Inter-industry Wage Differentials Revisited: Wage Volatility and the Option Value of Mobility

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Abstract

I document that the volatility of persistent idiosyncratic shocks to wages varies inversely with inter-industry wage differentials. I then show that this striking feature of the data arises naturally in a general equilibrium, incomplete markets, life cycle model which allows for inter-industry mobility. There are two key forces at play in the model. On one hand, since agents are risk averse and markets are incomplete, they must be compensated for taking on increased wage risk. On the other hand, given that agents can always switch to another industry in which they are more productive, they value wage volatility because it offers the potential for faster wage growth with limited downside risk. For plausible calibrations, the option value of mobility dominates the risk premium effect, leading to a negative relationship between wage volatility and inter-industry wage differentials on the order of that observed in the data. A decrease in credit market imperfections like that observed since the early 1980's leads to an increase in measured productivity and can account for much of the increase in risk-taking by young workers in the labor market and steepening in the risk-return trade-off across industries observed in the data over this same period.

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1 Introduction

It is well known that there exist large and statistically significant wage differentials for observationally equivalent workers employed in different industries. The pattern of these differentials has proven remarkably stable over time, is similar across a diverse set of countries with varied labor market institutions, is much the same for both union and non-union workers, and is also highly correlated across occupations.[1] One strand of the literature, beginning with the seminal work of Krueger and Summers (1988), argues such differentials are only compatible with non-competitive theories of wage determination. Another strand of the literature, building on the work of Gibbons and Katz (1992), contends measured inter-industry wage differentials result from differences in workers' productive abilities not captured by individual-level data sets.[2] Although there is still no consensus in the academic literature, identifying the underlying source of these differentials is of primary importance for evaluating the ability of competitive markets to efficiently allocate labor across industries.

In this paper, I explore an alternative explanation for the emergence of inter-industry wage differentials. Specifically, I investigate both the empirical and theoretical relationship between inter-industry wage differentials and the volatility of long-term, persistent, uninsurable, and idiosyncratic shocks to wages. While standard economic reasoning implies that workers should be compensated for exposure to higher wage volatility, using individual-level wage data for working age males from the University of Michigan's Panel Study of Income Dynamics (PSID), I document that precisely the opposite is true – the volatility of shocks to wages varies inversely with inter-industry wage differentials. In other words, industries which offer the least (most) wage risk are those which pay the highest (lowest) wages. The average worker employed in the personal services industry, for example, will earn a wage

[1] Slichter (1950) was one of the first to provide empirical evidence in support of the existence of inter-industry wage differentials. Dickens and Katz (1987) offer a comprehensive review of the early empirical literature on this subject. More recently, Caju, Ktay, Lamo, Nicolitsas, and Poelhekke (2010) provide an updated literature review with an emphasis on studies of labor markets outside of the U.S.

[2] For example, workers with higher unobserved abilities will earn higher wages. Industries which employ proportionately more of these workers will then appear to pay higher average wages to what are observationally equivalent workers.

that is 13 log points lower and 25% more volatile than an observationally equivalent worker employed in the manufacturing sector. Moreover, I find that variations in the volatility of shocks to wages across industries can explain 60% of inter-industry wage differentials.

Theoretically, I demonstrate that this rather striking feature of the data actually arises naturally within the context of a general equilibrium, incomplete markets, life cycle model which allows for inter-industry mobility. In the model, risk averse agents are endowed with a vector of industry-specific idiosyncratic productivities. Industries differ in their wage rates and the volatility of the idiosyncratic uninsurable productivity shocks that workers face. Each period, agents optimally decide which industry to work in subject to an exogenous resource cost of switching industries. Conditional on their industry choice and realized productivity, agents make labor supply and savings decisions. There are two key forces at play in the model. On one hand, since agents are risk averse and markets are incomplete, they demand compensation for exposure to higher wage volatility. But because agents in the model can always switch to another industry in which they are more productive, industries with higher wage volatility offer the potential for rapid wage growth with limited downside risk. Inter-industry wage differentials and the allocation of workers across industries are jointly determined in equilibrium by the relative strength of these opposing forces. For plausible calibrations of the theoretical model, the option value of mobility dominates the risk premium effect leading to a negative relationship between wage volatility and inter-industry wage differentials on the order of that which I observe in the data.

