Financial Frictions and Occupational Mobility

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Abstract

We study the effects of financial market incompleteness on occupational mobility. Incomplete insurance not only generates an increase in consumption volatility, but also reduces occupational mobility. The correlation of labor supply with occupational productivity is lower than under complete markets. Low-asset workers remain in low-productivity occupations even when the expected value of switching is positive. Negative occupational productivity shocks therefore have larger effects on such workers’ future earnings than they would for better insured workers. In a calibrated model, we find that the welfare costs of market incompleteness can be as large as 12 percent of lifetime consumption.

JEL: D31, D52, E21, J24

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

1 Introduction

In the absence of complete markets, the nature of labor income risk is of fundamental importance for understanding the behavior of consumption and wealth in the cross-section and over time. A major source of labor income risk is occupation-level earnings shocks which are large and highly persistent, and therefore difficult for workers to insure against. Worse, market incompleteness potentially magnifies the effects of exogenous income shocks if it affects workers’ ability to switch away from occupations hit by negative productivity shocks. In this paper we quantify the importance of financial frictions for occupational mobility and for welfare in a Bewley model. In our benchmark model mobility is 9 percent lower than in a comparable complete markets framework. The welfare

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costs of market incompleteness are very large: in our benchmark calibration, the average gain from moving to complete markets is 6.2 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, and occupational mobility is costly for three reasons: first, because workers must pay a retraining cost to change occupations, second, because of the opportunity cost of wages forgone while moving, and third, because a worker who starts work in a new occupation loses the occupation-specific human capital she had built up in her former occupation. Unlike 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 by saving using a risk-free bond. This kind of insurance is only partial, because of the persistence of the shocks and because occupational mobility is undertaken precisely by those workers who have experienced negative shocks to their occupation, and hence, their earnings.

We calibrate the process for occupational-level earnings shocks to match information on U.S. occupational mobility from the Panel Study of Income Dynamics (PSID). Market incompleteness has substantial effects on occupational mobility. First, overall occupational mobility is lower under incomplete markets. In the benchmark calibration of the incomplete markets model, 6.6 percent of workers move occupations each quarter, while under complete markets mobility increases to 7.2 percent. Reduced occupational mobility comes at a cost in terms of productivity, because more workers work in less productive occupations. However, the picture is more complex since under complete markets, not all agents move more. Agents with occupation-specific human capital are better able to smooth their consumption under complete markets, and so are able to avoid changing occupations and losing their associated experience in response to small negative occupational earnings shocks. While 53 percent of agents are experienced in our incomplete markets benchmark, 67 percent are experienced under complete markets. The net effect is that effective labor supply is 5 percent higher under complete markets.

The welfare cost of market incompleteness is also large. As noted already, a randomly-chosen agent drawn from the incomplete markets economy would on average value the opportunity of trading thenceforth in complete insurance markets for her occupational labor productivity risk at 6.2 percent of her lifetime consumption. The welfare costs of incomplete markets mostly arise from greater consumption volatility, as expected in a Bewley model with highly persistent productivity shocks, but are significantly exacerbated by the worsening of occupational match quality just described.

Finally, we also consider the effects of more realistic policies which might increase occupational mobility. We consider the effect of subsidizing occupational mobility in a budget-neutral manner, paid for using a tax on labor income. This kind of policy increases occupational switching and leads to a better allocation of workers to productive occupations, and there are offsetting general equilibrium effects that reduces capital accumulation and wages; the net welfare effect appears to
be small.

Our paper contributes to several parts of macroeconomics and labor economics. 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). Our contribution is to show that incomplete markets are quantitatively relevant for understanding occupational mobility, and therefore also for understanding the cross-sectional distribution of occupational tenure, occupation-specific human capital, and wage dispersion. In our calibrated model, the standard deviation of log wages for full-time workers is 0.622 under incomplete markets, 11 percent greater than the corresponding complete markets value of 0.560. Market incompleteness thus increases the level of cross-sectional wage dispersion implied by occupation-level productivity shocks, implying that these shocks are even more important than suggested by Kambourov and Manovskii (2009a).

Relative to the Bewley class of models, our paper adds a novel feedback mechanism from incomplete markets to the process for future labor income. In Aiyagari (1994), agents’ endowment of efficiency units of labor is subject to exogenous shocks, and market incompleteness means that agents’ consumption also fluctuates. However, market incompleteness has no effect on the agent’s future labor productivity. In our model, on the other hand, because occupational mobility is costly, negative shocks to an agent’s labor productivity have different implications for rich and poor agents. Agents far from the lower bound on assets leave an occupation that receives negative shocks when doing so increases their permanent income. Agents near the lower bound, on the other hand, are unable to undertake the costly process of occupational mobility without an unacceptable reduction in their consumption, and so they endogenously end up with lower future labor income. This mechanism by which market incompleteness reduces the ability of some agents to undertake costly investment projects (such as occupational mobility) with positive net present value is closely related to work studying the effect of borrowing constraints on entrepreneurial choice (Evans and Jovanovic, 1989; Quadrini, 2000; Cagetti and De Nardi, 2006; Buera, 2009; Buera and Shin, 2011).

There are a few papers which allow for workers to respond endogenously to the underlying shocks to their labor productivity in a Bewley model. Pijoan-Mas (2006), Marcet, Obiols-Homs, and Weil (2007), and Heathcote, Storesletten, and Violante (2008) allow for workers to make a static labor-leisure choice in response to fluctuations in their labor productivity and asset position. However, in these papers, there is no dynamic component to the labor supply choice made by workers, while in our model the choice to stop supplying labor in a worker’s current occupation and undergo a costly

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1 We abstract for simplicity from other sources of wage dispersion, so that these measures of wage dispersion are smaller than their empirical counterparts. All agents in the model are ex ante identical, so we do not account for wage dispersion associated with education (Katz and Autor, 1999), gender (Goldin, 2006), other types of ex-ante heterogeneity, job search within occupations (Pavan, 2011), or other types of shocks.

2 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.

3 In an overlapping-generations setting, this mechanism could also be important for understanding choices made early in the life-cycle, such as educational choice or once-and-for-all occupational choice, as in Banerjee and Newman (1993) and Filmer and Pritchett (1999).
reallocation to a new occupation has a dynamic effect on future labor productivity. Technically most closely related to our paper but substantially different in emphasis is the work of Krusell et al. (2008), who study a model which combines an islands model of search along the lines of Lucas and Prescott (1974) with incomplete markets as in the Bewley tradition. However, their focus is on understanding flows between employment and non-employment, and not on heterogeneity across different jobs or occupations. Our work is therefore complementary to theirs.

Finally, our paper is also related to the literature on misallocation in macroeconomics. An extensive literature on the dispersion of productivity across firms within the same industry suggests that misallocation of resources across firms within a narrowly-defined sector is very important for understanding aggregate productivity differences across countries and over time (Foster, Haltiwanger, and Krizan, 2001; Hsieh and Klenow, 2009). Our paper suggests that limitations on occupational mobility due to financial frictions are, while less important, still quantitatively significant for understanding the levels of labor and total factor productivity.

