, and welfare. We do this by presenting comparisons between complete and incomplete markets economies.[25]

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 island the worker is located on is more strongly correlated with the current x for stayers than for movers. We can thus calculate a reservation 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

[25] Appendix C.3 describes how we compute the complete-markets steady state.

implicitly defined as the unique solution to

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

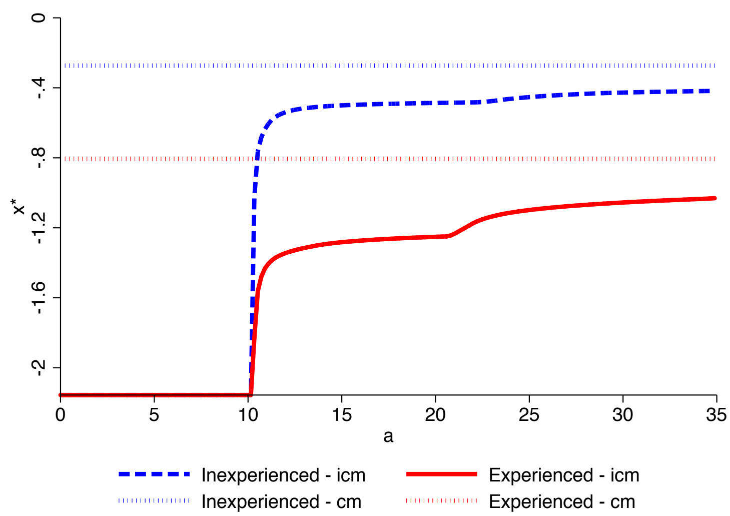

Figure 1. Reservation island productivities by assets, shown separately for inexperienced and experienced agents and separately under incomplete markets (icm) and complete markets (cm).

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.[26] The graph shows two important stylized features of mobility in our model. First, experienced agents, who have higher wages in their current occupation conditional on the value of 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 productivity 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. Notice also 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

[26]To put the reservation productivity in context, note that the unconditional mean of the distribution of x across islands is 0, and the cross-sectional standard deviation is $\sigma_x/\sqrt{1-\rho_x^2} = 0.394$. Because of endogenous mobility, the distribution of workers is better in the sense of first-order stochastic dominance; its mean and standard deviation are 0.049 and 0.373 respectively. For more discussion, see Section 4.3 below.

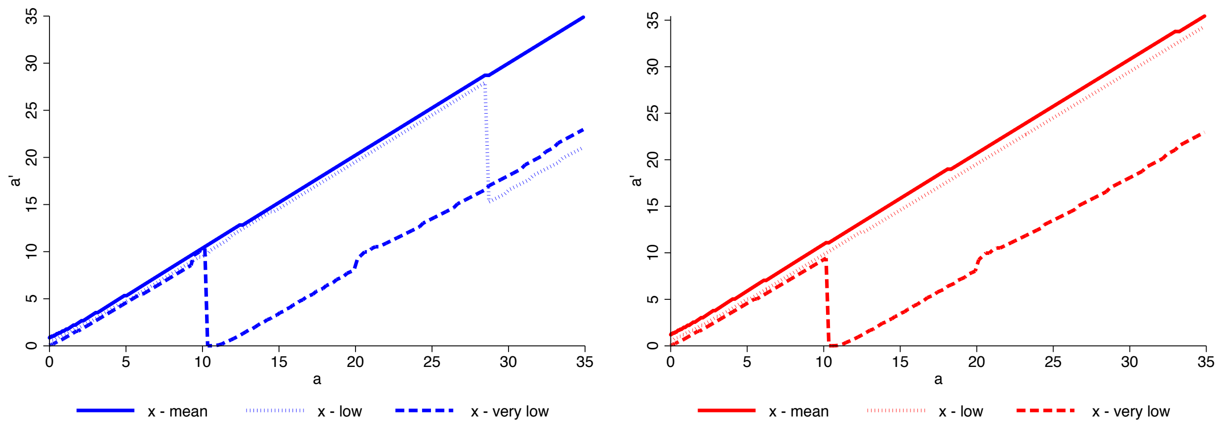

Figure 2. Savings policies under incomplete markets for inexperienced (left) and experienced individuals (right) for different values of occupation productivity x.