Agents in the model have three ways in which to insure themselves against labor market risk in addition to precautionary savings: borrow in credit markets using one-period uncontingent bonds, adjust their labor supply, or switch industries of employment. In order to quantify the relative importance of each insurance channel, I sequentially remove them from the calibrated baseline model and compute the resulting equilibrium risk-return trade-off across industries. My results suggest that inter-industry mobility is an important insurance channel against labor market risk which accounts for between 29% and 98% of the difference in the risk-return trade-off between the calibrated baseline model and a model in which the only insurance channel against labor market risk is precautionary savings. Moreover, I find that inter-industry mobility is critical for generating a negative relationship between wage volatility and inter-industry wage differentials like that which I observe in the data.

The model has sharp predictions for patterns of inter-industry mobility and wage growth over the life cycle which I use as external validation for the model. In particular, young workers value wage volatility more than their older counterparts since they have more time before retirement to either realize large productivity gains or exercise the option to switch industries. For this reason, young agents in the model disproportionately choose to work in high volatility industries. Over the life cycle, those who receive positive shocks remain, while those who don't choose to move to another industry in which they are more productive. While wages are initially lower for young agents who choose to work in a high volatility industry, on average they will grow faster and eventually exceed the wages earned by young agents who choose to work in a low volatility industry. Critically, I am able to demonstrate that these predictions of the model are consistent with the patterns of inter-industry mobility and expected wage profiles over the life cycle present in the data.

Another striking feature of the data is that the slope of the risk-return trade-off across industries became 41% more negative since the early 1980's. Over this same period, the fraction of young individuals choosing to start their working life in a high volatility industry increased by 25%. In the model, inter-industry wage differentials and the allocation of workers across industries are intimately related to the cost of borrowing in credit markets, both against the realization of positive persistent idiosyncratic productivity shocks and to finance the resource cost of switching industries. Given the broad consensus that consumers' access to credit has increased dramatically since the early 1980's, I use the calibrated model to quantify the extent to which a decrease in the spread between borrowing and lending rates on the order of that estimated in the literature can explain these facts.[3] I find that this

[3] Many explanations for this observation have been put forth in the literature. Campbell and Hercowitz (2006), for example, point to credit market innovations resulting from the Monetary Control Act of 1980

decrease in credit market imperfections can account for 43% of the increase in risk-taking by young workers in the labor market and 94% of the steepening in the risk-return trade-off across industries observed in the data over this period. Interestingly, this decrease in credit market imperfections also leads to a 1.4% rise in measured productivity.

The remainder of this paper proceeds as follows. Section 2 reviews related literature and describes the contribution of this paper. Section 3 illustrates the risk premium effect and the option value of mobility using a simple two-period example. Section 4 lays out the full theoretical model. Section 5 describes my calibration strategy. Section 6 characterizes the stationary equilibrium and compare its predictions to the data. Section 7 analyzes the role of inter-industry mobility as an insurance channel against labor market risk. Section 8 explores the extent to which decreased credit market imperfections since the early 1980's can explain the increase in risk-taking by young workers in the labor market and steepening of the risk-return trade-off across industries observed over this period. Section 9 concludes.

2 Related Literature

The existing literature on inter-industry wage differentials suggests that neither a simple unmeasured ability explanation nor a pure rent-based theory is fully consistent with the data.[4] This paper adds to the literature by documenting that variations in the volatility of long-term, persistent, idiosyncratic, and uninsurable shocks to wages across industries can explain a large portion of the observed pattern of inter-industry wage differentials. Mine is not the first, though, to consider variations in risk as a source of compensating wage differentials. Murphy and Topel (1987) analyze two-year panels of individuals in the 1977 – 1984 Current Population Survey (CPS) and document wide differences in the volatility of hours

and the Garn – St. Germain Act of 1982, Sanchez (2010) argues that information technology improved the capacity of credit card companies to assess risk, Drozd and Nosal (2008) cite a reduction in the cost of screening and soliciting credit customers, while Luzzetti and Neumuller (2012) contend that lenders reduced credit spreads as an endogenous response to the decreased frequency and severity of aggregate fluctuations.