The structure of the remainder of the paper is as follows. In Section 2, we describe the model, including both our incomplete-markets benchmark and a version with complete markets. We describe our calibration strategy in Section 3. In Section 4, we report results, focusing on the comparison between complete and incomplete markets. Section 5 discusses the effect of subsidizing occupational mobility under incomplete markets, while Section 6 shows that the effects of market incompleteness can be greater for young agents, something that is particularly important given the higher frequency of occupational switching among the young. Section 7 concludes briefly.

2 Model

In this section we describe the economic environments that we consider. To simplify the exposition, we will describe only steady-state versions of these environments.

2.1 Preferences

There is a continuum of workers of fixed measure, normalized to one. Workers are infinitely-lived, and derive utility from consumption \( c \). They discount the future with discount factor \( \beta \in (0, 1) \) (time is discrete). The felicity function is denoted \( u(c) \), and the expected utility function is given by \( \sum_{t=0}^{\infty} \beta^t u(c_t) \).

2.2 Occupations and Occupational Mobility

There is a continuum of islands, which we think of as representing occupations. Islands are indexed by \( i \in [0, 1] \). Each island \( i \) is characterized at any time \( t \) by an island-specific labor-augmenting productivity shock \( x_{it} \), which takes values in a finite set \( X \equiv \{ x_1, x_2, \ldots, x_M \} \). \( x_{it} \) follows a first-order Markov process; write \( f(x, x') \) for the probability that \( x_{i,t+1} = x' \) conditional on \( x_{it} = x \). We assume without loss of generality that the Markov process \( f(\cdot) \) has a unique ergodic distribution.
with full support; this is without loss of generality because we focus on steady states. Denote the ergodic distribution by $\Psi(\cdot)$.

At the beginning of each period, a nonnegative measure of workers is located on each island. Workers can be either inexperienced or experienced in the occupation that is undertaken on island $i$. Workers who are experienced are more productive, so that their raw labor is $1 + \chi > 1$ times as productive as the labor of inexperienced workers.\(^4\) The occupation productivity shock is labor-augmenting, so that on an island with productivity $x$, an inexperienced worker who works for fraction $h$ of his endowment of time supplies $xh$ efficiency units of labor, and an experienced worker who works for the same duration supplies $(1 + \chi)xh$ efficiency units. Denoting experience by $e$, with inexperienced agents having $e = 0$ and experienced agents $e = 1$, a unified expression for this is that a worker with experience $e$ supplies $(1 + \chi)^e x$ efficiency units of labor per unit of time worked.

A worker who is inexperienced in the occupation associated with island $i$ becomes experienced with probability $q \in [0, 1]$ each period that she remains and works on island $i$. The stochastic process of gaining experience conditional on remaining on an island is iid across workers, across islands, and over time. Define $\eta(e, e')$ to be the probability that next period’s experience level will be $e'$ conditional on today’s experience $e$; then $\eta(0, 0) = 1 - q$, $\eta(0, 1) = q$, $\eta(1, 0) = 0$, and $\eta(1, 1) = 1$.

Each period, at the beginning of the period before supplying labor to a firm on this island, any worker has an opportunity to move islands. More precisely, the worker has the option to move to one specific alternative island $i'$. (We have in mind that the worker hears about from a personal contact network about the prospects in a particular occupation.) The worker does not have to take up the option, and if she ignores it, she remains on her current island and can supply labor as usual during the current period. Write $\Psi^m(\cdot)$ for the cdf of island productivity across the islands the agent might arrive on next period, and $\psi^m(\cdot)$ for the corresponding pdf. We assume that at the time of deciding whether or not to accept the mobility opportunity, the worker only knows the distribution $\Psi^m(\cdot)$ and not the realization of $x_{i', t+1}$. Note that $\Psi^m(\cdot)$ can be different from $\Psi(\cdot)$.

Labor supply is inelastic at the intensive margin, but moving is time-consuming. Accordingly, a worker who remains on her island during the period supplies $\bar{h}$ units of raw labor, and a worker who undertakes an occupational switch does not supply labor during the period of the move. (The reduction in labor supply for moving agents models the idea that it might take time for the worker to find a new job in her new occupation, the required time for retraining, and the possibility of lower wages during an ‘apprenticeship’ period.) In addition, a worker who moves pays a mobility cost $\kappa \geq 0$. At the beginning of the next period, the worker will be located on her new island. Because we assume that human capital is specific to each occupation, she will be inexperienced.

\(^4\)This simple way of modeling the return to occupational tenure follows Kambourov and Manovskii (2009a).
2.3 Production

There is a single representative firm which rents capital and labor and produces output.\(^5\) If the firm rents \(k\) units of capital and \(l\) efficiency units of labor, its output is

\[ Y(k, l) \equiv k^\alpha l^{1-\alpha}, \]

units of the final good, where \(\alpha \in (0, 1)\). The firm is a price-taker in the rental market for capital. Capital is owned by workers, and rented each period to the firm. Capital 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 \(i\) 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.\(^6\) Finally, the firm is also a price-taker in the final good market. 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 markets to insure either against the occupation productivity shock or the idiosyncratic experience shock. A worker holds assets \(a\), which can never be lower than a lower bound \(a_\ast\), which can either be the natural borrowing limit or a strictly greater exogenous limit.

The state variables for an individual worker in the incomplete markets economy are the productivity of the island on which she is located, \(x\), whether or not she is experienced in her island’s occupation, \(e\), and her assets, \(a\). We write \(e = 0\) for an inexperienced agent and \(e = 1\) for an

\[^5\]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.

\[^6\]Note that efficiency units of labor supplied on different islands are perfect substitutes. This assumption differs from that made by Kambourov and Manovskii (2009a), who assume imperfect substitutability. There are three reasons we make this modeling choice. First, the primitive shock process in our model is essentially to occupation-level wages, so that allowing for a finite elasticity of substitution between the goods produced on different islands should intuitively deliver similar results to ours—at least, as far as the decision problem of an individual agent is concerned—provided that one recalibrates the volatility of the island productivity process appropriately. Of course, this need not be true for the general equilibrium effects, but assuming that the elasticity of substitution between island-level output is high, for example, around 3 as suggested by both Kambourov and Manovskii (2009b) and Alvarez and Shimer (2011), in the latter case following the estimates in Broda and Weinstein (2006) for the elasticity of substitution, then the results we obtain should not differ too much from those that obtain under imperfect substitutability.

Second, if one regards the island-level shocks in our model as belonging not to the level of an occupation but of an occupation-worker match, perfect substitutability (that is, the absence of decreasing returns) is further justified since a worker’s \(x\) shock turning bad might then reflect mostly on his own occupational match quality, rather than on occupational-level shocks. Assuming that an individual worker faces factor prices that are independent of her decisions, the substance of the perfect substitutes assumption, then seems natural.