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 1 and 5 standard deviations below the mean, respectively. The right panel shows the corresponding policies for experienced agents.

As expected, future assets are increasing in current occupation productivity and in experience (each of which corresponds to higher current labor income). The policy for future assets is in general increasing in current assets. However, the zero-one 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

Table 3 reports results for economic aggregates. Columns (1) and (2) present results for the baseline incomplete-markets economy and the complete-markets equivalent, respectively. (Columns (3) and (4) show the aggregates implied by policies discussed in Section 5 below.) The capital stock is higher in steady state in the 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). Under complete markets, the lower capital stock leads to slightly lower aggregate output, despite the fact that better occupational sorting increases effective labor supply by nearly 1.5 percent. Consumption is also slightly lower under complete markets, although by a much smaller fraction than aggregate

Statistic	Incomplete markets (1)	Complete markets (2)	Mobility subsidy (3)	Income tax (4)
Output, Y	8.05	7.98	8.19	8.00
		[−0.8]	[1.7]	[−0.6]
Consumption, C	5.92	5.90	5.96	5.91
		[−0.3]	[0.5]	[−0.2]
Capital, K	247.17	235.44	251.78	243.50
		[−4.7]	[1.9]	[−1.5]
Labor (efficiency units), L	1.17	1.19	1.19	1.17
		[1.4]	[1.7]	[−0.2]
Experience rate (%)	31.69	31.17	30.39	31.85
		[−1.6]	[−4.1]	[0.5]
Overall mobility rate (%)	2.20	2.68	2.88	2.15
		[21.8]	[31.0]	[−2.5]
Voluntary mobility rate (%)	0.49	0.97	1.17	0.43
		[98.8]	[140.2]	[−11.2]
Wage, w	4.39	4.29	4.40	4.37
		[−2.2]	[0.1]	[−0.5]
Real interest rate, r	0.33	0.38	0.33	0.34
		[14.4]	[−0.4]	[3.0]

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.

output, consistent with lower depreciation as a result of the lower capital stock.

Related to the difference in effective labor are the differences in mobility rates across the two market environments. The monthly mobility rate is nearly half a percentage point 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 conserving assets and refraining from paying the mobility cost or 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. We delve further into this finding in the next section.

Finally, regarding prices, under complete markets the lower capital stock and higher effective labor supply lead to a higher marginal product of capital, and hence interest rate, compared to the benchmark. The correspondingly lower marginal product of labor is associated with a lower wage.

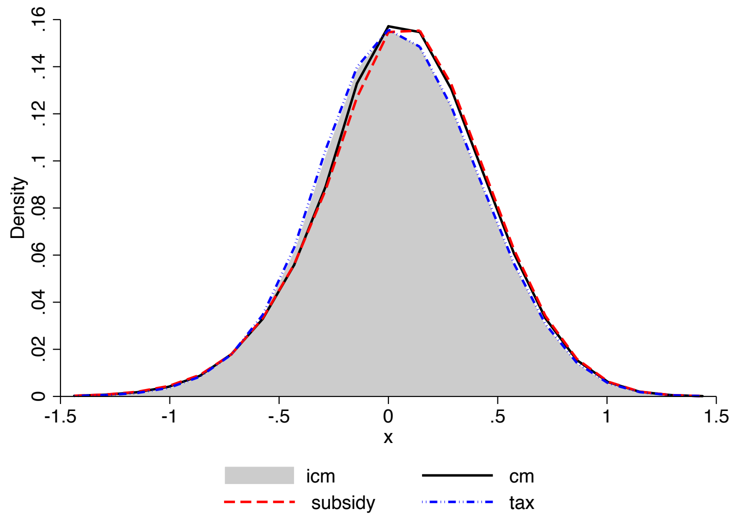

Figure 3. Distributions of workers across islands in the benchmark model (icm), under complete markets (cm), and in the two policy experiments described in Section 5.