[4] Gibbons, Katz, Lemieux, and Parent (2005), for example, argue that comparative advantage combined with learning can explain the observed wage premia in some industries but not others.

worked and annual earnings across industries. The authors conclude, though, that the lack of a valid instrument calls into question estimates of compensating wage differentials based on industry differences in job characteristics. My approach improves upon this work in two ways. First, by using the PSID which offers a longer panel structure I am able to disentangle transitory fluctuations in wages from long-term, persistent shocks. Second, employing a general equilibrium structural model to estimate the pattern of inter-industry wage differentials that is consistent with the data avoids issues related to instrument exogeneity.

Using a similar empirical strategy to the one I apply here, Cubas and Silos (2012) find a positive relationship between wage volatility and the average wage across industries in data from the Survey of Income and Program Participants (SIPP). The authors then construct a general equilibrium model of sorting in the labor market in which agents are ex-ante heterogeneous in terms of their comparative advantage to work in each sector in order to decompose how much of the variation in average earnings across industries can be attributed to compensation for earnings risk as opposed to sorting on unobserved ability or comparative advantage. While their model abstracts from inter-industry mobility, we know from Kambourov and Manovskii (2008) that workers change their industry affiliation frequently and at a rate that has been steadily increasing over time. Motivated by these facts, I explicitly model inter-industry mobility and find that this feature of the model is crucial for understanding the negative relationship between wage volatility and inter-industry wage differentials that I observe in the data.

This paper also contributes to the existing literature by demonstrating that the option to switch industries is an important insurance channel against labor market risk. In a related studies, Kaplan (2012) shows that the option to move in and out of the parental home allows young individuals to pursue risky jobs which offer the potential for high wage growth, Vereshchagina and Hopenhayn (2009) demonstrate that the implicit option owned by entrepreneurs to close down their business and enter the workforce acts as an insurance mechanism against the realization of low entrepreneurial returns, while Ruffino (2012) contends that the option to switch employers is equivalent to holding a put option on one's own company stock, meaning that workers need to allocate a relatively large share of their financial assets to their own company's stock simply to restore their overall portfolio balance.[5] My work differs from these previous studies in that I explicitly model the sectoral allocation problem faced by workers over their life cycle, which is an important factor for understanding the negative relationship between wage risk and inter-industry wage differentials in the data.

The theoretical model I develop here is closely related to the multi-armed bandit problem analyzed by Miller (1984) to characterize the optimal series of occupational choices over the life cycle for the case in which individuals have prior uncertainty over their innate job-specific abilities and rates of learning are allowed to vary across jobs. While I abstract from explicitly modeling learning dynamics, I introduce endogenous labor supply and savings decisions, as well as the equilibrium determination of wages and the return on capital, to his framework which allows me to address the puzzle of inter-industry wage differentials. Also related is the work of Dillon (2012) who structurally estimates a model of occupational choice over the life cycle using data from the PSID and concludes that compensation for earnings risk is a key factor in explaining variations in expected lifetime earnings across careers.

This paper is also related to Hsieh, Hurst, Jones, and Klenow (2012) who quantify the effects of changes in the labor market outcomes of minorities between 1960 and 2008 on aggregate productivity and wages. While their analysis focuses on the role of discrimination in shaping human capital accumulation and occupational choice, my work highlights the importance credit market imperfections for the allocation of workers across industries. In a related study, Buera and Moll (2012) use a model of entrepreneurship to analyze the impact of financial frictions on aggregate productivity.

[5] Abbring and Campbell (2005) find that the largest component of a new firm's value is actually embedded in the option to exit.

3 A Two-Period Example

In this section, I analyze a simplified partial equilibrium version of the full theoretical model for which I can sharply characterize the risk premium effect and the option value of mobility, as well as their roles in determining inter-industry wage differentials. Formal proofs of the results described below are gathered in the appendix.

3.1 Overview

Consider the decision problem of a worker who lives for two periods, discounts the future at rate β, has CRRA preferences over consumption in each period with coefficient of relative risk aversion γ, and is restricted from saving or borrowing in credit markets. I represent industries as islands. Suppose the worker is endowed with island-specific log efficiency units of labor $\mathbf{z} \in \mathbb{R}^J$, where J is the number of islands and $z_j \sim N(-\frac{1}{2}\sigma_j^2, \sigma_j^2)$ is learned upon arrival on island j. For simplicity, I assume that $j \in \{1, 2\}$, where $\sigma_1 = 0$ and $\sigma_2 > 0$. The worker has one unit of time each period which she supplies inelastically to the representative firm on the island of her choosing.