Finally, our incomplete markets model is intractable if islands produce imperfectly substitutable goods. This is because the entire distribution of assets of agents on the island becomes a state variable for a given agent. In order to predict his own future wages conditional on staying on the island, he needs to predict the future price of the island’s output, which in turn depends on the number of workers on the island, and then in turn on the mobility decisions of other agents, and so finally on their asset holdings.
experienced agent. The Bellman value $V(x,e,a)$ of a worker who begins a period in state $(x,e,a)$ satisfies

$$V(x,e,a) = \max \{ V_w(x,e,a), V_m(a) \}$$

where $V_w(x,e,a)$ is the value of working on the current island, and $V_m(a)$ is the value of leaving the current island and moving to a new island. The value of working satisfies

$$V_w(x,e,a) = \max_{c,a'} u(c) + \beta \sum_{x'} \sum_{e'} V(x',e',a') f(x,x') \eta(e,e')$$

s.t. $c + a' = (1 + r)a + (1 + \chi) e x w h$

$$a' \geq a \quad \text{and} \quad c \geq 0.$$ 

The value of moving is

$$V_m(a) = \max_{c,a'} u(c) + \beta \sum V(x',0,a') \psi^m(x')$$

s.t. $c + a' = (1 + r)a - \kappa$

$$a' \geq a \quad \text{and} \quad c \geq 0.$$ 

Note that the value of moving depends only on the agent’s current asset level and not on the productivity of her current island $x$ or on her experience $e$, since she will not supply any more labor on the current island. The worker takes as given the interest rate on assets $r$ and the wage per efficiency unit of labor $w$. We write $g^a(x,e,a) = a'(x,e,a)$ for the savings policy of an agent in state $(x,e,a)$, $g^c(x,e,a)$ for the consumption policy, and $m(x,e,a)$ for her mobility decision (setting $m(x,e,a) = 1$ if and only if the agent moves when she receives a mobility opportunity).

Because of the non-convexity introduced by the option to move islands, characterizing the solution to this problem analytically is not entirely straightforward. We therefore use a numerical approach to understanding the model. In our simulations, when $\beta(1 + r) < 1$ and $u(\cdot)$ has constant

7If mobility were exogenous, the problem would reduce to a standard income fluctuations problem as in Huggett (1993) and Aiyagari (1994). In that environment, it can be shown as in Proposition 4 of Aiyagari (1993) that if $\beta(1 + r) < 1$ and the coefficient of relative risk aversion is bounded above as $c \to \infty$, then there is a unique solution for the value functions $V(\cdot)$, $V^w(\cdot)$, and $V^m(\cdot)$ and for the savings policy $g^a(\cdot)$, and that there is an upper bound on assets. However, the introduction of endogenous mobility introduces a nonconvexity, which makes standard tools of dynamic programming inapplicable, and in particular, it is no longer true, for example, that $g^a(x,e,a)$ need be monotone in $a$. The issue is not that mobility is not chosen from a convex set—that could be handled in the usual way by allowing for lotteries over mobility—but that as in Buera (2007) and Vereshchagina and Hopenhayn (2009), the agent’s value of assets depends on whether she moves occupation or not. This gives rise to a nonmonotonic savings policy as a function of current assets, and would also lead to a demand for lotteries over wealth. Given the quantitative goal of our paper, we do not allow for lotteries and we do not formally establish conditions under which the properties of the value and policy functions described in the main text hold.

It is also worth noting that if we assumed that agents’ preferences exhibited constant absolute risk aversion, allowed for negative consumption, and replaced the borrowing constraint with a no-Ponzi game condition, we could characterize the solution analytically following Shimer and Werning (2008). However, we do not take this route since in our model the most important effect of financial market incompleteness is that agents with low assets have a liquidity problem and cannot invest in occupational mobility even when it would be beneficial to do so in the sense of increasing the expected present discounted value of labor income net of mobility costs. Assuming away this problem would not allow us to study the phenomenon we are interested in.

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coefficient of relative risk aversion no less than 1, there is a unique solution for the value functions \(V(\cdot), V^w(\cdot), \text{and } V^m(\cdot)\), as well as for the mobility policy \(m(x, e, a)\) and the savings policy \(g^a(\cdot)\). Moreover, there is \(\bar{a} > a\) such that for all \((x, e, a)\) with \(a \in [a, \bar{a}]\), \(g^a(x, e, a) \in [a, \bar{a}]\).

Given the mobility and savings policies of agents, the process for individual state variables is Markov. If \(S\) is a Borel\(^8\) subset of \(Y = X \times \{0, 1\} \times [a, \bar{a}]\), write \(P(x, e, a, S)\) for the probability that \((x', e', a')\) lies in \(S\), that is,

\[
P(x, e, a, S) = \begin{cases} 
\sum_{(x', e', g^a(x, e, a)) \in S} f(x, x') & \text{if } m(x, e, a) = 0 \\
\sum_{x'(x', 0, g^a(x, e, a)) \in S} v^m(x') & \text{if } m(x, e, a) = 1.
\end{cases}
\]

Then given the probability measure \(\mu\) for today’s states \((x, e, a)\), the probability measure for next period’s states, \(\mu'\), satisfies

\[
\mu'(S) = \int_{X \times \{0, 1\} \times [a, \bar{a}]} P(x, e, a, S) \, d\mu(x, e, a).
\]

A steady-state equilibrium under incomplete markets is a set of functions \(\{V(\cdot), V^w(\cdot), V^m(\cdot), g^a(\cdot), g^c(\cdot), m(\cdot)\}\), a measure \(\mu\), aggregate capital and labor \(K\) and \(L\), and prices \(w\) and \(r\) such that

1. given the prices \(w\) and \(r\), the functions \(\{V(\cdot), V^w(\cdot), V^m(\cdot), g^a(\cdot), g^c(\cdot), m(\cdot)\}\) solve the household’s decision problem;
2. prices equal marginal productivities, \(w = Y_L(K, L)\) and \(r = Y_K(K, L) - \delta\);
3. factor markets clear, \(L = \int (1 - m(x, e, a))(1 + \chi)^e x \, d\mu(x, e, a)\) and \(K = \int a \, d\mu(x, e, a)\); and
4. the measure \(\mu\) is invariant, \(\mu(S) = \int_{X \times \{0, 1\} \times [a, \bar{a}]} P(x, e, a, S) \, d\mu(x, e, a)\).

Market clearing in the market for the produced good follows from Walras’ law.\(^9\)

### 2.5 Complete markets model

Under complete markets, the economic environment is unchanged from that described above, with the exception that we now allow for complete markets for both occupational productivity shocks and idiosyncratic shocks.

We implement complete markets using trade in Arrow securities. We assume that agents invest in Arrow securities which pay off in the following period conditional on the occupational productivity shock \(x'\) and experience level \(e'\) which will apply to the agent in that period. Denote by \(b'(x', e')\) the number of units of the Arrow security corresponding to state \((x', e')\) purchased by the agent in the current period; there is an Arrow security for each possible (joint) realization of \((x', e')\).

\(^8\)The topology on \(Y\) is the product of the discrete topologies on the two finite sets \(X\) and \(\{0, 1\}\) and the standard Euclidean topology on \([a, \bar{a}]\).