Statistic	Incomplete markets			Complete markets		
	Overall	Inexp.	Exp.	Overall	Inexp.	Exp.
Mean	0.049	0.055	0.036	0.066	0.072	0.053
Variance	0.139	0.137	0.144	0.141	0.142	0.143
1st percentile	−0.938	−0.951	−0.910	−0.956	−0.986	−0.861
5th percentile	−0.644	−0.631	−0.664	−0.647	−0.650	−0.641
50th percentile	−0.025	−0.019	−0.038	−0.001	0.007	−0.021
95th percentile	0.591	0.590	0.593	0.606	0.606	0.607
99th percentile	0.843	0.840	0.849	0.845	0.847	0.856

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

4.3 Cross-sectional features

Under complete markets, agents tend to locate on more productive islands. To demonstrate this graphically, Figure 3 displays the overall pdfs over occupational productivity for each market arrangement.[27] 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 1.7 log points more productive than under incomplete markets, and this holds true for both inexperienced and experienced agents.

The dispersion of occupational productivity is slightly higher under complete markets. As shown in the second row of Table 4, however, this masks important differences across experience levels: all of the greater dispersion is attributable to inexperienced agents, while the variance of occupational

[27]This figure also shows the distributions implied by the policies discussed in Section 5 below.

productivity for experienced agents is slightly lower 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.[28] The biggest differences are seen for workers on low-productivity islands. Under complete markets, the first percentile of the occupation distribution for inexperienced workers is 3.5 log points *worse* than in the benchmark, while the corresponding percentile for experienced workers is around 4.9 log points *better*. 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 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 wages and 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 in the lowest tercile of 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 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 3.4 percentage points higher under complete markets. This difference is compositional. Across terciles of wages of the current occupation the average gain upon switching is quite similar across models. Rather, the increased mobility of low wage workers, who have the greatest benefits from moving, accounts for the higher average wage gain for movers when markets are complete.

4.4 Welfare cost of incomplete markets

	Complete markets				Mobility subsidy	Income tax
	Across st. states (1)	Prices constant (2)	Mobility constant (3)	Along transition (4)	Across st. states (5)	Across st. states (6)
Welfare Gain (%)	2.38	3.47	2.09	2.41	−0.06	0.47

Table 5. Consumption equivalent welfare gains (in percent). Columns (1)-(4) show gains associated with completing markets and are described in this section. Columns (5)-(6) show gains associated with the policy experiments described in Section 5.

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

[28] The percentiles shown in the table are calculated using linear interpolation: see Appendix C.4 for details.

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) of Table 5 reports that the average welfare gains according to our preferred measure are significant, averaging 2.38 percent.[29]

The welfare gains associated with completing markets vary somewhat across workers. Figure 4 shows how these gains vary by occupational productivity x, averaging over the remaining states, that is, the transitory 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.[30] 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 a higher interest rate under complete markets because the capital stock is lower.

Average gains are quite similar across experience levels, consistent with the idea that the main source of welfare gains is improving consumption smoothing relative to the persistent process for occupational productivity x.[31]

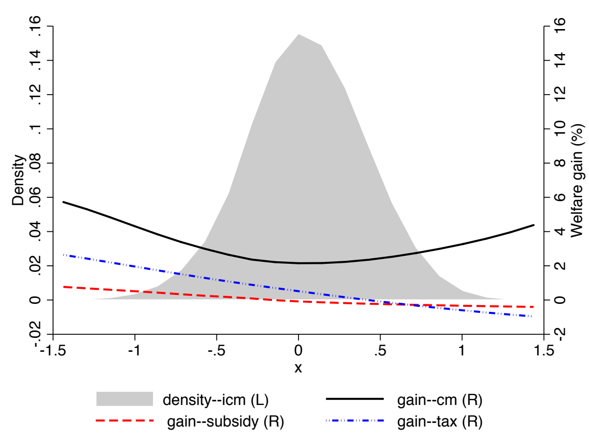

Figure 4. Average welfare gains from introducing complete markets ('cm') and from the two policy experiments described in Section 5 ('subsidy' and 'tax'). The shaded area represents the distribution of workers across islands in the incomplete-markets benchmark.