3.2 Case 1: No Mobility

Suppose the worker must remain on her initial island of choice for both periods. In this case, the value of selecting island 1 is deterministic and given by

$$V_1 = \frac{w_1^{1-\gamma}}{1-\gamma} + \beta \frac{w_1^{1-\gamma}}{1-\gamma},$$

where w_1 is the wage rate on island 1 in units of consumption per efficiency unit of labor. The value of selecting island 2, on the other hand, is given by

$$V_2 = \mathbb{E}_{z_2} \left[\frac{(w_2 e^{z_2})^{1-\gamma}}{1-\gamma} + \beta \frac{(w_2 e^{z_2})^{1-\gamma}}{1-\gamma} \right],$$

where w_2 is the wage rate on island 2. It is easy to show that the log wage differential, $\ln(w_1/w_2)$, which makes the worker indifferent between selecting islands 1 and 2 is given by

$$\ln\left(\frac{w_1}{w_2}\right) = -\gamma\frac{\sigma_2^2}{2},$$

which is strictly less than zero for all $\gamma > 0$. It follows that $w_1 < w_2$, meaning that the worker will demand a premium to work on the island with an uncertain payoff.

3.3 Case 2: With Mobility

Now consider the case in which the worker is allowed to switch islands after the first period of employment. If the worker initially selects island 1, then she will never find it optimal to switch to island 2 after the first period. It follows that the value of selecting island 1 in the first period is unchanged from Case 1:

$$V_1 = \frac{w_1^{1-\gamma}}{1-\gamma} + \beta\frac{w_1^{1-\gamma}}{1-\gamma}.$$

The value of selecting island 2 in the first period, on the other hand, is now given by

$$V_2 = \mathbb{E}_{z_2}\left[\frac{(w_2e^{z_2})^{1-\gamma}}{1-\gamma} + \beta\max\left\{\frac{w_1^{1-\gamma}}{1-\gamma}, \frac{(w_2e^{z_2})^{1-\gamma}}{1-\gamma}\right\}\right],$$

where the max operator represents the option to switch islands after the first period of employment. This choice is characterized by a threshold z_2^* such that if $z_2 \geq z_2^*$, then the worker will remain on island 2. Otherwise, the worker will find it optimal to exercise her option to switch islands. The value of z_2^* is defined by the following indifference condition:

$$w_1 = w_2e^{z_2^*}.$$

It can be shown that the log wage differential, $\ln(w_1/w_2)$, which makes the worker indifferent between selecting islands 1 and 2 in the first period solves the following fixed point problem:

$$\ln\left(\frac{w_1}{w_2}\right) = -\gamma\frac{\sigma_2^2}{2} + G\left(\beta, \gamma, \sigma_2, \ln\left(\frac{w_1}{w_2}\right)\right),$$

where the first term on the right hand side is the risk premium effect and the second represents the option value of mobility.

Figure 1 plots the risk premium effect, the option value of mobility, and the resulting log wage differential separately as functions of σ_2 for the case in which $\beta = 0.5$ and $\gamma = 2$. While the risk premium effect is negative and decreasing for all $\sigma_2 > 0$, the option value of mobility is positive and increasing. The resulting log wage differential is positive for all $\sigma_2 \in (0, 0.16)$. In this range of volatilities, the option value of mobility dominates the risk premium effect, meaning that the worker is willing to accept a relatively low wage in exchange for the possibility of realizing a large positive productivity shock. In my quantitative model, I will show that for empirically plausible parameterizations, a similar negative relationship arises between wage volatility and inter-island wage differentials.

4 Theoretical Framework

In this section, I outline the general equilibrium life cycle model which I use to study the relationship between wage risk and inter-industry wage differentials, as well as the aggregate implications of changes in the degree of credit market imperfections.

4.1 Overview

The economy consists of overlapping generations of ex ante identical agents who live for $N + R$ periods and have time separable preferences over consumption and leisure. There are J islands, each representing an industry and containing a representative firm which hires labor to produce a differentiated intermediate good. A representative firm combines intermediate goods and capital to produce a homogeneous final consumption good. There is also a financial intermediary which rents capital to the final goods producer and borrows and lends to agents using one-period risk-free bonds subject to a proportional transaction cost τ of issuing debt.