\(^9\)To aid comparison, the form of the equilibrium definition is very similar to that in Pijoan-Mas (2006).
Because the probability of state \((x', e')\) depends on whether the agent works or moves during the current period, we assume that the markets for trading these Arrow securities \(\{b'(x', e')\}\) open only after the agent has committed to her decision of whether or not to move occupations. This implies that the prices of the Arrow securities will depend on the agent’s mobility choice. Denote by \(q^w(x, e, x', e')\) the price of a security paying off in state \((x', e')\) given that the agent’s current state is \((x, e)\) and that she works on her current island, and by \(q^m(x')\) the price of a security paying off in state \((x', 0)\) when the agent moves.

The agent enters the current period with a payment \(b(x, e)\) from the Arrow security she invested in for the realized state \((x, e)\) in the previous period. The agent’s problem can be written

\[
\tilde{V}(x, e, b) = \max \{\tilde{V}_w(x, e, b), \tilde{V}_m(b)\}
\]

where \(\tilde{V}_w(x, e, a)\) is the value of working and \(\tilde{V}_m(b)\) is the value of leaving. These values in turn satisfy

\[
\tilde{V}_w(x, e, b) = \max_{c \geq 0, b'(\cdot)} u(c) + \beta \sum_{x', e'} \tilde{V}(x', e', b'(x', e')) f(x, x') \eta(e, e')
\]

s.t. \(c + \sum_{x', e'} q^w(x, e, x', e') b(x', e') = (1 + \chi)^e x w \tilde{h}_w + b\)

and

\[
\tilde{V}_m(b) = \max_{c \geq 0, b'(\cdot)} u(c) + \beta \sum_x \tilde{V}(x', 0, b'(x', 0)) \psi^m(x')
\]

s.t. \(c + \sum_x q^m(x') b(x') = (1 + \chi)^e x w \tilde{h}_m - \kappa + b\),

where in each case we also impose the natural debt limit to prevent Ponzi schemes. Write the policy functions for the agent as \(\hat{m}(x, e)\), \(c = \hat{g}^c(x, e)\), and \(b'(x', e') = \hat{g}^b(x, e, b, x', e')\). Write \(\Gamma(x, e, x', e')\) for the probability of state \((x', e')\) next period conditional on the current state \((x, e)\) and the mobility policy \(\hat{m}(\cdot)\); then

\[
\Gamma(x, e, x', e') = \begin{cases} 
    f(x, x') \eta(e, e') & \hat{m}(x, e) = 0 \\
    \psi^m(x) \mathbb{1}(e' = 0) & \hat{m}(x, e) = 1 
\end{cases}
\]

Also write

\[
q(x, e, x', e') = \begin{cases} 
    q^w(x, e, x', e') & \hat{m}(x, e) = 0 \\
    q^m(x') & \hat{m}(x, e) = 1 
\end{cases}
\]

using the fact that a moving agent will not be experienced in the next period.
The Euler equation for an agent in state \((x, e, b)\) is

\[ u_c(c) = \beta \Gamma(x, e, x', e') q(x, e, x', e') u_c(c') \]

When insurance markets are competitive, the no-arbitrage condition implies that

\[ q^w(x, e, x', e') = \frac{1}{1 + r} f(x, x') \eta(e, e') \]

and

\[ q^m(x') = \frac{1}{1 + r} \psi^m(x'). \]

Substituting into the agent’s Euler equation gives that, as is standard under complete markets, independently of the realization of \((x', e')\),

\[ u_c(c) = \beta (1 + r) u_c(c'). \]

This implies that \(\beta(1 + r) = 1\) is a necessary condition for a steady-state equilibrium (although we can consider the problem of an individual agent more generally; this will be useful in understanding the welfare gains associated with completing markets).

Finally, as under incomplete markets, we can define a law of motion \(\tilde{P}(\cdot)\) so that for any \(x \in X, e \in \{0, 1\}, b \in \mathbb{R}\) and any Borel subset \(S\) of \(X \times \{0, 1\} \times \mathbb{R}\), \(\tilde{P}(x, e, b, S)\) is the probability \((x', e', b')\) lies in \(S\). We also have an associated law of motion for the measure of agents over \(X \times \{0, 1\} \times \mathbb{R}\), defined analogously to (3) above.

A steady state equilibrium under complete markets is a set of functions \(\{\tilde{V}(\cdot), \tilde{V}_w(\cdot), \tilde{V}_m(\cdot), \tilde{g}^b(\cdot), \tilde{g}^c(\cdot), \tilde{m}(\cdot)\}\), a measure \(\tilde{\mu}\), aggregate capital and labor \(K\) and \(L\), and prices \(w, r, q^w(\cdot), q^m(\cdot)\) such that

1. given the prices \(w, r, q^w(\cdot), q^m(\cdot)\), the functions \(\{\tilde{V}(\cdot), \tilde{V}_w(\cdot), \tilde{V}_m(\cdot), \tilde{g}^b(\cdot), \tilde{g}^c(\cdot), \tilde{m}(\cdot)\}\) solve the household’s decision problem;
2. prices equal marginal productivities, \(w = Y_L(K, L)\) and \(r = Y_K(K, L) - \delta\);
3. factor markets clear, \(L = \int (1 - \tilde{m}(x, e, b))(1 + \chi)^e x d\tilde{\mu}(x, e, b)\) and \(K = \int b d\tilde{\mu}(x, e, b)\);
4. insurance is competitively priced, \(q^w(x, e, x', e') = \frac{1}{1 + r} f(x, x') \eta(e, e')\) and \(q^m(x') = \frac{1}{1 + r} \psi^m(x')\);
5. \(\beta(1 + r) = 1\); and
6. the measure \(\mu\) is invariant, \(\mu(S) = \int_{X \times \{0, 1\} \times \mathbb{R}} \tilde{P}(x, e, b, S) d\mu(x, e, b)\).

Market clearing in the market for the produced good again follows from Walras’ law.

Under complete markets, all agents choose mobility to maximize the expected present discounted value of labor income net of mobility costs. However, the distribution of consumption across agents is not uniquely characterized.
3 Model Parametrization and Calibration

In this section we describe the model parametrization and calibration procedure.

3.1 Parametrization

We assume that the model period is one year in order to minimize computational time, given the complicated nature of our model. In future work, we plan to recast the model at a quarterly frequency. Utility is logarithmic, \( u(c) = \log(c) \), to allow for a balanced growth path. In addition, no borrowing is allowed, \( \varrho = 0 \).\(^{10}\)

An important assumption is on the distribution from which moving agents draw the productivity of their new island. One possible modeling assumption is to assume that occupational mobility is completely random, following Alvarez and Veracierto (1999). This models a situation where workers know nothing about their new island prior to making a switch. This would be appropriate if a worker’s productivity in an occupation is an experience good, so that before starting work in the occupation, a worker has no information about her productivity there. It would also be appropriate if occupational productivity largely arises from the quality of the match between a worker and an occupation, rather from the characteristics of the occupation itself. An alternative would be to assume that occupational mobility is fully directed, following Lucas and Prescott (1974). In this case workers move only to occupations in which their productivity is high. This would be appropriate if a worker’s occupational productivity largely arises from the characteristics of the occupation itself, rather than being match-specific.