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

[29]We describe how we compute welfare gains in more detail in Appendix C.5.1.
[30]The figure also shows the gains associated with the experiments discussed in Section 5 below.
[31]Appendix F presents figures by experience level.

The results of this exercise are shown in column (2) of Table 5. The expected value for the welfare gain associated with completing markets is 3.47 percent, more than a percentage point higher than when prices adjust. Welfare gains are larger for agents on less productive islands.[32]

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 according 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. Column (3) of Table 5 reports the results. Average welfare gains under this arrangement are 2.09 percent, suggesting improved mobility accounts for nearly 0.3 percentage points of the headline 2.38 percentage point gain from completing markets. This gain is quite similar across agents of different experience levels: for inexperienced agents, improved mobility of inexperienced agents accounts for 0.26 percentage points of their overall gain, while the corresponding figure for experienced agents is 0.35 percentage points.[33]

Finally, we also investigate the importance of transitional dynamics. We imagine that the economy begins in the incomplete-markets steady state, and that suddenly and unexpectedly complete markets against idiosyncratic and occupational risk become available. We solve for the transition to the new steady state and compute the associated welfare gains. Because the difference across steady states is not too large, these are very similar to our preferred measure, averaging 2.41 percent rather than 2.38 percent. This can be seen by comparing columns (1) and (4) in Table 5. 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.

5 Policy experiments

We have so far reported the effects of market incompleteness on occupational mobility and on welfare by comparing two extreme environments, namely, a benchmark incomplete markets environment with no borrowing and a complete markets equivalent. However, an alternative 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. In this section we consider the effects of two such policies. In the first experiment we target

[32] We discuss this exercise in more detail in Appendix C.5.2, and we describe the cross-sectional distribution of welfare gains in Appendix F.

[33] We can also compute welfare gains holding both prices and mobility constant: under this specification, gains are 3.15 percent on average, 3.28 percent for inexperienced agents and 2.86 percent for those with experience. Appendix C.6 gives more detail on the model with mobility held constant.

occupational mobility directly by introducing a subsidy to the training cost of voluntary moves. In the second experiment, we analyze the effects of a progressive tax-and-transfer scheme.

5.1 The Effects of a Training Subsidy

For this experiment, we assume that a benevolent government subsidizes mobility by paying half of the cost of training. This reduces the cost of mobility faced by agents from κ (which was equal to two months of wages of the mean worker in the benchmark environment) to $\kappa/2$. The government finances the subsidy using a distortionary tax on labor income. Denote the tax rate by τ. These changes modify equation (3) in the worker's decision problem to take the following form:

$$\begin{aligned} W(s,\mu,a) &= \max_{c>0,a'} u(c) + \beta \mathbf{E}_\mu \left[V(s',m',a') \,|\, s \right] \\ \text{s.t.} \quad c + a' &= (1+r)a + \mathbb{I}_{\mu=n}(1-\tau)wxz(1+\chi)^e - \mathbb{I}_{\mu=vm}\frac{\kappa}{2} \quad \text{and} \quad a' \geq \underline{a}. \end{aligned}$$

The decision problem is otherwise unchanged. We assume that the government chooses the tax rate τ to balance the budget. It achieves this using a tax rate of 1.15 percent.

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. The overall mobility rate rises from 2.21 percent to 2.89 percent per month. Moreover, this mobility arises from increased mobility among low-wage agents. This can be seen by comparing columns (2) and (4) of the top panel of Table 1, which shows that the rise in mobility is all attributable to workers in the lowest tercile of the wage distribution.

Second, the subsidy is also effective in increasing aggregate output, labor, and capital, which all expand by between 1.7 and 1.9 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 in steady state, this increases 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 as workers leave marginal islands despite being experienced there. Capital rises almost proportionally with total labor income: the share of workers' income that is saved 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 mobility rate, and in particular, in the repeat mobility rate.[34]

[34] As seen in Table 1, the average number of moves over four years, conditional on having moved at least once, rises from 1.68 to 2.00.