4.2 Problem of an Agent

Each agent is endowed with a vector of island-specific idiosyncratic productivities $\mathbf{z} \in \mathbb{R}^J$, where z_j is the log efficiency units of labor the agent has available to supply to the representative firm on island j.[6] While working on island j, z_j follows a random walk, while $z_{k \neq j}$ remain fixed. Islands differ in the volatility of the idiosyncratic productivity shocks that workers face. Agents decide on which island to work optimally each period during their first N periods of life subject to a resource cost $\chi > 0$ of switching islands. During their final R periods of life, agents are restricted from working and therefore simply enjoy leisure and consume from their savings.

Each period, the problem of an agent is divided into two stages. In the first stage, the agent selects an island j on which to work conditional on their age a, bond holdings b, productivity vector $\mathbf{z}_{-1}$, and previous island of employment m:

$$V_m^a(b, \mathbf{z}_{-1}) = \max_{j \in \{1,\ldots,J\}} \mathbb{E}_{\zeta,e}\left[W_{j,m}^a(b, \mathbf{z}, e)\right] \tag{1}$$

subject to

$$z_j = z_{j,-1} + \zeta \tag{2}$$

[6]While Gibbons et al. (2005) assume that a worker's performance in one industry is perfectly correlated with their ability in others, I assume that a worker's ability is both independent across industries and evolves only with industry-specific experience. These assumptions are consistent with Jovanovic (1979) who develops a model of learning about job-specific ability to explain the negative empirical relationship between job turnover and job tenure. Neal (1995) analyzes wage data from Displaced Worker Surveys and concludes that industry-specific human capital is an important factor in explaining the observed relationship between wages and seniority. Parent (2000) finds similar patterns in data from the PSID and the National Longitudinal Survey of Youth (NLSY79) and concludes that what matters most for the wage profile is the accumulation of industry-specific human capital.

and

$$z_k = z_{k,-1} \text{ for all } k \neq j, \tag{3}$$

where $W^a_{j,m}(b, \mathbf{z}, e)$ is the value of working on island j conditional on the realizations of an idiosyncratic island-specific permanent productivity shock $\zeta \sim N\left(-\frac{1}{2}\sigma^2_{\zeta,j}, \sigma^2_{\zeta,j}\right)$ and an idiosyncratic transitory productivity shock $e \sim N\left(-\frac{1}{2}\sigma^2_{e,j}, \sigma^2_{e,j}\right)$.[7] Importantly, the volatility of both productivity shocks is allowed to vary across islands.[8]

In the second stage, the agent first draws ζ and e, and then optimally selects the bond holdings b' to carry into the following period and the fraction of time to spend working in the current period h subject to their time endowment $\overline{h}$:

$$W^a_{j,m}(b, \mathbf{z}, e) = \max_{h \in \left[0, \overline{h}\right], b'} u(c, h) + \beta V^{a+1}_j (b', \mathbf{z}) \tag{4}$$

subject to

$$c + b' + \chi \mathbb{I}[j \neq m] = \left(1 + r + \tau \mathbb{I}[b \leq 0]\right) b + w_j \phi_j h, \tag{5}$$

and

$$\ln \phi_j = f(a) + z_j + e, \tag{6}$$

where r is the interest rate, w_j is the wage on island j in units of consumption per efficiency unit of labor, and ϕ_j is the efficiency units of labor the agent has available to supply to the representative firm on island j, which itself is a function of the agent's age a, island-specific productivity z_j, and transitory shock e. For agents in their first N periods of life, $\overline{h} = 1$,

[7]I assume that both productivity shocks have bounded support, $\zeta \in [\underline{\zeta}, \overline{\zeta}]$ and $e \in [\underline{e}, \overline{e}]$, which, when combined with my assumption that agents cannot work during retirement, leads to an endogenous borrowing constraint that varies with age a, industry of employment j, and productivity vector $\mathbf{z}$.