In order to nest these two possibilities, along with intermediate cases, we allow for partially directed search, so that the next-period productivity \( x'_{i',t+1} \) of the destination island \( i' \) is drawn from the top \( 1 - d \) quantiles of the ergodic distribution of island productivity shocks. That is, we set the distribution of destination islands for agents who move to be:

\[
\Psi^m(\xi) = \begin{cases} 
\frac{\Psi(\xi) - c}{1-d} & \text{if } \Psi(\xi) \geq 1-d; \\
0 & \text{otherwise}.
\end{cases}
\]

This formulation nests the two extreme cases discussed above. If \( d = 0 \), then occupational mobility is fully random, while if \( d = 1 \) then occupational mobility is fully directed.

Finally, we assume that the first order Markov process for \( x \) approximates an AR(1) process of \( \log(x) \):

\[
\log(x') = \rho_x \log(x) + \epsilon_x \quad \text{s.t.} \quad \epsilon_x \sim N(0, \sigma_x)
\]

\(^{10}\)We will investigate the robustness of the results to this assumption in a future version of this paper.
3.2 Calibration

We set the time period of our model to be quarterly. (This has economic content in our model, since a worker who moves forgoes working for one period.)

We set three parameters, $\alpha$, $\beta$, and $\delta$, following standard practices in the literature. We calibrate the capital income share $\alpha$ to 0.36 and the annual depreciation rate $\delta$ to 8 percent. Following Chang and Kim (2006), we calibrate $\beta$ so that in equilibrium the annual real interest rate is 4 percent.

The more distinctive structural parameters of our model are those governing the island productivity shock process $\sigma_x$ and $\rho_x$; the returns to occupational experience $\chi, q$; the financial cost of moving $\kappa$; and the directedness of mobility $d$. We jointly calibrate three parameters, specifically $\sigma_x$, $\rho_x$, and $d$, so that the model matches the empirical cross-sectional dispersion of wages along with the empirical characteristics of occupational mobility. We choose our calibration targets for all three of these moments following Kambourov and Manovskii (2009a). We target a cross-sectional variance of log wages of 0.293, following Kambourov and Manovskii’s Within-Group 2 measure calculated from the Panel Study of Income Dynamics (PSID) for the period 1993-1996. We also replicate the frequency and persistence of occupational mobility observed in the PSID for the 1970-73 period. Specifically, we aim to reproduce two targets: (1) an average annual rate of occupational mobility at the three-digit level of 21 percent; and (2) the average number of switches for those who switched occupations at least once over the period, which is 1.71. Because $d$, $\rho_x$, and $\sigma_x$ all affect all these targets, we use a Simulated Method of Moments (SMM) approach whereby the (unweighted) sum of squared deviations between model-simulated and data moments is minimized. The resulting parameters are $\sigma_x = 0.52$, $\rho_x = 0.72$, and $d = 0.15$. The model is not able to match the calibration targets exactly; we generate a variance of log wages of 0.27, an annual rate of occupational mobility of 22 percent and a mean of 2.06 occupational switches conditional on at least one switch.

Similarly to Kambourov and Manovskii (2009a), we calibrate $\chi$ and $q$ so that in the model it takes 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 that the average vocational training program in the US 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 take a slightly different approach and set the mobility cost to two months of wages for the mean worker in our model. Unreported robustness exercises show that our main results are robust to modest changes in the mobility cost. Also n that casting the model at an annual frequency exaggerates the indirect (time away from work) cost of moving.

Following Chang and Kim (2006), we assume that when working individuals supply $h_w = 1/3$ of their time. (Individuals who choose to move cannot work during the period of the move.) Since the period length is one quarter, this allows for the three months duration of the typical training program (Heckman, Lalonde, and Smith, 1999). This reduction in labor supply for moving agents should be thought of as a lower bound, since it abstracts from any time spent physically moving...
locations, in job search, or in learning about the potential occupational match.

We briefly discuss identification of the parameters $\sigma_x$, $\rho_x$, and $d$. The high level of repeat occupational mobility among those who move at least once can arise from two possible channels in the model. First, if income shocks are not too persistent, repeat mobility can arise as an agent who recently moved islands quickly experiences negative occupational shocks and chooses to move again. However, because mobility costs are high, this case will only arise if occupational shocks are also extremely volatile (so as to give a reason to move in search of transitory income gains). This section of the parameter space then can be consistent with the high levels of occupational mobility only if there is also excessive wage dispersion. An alternative way for repeat mobility to arise is if income shocks are more persistent but mobility is close to random. In this case, an agent who leaves one occupation is quite likely to land on a worse one, and need to move again. The model finds that an intermediate level of persistence of occupational-level earnings shocks, together with quite undirected search, is best for fitting the calibration targets.\footnote{It is worth noting that if search were fully directed, $d = 1$, then the model would not only perform badly in terms of hitting the targets just described, but would also do badly in untargeted dimensions. For example, there would be no wage dispersion among workers conditional on switching occupations. Moreover, the OLS return to occupational tenure would be substantially more negative than the true return to tenure, because workers would move only to occupations with maximal productivity, which would then revert to the mean. However, using a strategy pioneered by Altonji and Shakotko (1987), Kambourov and Manovskii (2009b) find that empirically OLS returns to tenure are in fact upward-biased. Fully random search, $d = 0$, would also be problematic. In that case, we would see many workers experience substantial wage cuts upon switching occupations. Mobility into declining occupations would be equally likely as mobility into growing occupations, contrary to evidence reported by Şahin et al. (2011).}

Table 1 summarizes the calibration targets and parameter values.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Target</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>Capital income share</td>
<td>0.36</td>
</tr>
<tr>
<td>$\delta$</td>
<td>Annual depreciation rate</td>
<td>0.08</td>
</tr>
<tr>
<td>$\beta$</td>
<td>Annual real interest rate $r = 0.04$</td>
<td>0.933</td>
</tr>
<tr>
<td>$\rho_x, \sigma_x$</td>
<td>3-digit annual occupational mobility and average number of switches for those who switched occupations at least once in a 4-year period</td>
<td>0.945, 0.350</td>
</tr>
<tr>
<td>$\kappa$</td>
<td>Two months of forgone wages for mean worker</td>
<td>0.478</td>
</tr>
<tr>
<td>$\chi, q$</td>
<td>Return to 10 years of occupational experience</td>
<td>0.2, 0.1</td>
</tr>
</tbody>
</table>

Table 1. Calibration targets and parameter values
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.

4.1 Occupational Mobility Policies

We begin by describing the policy functions for occupational mobility under the two market environments. Figure 1 depicts the mobility policies in the incomplete markets model graphically. The figure shows the reservation productivity level below which agents are willing to move rather than work, as a function of the asset level (shown on the horizontal axis) and experience level (shown by the two different curves corresponding to inexperienced and experience agents) of the agent. The graph shows two important stylized features of mobility in our model. First, experienced agents (whose opportunity cost of moving is greater) 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 his 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 his assets is entirely because of incomplete markets: the complete markets analog to Figure 1 would show horizontal reservation wages independent of the agent’s holdings of Arrow securities. Under complete markets, mobility is independent of assets and agents act to maximize the present discounted value of income. This requires that all agents move away from all islands with productivity less than a threshold value.