Last, however, despite these two seemingly positive effects of the subsidy, agents on average experience a welfare loss from its introduction. This can be seen in column (5) of Table 5, 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 loss is equal to 0.06 percent; both inexperienced and experienced agents experience losses, with experienced agents losing slightly more (0.16 percent).[35]

To understand the source of the welfare loss better, we investigate how it varies 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 welfare losses are incurred by agents who prefer to work rather than move. Some agents do gain from the policy, in particular, inexperienced agents on low-productivity islands; the largest average gains are near 1 percent.[36] Taken together, this suggests that the source of the losses is twofold. First, more productive agents experience a loss as their after-tax income is reduced by the tax used to fund the mobility subsidy. Second, while the subsidy does deliver an increase in expected future occupational productivity for agents on marginal islands (who are likely to undertake occupational mobility in the near future), the associated welfare gain is small since increased mobility also exposes agents to increased occupational risk.[37]

5.2 The Effects of a Progressive Tax-and-Transfer System

For this experiment we assume that the government imposes a proportional tax on labor income and rebates the proceeds equally to all agents in a lump-sum fashion. This is a simple form of progressive tax-and-transfer system.

Denote the tax rate by τ and the transfer by T; then, more formally, this change modifies equation (3) in the worker's decision problem as follows:

$$\begin{aligned} W(s, \mu, a) &= \max_{c>0, a'} u(c) + \beta \mathbf{E}_\mu \left[V(s', m', a') \mid s \right] \\ \text{s.t.} \quad & c + a' = T + (1+r)a + \mathbb{I}_{\mu=n}(1-\tau) w x z (1+\chi)^e - \mathbb{I}_{\mu=vm}\kappa \quad \text{and} \quad a' \geq \underline{a}. \end{aligned}$$

We assume that the government sets a tax rate $\tau = 0.10$ and chooses the transfer T to balance the budget. This is achieved with $T = 0.52$.

The effects on economic aggregates, in the new steady state which arises once the tax and transfer scheme has been imposed, are reported in column (4) 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

[35] Allowing for the transition to the new steady state makes little difference. The average welfare loss increases to 0.08 percent. See Appendix D.2 for more detail.

[36] See Appendix F for details.

[37] Compared to the benchmark economy, under the mobility subsidy the cross-section variance of wages rises from 0.146 to 0.151. The variance of wage gains conditional on switching occupations also rises from 0.122 to 0.148.

the blue dash-dotted line in Figure 3.

Output under the labor income tax regime is slightly lower than in the baseline model because both capital and effective labor fall. The reason for the reduction in capital is that 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 islands, 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 island-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 (6) of Table 5 displays the average welfare gains associated with instituting this labor income tax. On average, agents are willing to sacrifice 0.47 percent of lifetime consumption to move to the steady state with the tax.[38] 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. Inexperienced individuals benefit slightly more due to their lower average labor income.[39]

The fact that the tax is beneficial is likely to be sensitive to allowing for additional margins by which workers can adjust their labor supply other than occupational mobility. In our model, labor supply is inelastic enough that the insurance benefit of taxing labor income dominates the associated distortions. However, the insight from the experiment we conduct here, that occupational mobility will be dampened by such a progressive tax scheme, seems likely to be robust.

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. Earnings 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 3.5 percent (with prices held constant) or 2.4 percent (in general equilibrium) of lifetime consumption, and a significant component of this, around 0.3 percentage points, arises from a worsening of workers'

[38] Allowing for the transition again makes almost no difference. Average welfare gains increase to 0.49 percent. See Appendix D.2 for more detail.

[39] See Appendix F for details.

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, but the tax reduces the welfare of those with good occupational matches sufficiently that it does not raise welfare overall. A progressive tax and transfer scheme does raise welfare, but it does so by reducing the dispersion of consumption across states of the world; in fact, such a policy depresses occupational mobility.

The specification we studied is deliberately parsimonious: we made the 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 social insurance programs, so that we may overstate the degree of consumption risk faced by agents. 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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