[8]Industry-specific productivity shocks are intended to capture a multitude of factors which affect the wages earned by an individual in their current industry of employment. Such factors include changes in the relative demand for the individual's skill set (occupation, experience, education, etc.) within the industry in which they are currently employed, learning about industry-specific ability (think of the consulting industry, for example, in which many enter but only a select few have both the talent and desire to become partner), or varying degrees of insurance against aggregate, industry, and firm-level shocks provided by employers. Lagakos and Ordoez (2011), for example, use a model of limited commitment to demonstrate that workers who are employed in industries with high displacement costs get more insurance from their employer, and, as a result, wages are smooth for workers in these industries even when firm productivity is volatile.

while for agents in their final R periods of life, $\overline{h} = 0$. The interest rate r will be determined in equilibrium by the market clearing condition for capital, while the wages $\{w_j\}_{j=1}^J$ will be pinned down by the market clearing condition for labor on each island.

4.3 Intermediate Goods Producers

The representative firm on island j produces a differentiated intermediate good according to a technology that is linear in efficiency units of labor L_j. The firm chooses the quantity of labor that maximizes their static profits taking the wage on their island w_j and the price of their output p_j as given:

$$\pi_j = \max_{L_j} p_j x_j - w_j L_j \tag{7}$$

subject to the production function

$$x_j = L_j. \tag{8}$$

The first order condition for profit maximization implies that the equilibrium wage on island j is equal to the price of the intermediate good produced on island j:

$$w_j = p_j. \tag{9}$$

4.4 Final Goods Producer

A representative firm produces a homogeneous final consumption good using capital and a CES aggregation of the differentiated intermediate goods produced on islands $j \in \{1, ..., J\}$. Each period, the firm maximizes their static profits taking the rental rate r and the prices of intermediate goods $\{p_j\}_{j=1}^J$ as given:

$$\Pi = \max_{K, \{X_j\}_{j=1}^J} Y - (r + \delta)K - \sum_{j=1}^{J} p_j X_j \tag{10}$$

subject to the production function

$$Y = K^{\alpha} \left(\sum_{j=1}^{J} X_j^{\rho} \right)^{(1-\alpha)/\rho}, \tag{11}$$

where δ is the depreciation rate of capital and $1/(1-\rho)$ is the elasticity of substitution between intermediate goods. The first order conditions for profit maximization pin down the equilibrium interest rate

$$r = \alpha K^{\alpha-1} \left(\sum_{j=1}^{J} X_j^{\rho} \right)^{(1-\alpha)/\rho} - \delta \tag{12}$$

and the equilibrium price of each intermediate good $j \in \{1, ..., J\}$

$$p_j = (1-\alpha) X_j^{\rho-1} K^{\alpha} \left(\sum_{j=1}^{J} X_j^{\rho} \right)^{(1-\alpha-\rho)/\rho}. \tag{13}$$

4.5 Market Clearing

Let $\Gamma(b, \mathbf{z}_{-1}, \mathbf{z}, e; a, m)$ be the distribution of agents over states. There are markets for labor on each island, capital, intermediate goods, and the final consumption good, all of which must clear in equilibrium.

The market clearing condition for labor on each island $j \in \{1, ..., J\}$ is given by:

$$\int d_j(b, \mathbf{z}_{-1}; a, m) \phi_j(b, \mathbf{z}, e; a, m) h(b, \mathbf{z}, e; a, m) d\Gamma(b, \mathbf{z}_{-1}, \mathbf{z}, e; a, m) = L_j, \tag{14}$$

where $d_j(\cdot)$ is equal to one if the agent is employed on island j and zero otherwise. This condition states that the total efficiency units of labor supplied by agents to the representative firm on island j must be equal to the total efficiency units of labor demanded by the representative firm on island j. The relative wages $\{w_j\}_{j=1}^{J}$ adjust to clear the market for labor on each island.

Assuming that risk-free bonds are in zero net supply, the market clearing condition for the capital market is given by:

$$\int b'(b, \mathbf{z}, e; a, m) \; d\Gamma(b, \mathbf{z}_{-1}, \mathbf{z}, e; a, m) = K. \tag{15}$$

The interest rate r adjusts to clear the market for capital.

The market for each intermediate good $j \in \{1, ..., J\}$ clears when the quantity produced by the representative firm on island j is equal to the quantity demanded by the final goods producer:

$$X_j = x_j. \tag{16}$$

The price of each intermediate good p_j adjusts to clear the market for the intermediate good produced on island j.