Figure 2 shows the savings policies in the incomplete markets model. The left panel of the figure shows the savings policy $g^a(x, 0, a)$ for inexperienced agents; the right panel shows the corresponding policy $g^a(x, 1, a)$ for experienced agents. As expected, future assets are increasing in current island...
Figure 2. Savings policies for inexperienced (left) and experienced individuals (right), incomplete markets.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$K$</th>
<th>$Y$</th>
<th>$C$</th>
<th>Mob. rate</th>
<th>Frac. exper.</th>
<th>$L$ (Raw)</th>
<th>$L$ (Eff. units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark</td>
<td>21.42</td>
<td>2.08</td>
<td>1.48</td>
<td>0.066</td>
<td>0.53</td>
<td>0.934</td>
<td>0.56</td>
</tr>
<tr>
<td>Complete markets</td>
<td>20.47</td>
<td>2.11</td>
<td>1.53</td>
<td>0.072</td>
<td>0.67</td>
<td>0.928</td>
<td>0.59</td>
</tr>
<tr>
<td>(CM/IM)-1</td>
<td>-0.05</td>
<td>0.01</td>
<td>0.04</td>
<td>0.09</td>
<td>0.27</td>
<td>-0.007</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Table 2. Economic Aggregates

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 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, earns a low current labor income, 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.

4.2 Economic aggregates

Table 2 reports results for the basic economic aggregates. 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). The lower capital stock leads to slightly lower aggregate output, despite the slightly higher effective labor supply that arises from greater occupational mobility under complete markets. Consumption is also slightly lower under complete markets, although by a much smaller fraction than aggregate output, consistent with lower depreciation as a result of the lower capital stock.

More striking are the differences in mobility rates across the two market environments. Mobility is 9 percent higher in the complete markets steady state, as agents move whenever it increases
the present discounted value of labor income. Under incomplete markets, the need to smooth consumption by conserving assets and not paying the mobility cost and forgoing earnings looms larger. The flip side of higher mobility is lower raw labor supply (the mobility rate and the employment rate sum to unity by construction). However, despite greater mobility, agents are more likely to have become experienced in their occupation under complete markets. These two features seem inconsistent, but are not so: under complete markets, experienced agents on relatively unproductive islands are able to wait around, preserving their experience, in case their island regains its productivity, while under incomplete markets, these agents are more likely to move. Inexperienced agents, on the other hand, are more mobile under complete markets, as they are willing to move whenever this increases their expected present discounted value of income net of mobility costs, while under incomplete markets, these agents do not move so readily, so as to preserve their assets. Finally, the distribution of agents across island productivities is somewhat improved under complete markets. The net effect of these competing forces is that effective labor supply is around 5 percent higher under complete markets.

Table 3 reports the corresponding results for prices. The lower aggregate capital stock and higher effective labor supply under incomplete markets lead to a sharp increase in the marginal product of capital, and hence in the interest rate. There is a corresponding reduction in the marginal product of labor and the wage.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$w$</th>
<th>$r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark</td>
<td>2.37</td>
<td>0.0100</td>
</tr>
<tr>
<td>Complete markets</td>
<td>2.30</td>
<td>0.0122</td>
</tr>
<tr>
<td>(CM/IM)-1</td>
<td>-0.03</td>
<td>0.22</td>
</tr>
</tbody>
</table>

Table 3. Prices
4.3 Cross-sectional features

One effect of the market environment is that under complete markets, agents are more concentrated on productive islands. The left panel of Figure 3 shows this graphically. The distribution of agents across islands under complete markets dominates that in the benchmark, in the sense of first-order stochastic dominance. This is particularly true for experienced agents; the distribution of these agents is seen in the right panel of the Figure.

The reason for the improvement in the distribution of workers over island productivity under complete markets must arise from a difference in the probability of occupational switching conditional on island productivity in that environment. This can be seen directly in Figure 4. The left panel shows the mobility rates, conditional on island productivity and experience, separately for all workers, inexperienced workers, and experienced workers; the right panel shows the complete markets analog. Under complete markets, agents leave an occupation if and only if its productivity falls below the threshold at which the expected present discounted value of future labor income, net of mobility costs, is increased by moving. When markets are incomplete, however, agents do not move as frequently. Agents on low-productivity islands likely have low assets, due to a history of negative productivity shocks leading to repeated costly mobility. In fact, the mobility rate actually falls as island productivity gets sufficiently bad in the incomplete markets model; this is because of the correlation between assets and island productivity.

Because agents are more concentrated on productive islands in the complete markets steady state, the dispersion of wages is also lower. The variance of log wages for agents who do not move, and therefore work for the entire period, falls from 0.27 in the incomplete markets benchmark to 0.22 when markets are complete.

The cross-sectional dispersion of log wages in the model is targeted to be similar to that reported by Kambourov and Manovskii (2009a). Kambourov and Manovskii report that in the PSID for the period 1993-96, the variance of log wages was 0.354; however, part of this variation projects
on observable heterogeneity in race, sex, age, and education from which we abstract in our model. However, much of the variation in wages occurs within narrowly-defined groups of observationally-equivalent workers. Therefore, we match Kambourov and Manovskii’s preferred measure of wage variation (their Within-Group 2 measure) for which they report a variance of log wages of 0.293. Our calibration is currently preliminary in two senses. First, some authors would argue that a smaller cross-sectional variance of wages would be desirable, since Kambourov and Manovskii’s concept of wages attributes to occupational wage dispersion all residual wage dispersion that cannot be accounted for by the observables accounted for in their Within-Group 2 measure. Second, the current wage distribution generated by the model does not match its empirical counterpart in one important dimension: model-generated wages are much too transitory, with a quarterly autocorrelation of 0.64. In future we will adjust our calibration strategy to take account of this.

Under incomplete markets, uninsurable labor income risk implies that consumption varies both in the cross-section and over time for each individual agent. Table 4 reports key statistics on consumption. As can be seen, the cross-sectional variance of consumption is very high, and consumption is volatile and highly correlated with current income, assets, and island productivity, all of which indicate that markets are substantially incomplete.

By contrast, in the steady state under complete markets, consumption is constant for each individual agent, but the cross-sectional variance of consumption is not uniquely determined. Throughout the paper, we report consumption statistics for the complete markets model that arises after the completion of a transition process of an economy which begins in the steady state of our benchmark incomplete markets model, in which at time 0 complete markets for future idiosyncratic and occupational risk are opened. The wealth of an agent in this model is given by the expected present discounted value of her future labor income net of mobility costs, plus her assets inherited from the incomplete markets environment. She chooses future mobility to maximize the present value of her income, then chooses consumption according to her lifetime budget constraint. This generates a
cross-sectional variance of log consumption of 0.014, dramatically less than the corresponding variance of log consumption in the benchmark steady state of 0.08. Because mobility is independent of wealth, consumption in the complete markets steady state is therefore uncorrelated with labor income, earnings, assets, or island productivity, and is perfectly autocorrelated.