Finally, the market for the final consumption good clears when the aggregate quantity demanded by agents equals the total quantity produced by the final goods producer:

$$\int c(b, \mathbf{z}, e; a, m) \; d\Gamma(b, \mathbf{z}_{-1}, \mathbf{z}, e; a, m) = Y. \tag{17}$$

Note that by Walras' Law, if the markets for labor, capital, and intermediate goods clear, then the market for the final consumption good also clears.

4.6 Defining a Stationary Equilibrium

A stationary equilibrium is a set of decision rules for agents $\{d_j(b, \mathbf{z}_{-1}; a, m), b'(b, \mathbf{z}, e; a, m), l(b, \mathbf{z}, e; a, m)\}$, demand for labor by intermediate goods producers $\{L_j\}_{j=1}^{J}$, demand for capital and intermediate goods by the final goods producer $\{K, \{X_j\}_{j=1}^{J}\}$, wages and output prices on each island $\{w_j, p_j\}_{j=1}^{J}$, an interest rate r, and a distribution of agents over states $\Gamma(b, \mathbf{z}_{-1}, \mathbf{z}, e; a, m)$ such that:

- Taking $\{w_j\}_{j=1}^{J}$ and r as given, $\{d_j(b, \mathbf{z}_{-1}; a, m), b'(b, \mathbf{z}, e; a, m), l(b, \mathbf{z}, e; a, m)\}$ solve each agent's optimization problem.

- Taking $\{w_j, p_j\}_{j=1}^{J}$ as given, $\{L_j\}_{j=1}^{J}$ maximizes the static profits earned by the intermediate goods producer on each island $j = \{1, ..., J\}$.

- Taking r and $\{p_j\}_{j=1}^{J}$ as given, $\{K, \{X_j\}_{j=1}^{J}\}$ maximizes the static profits earned by the final goods producer.

- Given $\Gamma(b, \mathbf{z}_{-1}, \mathbf{z}, e; a, m)$ and the decision rules for agents and firms, the markets for labor, capital, and intermediate goods clear.

5 Calibration

I start by selecting those parameters which can be reasonably calibrated outside of the model. I then turn to micro-level wage data in order to identify the within industry volatility of persistent and transitory idiosyncratic shocks to wages. Finally, I use the model to calibrate the remaining set of parameters in my baseline calibration.

5.1 Parameters Selected Outside of the Model

I assume agents are born at age 18, retire at age 58, and die with probability one at age 78. Each period in the model represents one year, and therefore I take $N = 40$ and $R = 20$. I assume agents have the following period utility function:

$$u(c, h) = \frac{\left[c^{\nu}(1-h)^{1-\nu}\right]^{1-\gamma}}{1-\gamma} \tag{18}$$

where γ is the coefficient of relative risk aversion and ν governs the time spent enjoying leisure relative to consumption. As is standard in the literature, I set γ equal to 2 and the discount factor β equal to 0.96. I assume all agents start life with zero assets and productivity vector $\mathbf{z} = (0, ..., 0)$. I set the depreciation rate δ equal to 0.06 and follow

Hsieh et al. (2012) in setting the parameter governing the elasticity of substitution between intermediate goods, ρ, equal to 0.75. The remaining parameters to be calibrated are the resource cost of switching industries χ, the age-earnings profile $f(a)$, the shock volatilities $\{\sigma_{\zeta,j}, \sigma_{e,j}\}_{j=1}^{J}$, the proportional transaction cost τ, and the preference parameter ν. Next, I describe the micro-level wage data that I use to guide my selection of $f(a)$ and $\{\sigma_{\zeta,j}, \sigma_{e,j}\}_{j=1}^{J}$. Later I describe how values for χ, τ, and ν are chosen.

5.2 The Data

The University of Michigan's Panel Study of Income Dynamics (PSID) is a longitudinal household survey that began in 1968 with a nationally representative sample of over 18,000 individuals living in 5,000 families in the United States. Of these families, about 3,000 were representative of the US population as a whole (Survey Research Center Sample) while the remaining 2,000 were an over-sampling of low-income families (Survey of Economic Opportunity). Information on individuals and their descendants was collected annually through 1997 and biennially thereafter. At the time of the most recent survey, the PSID has grown to include more than 22,000 individuals living in 9,000 families.