### 4.4 Welfare cost of incomplete markets

#### 4.4.1 Comparison of steady states

Our main results concern the welfare gains of complete markets in the model of occupational mobility that we study. We measure welfare gains as equivalent variation: what fraction 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? Table 5 reports the basic result that the average welfare gains are very large, and average 6.2 percent of consumption.

There is some variation across agents in the gains from introducing complete markets, which arises from the heterogeneity in current island productivity, experience, and assets at the time of the introduction. This variation can be seen in Figure 5, which reports the average welfare gains conditional on assets, and Figure 6, which reports the average welfare gains conditional on island productivity and experience. In Figure 5, we show the gains for agents with three different island productivity levels $x_{10} < x_{13} < x_{17}$, respectively the tenth percentile, the median, and the maximum of the ergodic distribution of agents across island productivities.

The benefits of complete markets are most pronounced for those with low assets and those located on unproductive islands, who gain from two sources: they can immediately make occupational switches to more productive islands which 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. It is noticeable also that agents with high assets gain substantially from the transition to complete markets. This is a general equilibrium effect: because the capital stock is substantially lower under complete markets, the interest rate rises, benefiting agents who hold substantial assets when complete markets are introduced.

To make these intuitions more precise, we also report welfare effects from two experiments that aim to distinguish the pure partial equilibrium effect of completing markets from the pure general equilibrium effect of price changes. We define the price-constant, partial equilibrium welfare gain as the equivalent variation associated with providing the agent with complete markets against idiosyncratic and occupational risk, but holding factor prices $w$ and $r$ constant at the levels associated with the benchmark incomplete-markets steady state. We define the general equilibrium welfare gain as the equivalent variation associated with preserving the incomplete market structure of the benchmark model, but exogenously altering prices to the values they take under the complete markets steady state. (Of course, neither experiment is consistent with steady-state equilibrium, since prices are endogenous in this model, but we can still calculate welfare gains for agents exogenously subject to such prices and market structures.)
The price-constant gains exceed the full welfare gains: they are as high as 8.7 percent. Again there is substantial variation in the distribution of these gains across agents. Rich agents no longer benefit from a high interest rate, but the gains for poor agents are enhanced (because the wage per efficiency unit of labor is higher under incomplete markets, due to the higher capital stock). The distribution of price-constant welfare gains by assets is shown in Figure 7, and that by island productivity and experience as the uppermost curve in Figure 9. The general equilibrium effects are relatively small, 0.3 percent on average, and mostly arise from the large change in the interest rate, which particularly benefits rich agents. This can be seen in Figure 8 and the lowest curve in Figure 9.

4.4.2 Allowing for the transition

Welfare gains are slightly higher if we allow for the transition to the steady state after the introduction of complete markets for idiosyncratic and occupational risk into the incomplete markets steady state. The average equivalent variation increases from 6.2 percent to 6.3 percent. The reason for this is the same as in Pijoan-Mas (2006): the capital stock is higher in the steady state of the benchmark incomplete markets economy, and during the transition, agents consume this capital stock. In addition, there is a period while capital remains higher than in the steady state, which increases wages and reduces the interest rate. This benefits especially those agents who are located on productive islands when the transition begins.

It is not surprising that the welfare gains in transition do not differ significantly from those
Figure 6. Distribution of welfare gains by island and experience (right scale). Shaded: distribution of individuals across islands (left scale).

Figure 7. Price constant welfare gains for inexperienced (left) and experienced (right) individuals.

Figure 8. GE welfare gains for inexperienced (left) and experienced (right) individuals.
obtained by more simply comparing steady states, since the transition is quite rapid. The time path for the transition of the key aggregate variables, $K$ and $L$, as well as the key prices $r$ and $w$, can be seen in Figure 10. Variables are shown as log deviations from their complete-markets steady state values. Notice that labor rises during the transition, as agents choose mobility policies that are not constrained by their asset position.

5 Policy experiment: the Effects of a Training Subsidy

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
Table 6. The Effects of Subsidizing Mobility Costs

<table>
<thead>
<tr>
<th>Variable</th>
<th>Y</th>
<th>K</th>
<th>C</th>
<th>Mob. rate</th>
<th>Frac exper.</th>
<th>L (Raw)</th>
<th>L (Eff. units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmark</td>
<td>2.08</td>
<td>21.42</td>
<td>1.48</td>
<td>0.066</td>
<td>0.53</td>
<td>0.934</td>
<td>0.56</td>
</tr>
<tr>
<td>Mobility Subsidy</td>
<td>2.03</td>
<td>19.43</td>
<td>1.46</td>
<td>0.097</td>
<td>0.341</td>
<td>0.903</td>
<td>0.57</td>
</tr>
<tr>
<td>(Subs./Bench.)-1</td>
<td>-0.05</td>
<td>-0.09</td>
<td>-0.01</td>
<td>0.47</td>
<td>-0.36</td>
<td>-0.03</td>
<td>0.02</td>
</tr>
</tbody>
</table>

on occupational mobility while preserving the basic incomplete market structure of the benchmark model. In this section we consider the effect of a specific policy designed to encourage occupational mobility.

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 $\kappa$ (which was equal to two months of wages of the median 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 $\tau$. Then the value of working $V_w(\cdot)$, which was given by (1) in the benchmark, now satisfies

$$V_w(x, e, a) = \max_{c, a'} u(c) + \beta \sum_{x'} \sum_{e'} V(x', e', a') f(x, x') \eta(e, e')$$

s.t. $c + a' = (1 + r)a + (1 - \tau)(1 + \chi)xw\bar{h}_w$

$$a' \geq a \quad \text{and} \quad c \geq 0.$$  

The value of moving, previously given by (2), is now given by

$$V_m(a) = \max_{c, a'} u(c) + \beta \sum_{x'} V(x', 0, a') \psi_m(x')$$

s.t. $c + a' = (1 + r)a - \frac{1}{2} \kappa$

$$a' \geq a \quad \text{and} \quad c \geq 0.$$  

We assume that the government chooses the tax rate $\tau$ to balance the budget. It achieves this using a tax rate of 2.1 percent.

Table 6 reports the effects on economic aggregates of this policy. We show results for the new steady-state which arises once the subsidy and tax have been imposed. As expected, mobility and repeat mobility increase; because of this, mechanically, raw labor supply (that is, total hours worked) falls. In addition, much of the increased mobility is by experienced agents on marginal islands, so that the fraction of experienced agents falls substantially. The increased mobility does have an offsetting benefit of leading to better occupational match quality, so that labor supply in effective units increases by 2 percent despite the fall in raw labor supply and experience. Because the mobility subsidy allows workers to move more easily when hit by repeated bad island productivity shocks, precautionary savings fall, leading to an increase in the interest rate and a fall in the wage. This offsets the improvement in welfare due to the better island-level allocation of labor.

Output under the mobility subsidy is slightly lower than in the baseline model. This is the
result of two opposing effects. With a subsidized mobility cost there is less of a need to self-insure against negative occupational shocks that result in occupational switches. As a result capital falls slightly. On the other hand, effective labor supply is slightly higher, but not by enough to offset the fall in capital.

6 Occupational Mobility among the Young

We assume in our benchmark model that agents are infinitely-lived. This is convenient for expository purposes; however, an important limitation is that in such a model, we abstract from life-cycle variation in occupational mobility. In fact, because borrowing constraints are more likely to be binding for young agents, the effect of market incompleteness can be more significant for these agents. In this section we argue that this is quantitatively significant.

To model young agents, we consider the thought experiment of introducing a cohort of small measure of agents into the steady state of our benchmark model. We imagine that the initial occupation of each worker in this cohort is randomly drawn according to the ergodic distribution of island productivities, \( \Psi(\cdot) \). Each agent in the cohort starts off with no assets. Because this cohort is small, it does not affect the equilibrium, and in particular, equilibrium prices \( w \) and \( r \) are unchanged. It follows that the optimal policy for agents in the new cohort are the same as those in the benchmark model. The only difference between the new cohort and other agents is that the cross-sectional distribution of the new agents by island productivities, experience, and assets are not the same as the ergodic distribution \( \mu \) (the newborns are all inexperienced and have zero assets, and their productivity distribution is dominated, in the sense of first-order stochastic dominance, by the distribution for existing agents). Finally, to understand the effects of incomplete markets on occupational mobility and on welfare, we also conduct the same experiment in a complete markets environment. We do this in the complete markets steady-state, although the results would be essentially unchanged if we conducted a partial equilibrium analysis in the sense of the previous section by keeping \( w \) and \( r \) at the values from the incomplete markets steady state.

The results of this experiment are shown in Figures 11, 12, and 13. Each graph presents a simulated time series of a particular variable for the cohort of newborn agents, the solid blue line showing the benchmark (incomplete markets) model and the red dashed line the complete markets model. The age of the agents in the cohort under study (that is, the number of periods since their introduction into the model) is measured on the horizontal axis in each plot. Figure 11 shows mobility. While even in steady state occupational mobility is higher under complete markets, the difference is much starker for the new cohort of financially-constrained agents. Initial mobility exceeds 50 percent annually for several years under complete markets, as initially-unlucky agents seek more productive occupations; in the incomplete markets environment, on the other hand, young agents cannot pay the mobility cost and so do not move. The right panel of Figure 11 shows this difference in mobility even more starkly, by showing mobility rates conditional on a worker being located on an island with productivity low enough that the expected present discounted value
of wages of the worker is increased by leaving the island. Under complete markets, any worker on such an island leaves immediately, while in the incomplete-markets benchmark, most workers on such islands choose not to pay the cost of moving.

**Figure 11.** Young worker experiment. Blue solid line: benchmark; red dashed line: complete markets. Left panel: Average mobility, by cohort age. Right panel: Mobility rate conditional on positive expected present discounted value of moving, by cohort age.

**Figure 12.** Young worker experiment. Blue solid line: benchmark; red dashed line: complete markets. Left panel: Average island log productivity, by cohort age. Right panel: Cross-sectional variance of island log productivity, by cohort age.

**Figure 12** shows the effect of reduced mobility under incomplete markets for productivity. The left panel shows average log island productivity. In both market environments, average productivity improves with cohort age as workers relocate out of unproductive occupations, but the transition is much more protracted under incomplete markets. The differences in expected log occupation productivity for young workers substantially exceed the long-run differences. The right panel of **Figure 12** shows the cross-sectional variance of productivity, which also falls much more slowly under incomplete markets.
Finally, Figure 13 shows the cross-sectional variance of labor earnings (conditional on employment) and of consumption. It is striking that the variance of log labor income is hump-shaped in the benchmark: initially-lucky agents increase their assets, become better-insured, and move away from their occupation if it receives a negative productivity shock, while initially-unlucky agents cannot use this insurance mechanism. Under complete markets the cross-sectional variance of log labor income is essentially constant. As always, consumption shows the importance of complete markets most strikingly: in the incomplete market environment, the variance of log consumption tracks that of labor income\textsuperscript{12} while under complete markets, consumption is essentially constant across agents.\textsuperscript{13}

In summary, the effects of market incompleteness are substantially exacerbated for young, low-asset agents in our model. This suggests that average welfare effects could be even larger in a life-cycle version of our model. Constructing such a model would allow us to incorporate two important life-cycle effects that are missing in the infinite-horizon model in the current paper. First, finite horizon effects are quantitatively relevant near the end of the life-cycle, since the future income gain from occupational mobility decreases as the remaining working lifetime falls. Second, for the model to be consistent with the observed decline in occupational mobility by age (Kambourov and Manovskii, 2008), it is probably important to allow for agents to learn about their own occupational match quality, as in Neal (1999). We leave constructing a model with these features for future research.

\textsuperscript{12}Note that the distribution of labor earnings reported in the left panel of Figure 13 omits agents who switch occupations and have zero labor income; it is therefore not surprising that consumption variance (for all agents) can exceed income variance for the employed. This is reinforced by the highly persistent nature of occupation productivity shocks.

\textsuperscript{13}Consumption is precisely equated across agents under complete markets if agents can insure themselves, behind the veil of ignorance, against their initial island productivity. It is very small (0.0052) if this market is missing.
7 Conclusion

In this paper we study the effects of financial market incompleteness on occupational mobility, motivated by the fact that occupation-level earnings shocks are large and highly persistent, and therefore difficult for workers to insure against. Occupational choice is modeled using an equilibrium search model where the returns to working in an occupation are stochastic, and occupational mobility is costly. Unlike the existing literature on occupational mobility, we relax the assumption of complete markets and allow agents to self-insure by saving using a risk-free bond. Relative to the existing literature on incomplete markets, our paper adds a novel feedback mechanism from incomplete markets to the process for future labor income.

Our calibrated model suggests that the effects of market incompleteness on occupational mobility are quantitatively large. Relative to a comparable complete markets framework, mobility in our preferred calibration is 9 percent lower. Importantly, this leads to a reduction in labor productivity as more agents work in less productive occupations. We find that the welfare costs of market incompleteness can be as large as 6.2 percent of lifetime consumption.

The key mechanism by which market incompleteness is important for occupational mobility in our model arises from the fact that agents who experience negative income shocks do not have access to sufficient liquidity to finance profitable expected present value investments in occupational mobility, rather than because they are not sufficiently insured against adverse realizations of occupational productivity shocks. (Indeed, a version of our model in which agents had constant absolute risk aversion preferences and the borrowing constraint was replaced by a no-Ponzi game condition as in Shimer and Werning (2008) would immediately establish this.) The lack of liquidity means that a significant fraction of the welfare cost of market incompleteness arises from the lower expected present discounted value of income, and not from worse consumption smoothing conditional on the expected present discounted value of income.

We see two important and complementary directions of future research. First, our model has the prediction that agents with low assets find mobility too costly and therefore end up with lower future labor income. Given that this is the key mechanism in our model, verifying this prediction empirically with panel data on wealth, employment, and wages is crucial. Second, our welfare analysis suggests that the effects of market incompleteness can be larger when taking into account life-cycle differences across agents. Extending our model along this dimension is another potentially fruitful avenue to investigate.

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