The PSID survey is comprehensive and includes questions pertaining to employment, income, wealth, education, and health, as well as numerous other topics. I use data from the merged family– and individual–level files on age, years of education, labor force participation, self-employment status, labor income, hours worked, union membership status, and job tenure.[9] The PSID also reports each individual's occupation and industry affiliation at the three-digit level. Between 1968 and 1980, this information is based on the Retrospective Occupation-Industry Files, while from 1981 onward it is based on the main survey data.[10] Due to sample size restrictions and reporting practices, I choose to classify individuals using

[9] Labor income is defined as the sum of wages, bonuses, commissions, and overtime pay.

[10] Between 1968 and 1980, the PSID recorded occupations and industries using various combinations of one- and two-digit codes. The 1968–1980 Retrospective Occupation-Industry Files provide 1970 Census Three-digit Codes for the occupation and industry of each individual's main job for all sample years prior to 1981 based on a recoding of handwritten job descriptions.

the 2000 Standard Occupational Classification System (SOC) and the 1970 Census One-digit Industry Codes. Descriptions of each classification system are included in Tables 1 and 2.

For the purpose of studying wage risk, the PSID has many advantages and relatively few disadvantages compared with other longitudinal panels such as the Survey of Income and Program Participants (SIPP), the National Longitudinal Survey of Youth (NLSY79 and NLSY97), and the Current Population Survey Merged Outgoing Rotation Groups (CPS). For example, while the SIPP offers information on income and hours worked at a monthly frequency, the PSID allows for the analysis of wage changes over multiple years which is critical for identifying persistent shocks to wages. Although the CPS is much larger than the PSID and offers a two year panel structure, the lack of a third consecutive observation on each individual prevents the disentangling of persistent wage shocks from transitory fluctuations. While the NLSY79 and NLSY97 meet this requirement, the PSID offers data on a wider range of cohorts within each sample year. The main disadvantage of the PSID is its relatively small sample size which prevents a finely disaggregated analysis. Moreover, the PSID records the total labor earnings for each individual within each sample year, prohibiting the study of high frequency wage changes related to movements into and out of unemployment, which I abstract from in both my theoretical and empirical analysis.

5.3 Sample Selection

My sample selection procedure is as follows. I keep only heads of household who were in, or are descendants of, the nationally representative Survey Research Center sample. I also restrict my sample to include only those individuals aged 18 to 55 who were in the labor force, not self-employed, and worked at least 520 hours in the sample year.[11] I keep only males, and therefore abstract from the large increase in female labor force participation rates during my

[11]The hours worked restriction corresponds to 13 weeks of employment at 40 hours per week. While this step introduces some bias into my estimates of wage risk by eliminating from my sample all individuals who were unemployed for more than three-quarters of the given sample year, this fraction of individuals is quite small, and hence the effect on my estimates is minimal. The main purpose of this restriction is to ensure that my sample consists primarily of individuals who have a strong attachment to the labor force.

sample period. I compute the average real wage for each individual-year observation by first deflating total labor income using the Consumer Price Index reported by the Bureau of Economic Analysis with 1982 taken as the base year and then dividing by total hours worked in the sample year. In order to reduce errors in either the reporting or recording of labor income and hours worked, I drop those individual-year observations with real hourly wages less than \$2.50 or greater than \$250.[12] These criteria are similar to the ones used in previous studies (Abowd and Card (1989), Guvenen (2009), Heathcote, Storesletten, and Violante (2010), among others). There are a total of 51,059 individual-year observations for which I have non-missing data on age, years of education, labor income, hours worked, union membership status, firm tenure, and occupation and industry affiliation.

Some key summary statistics for my base sample are reported in Tables 3 and 4. Table 3 lists the number of observations and the average age, years of education, union membership rate, hours worked, and real hourly wage for each sample year.[13] The number of observations increases from just over 1,000 to an average of around 2,000 by the end of my sample period.[14] The average age in all sample years is between 34 and 39, while the average years of education increases gradually from about 12 in 1967 to nearly 14 by 2008, the latter being broadly consistent with the known increase in college enrollment. Interestingly, the union membership rate declined by over 50% during my sample period. Table 2 reports the distribution of individual-year observations across the twelve 1970 census one-digit industries in each sample year. Notably, the manufacturing industry experienced a sharp decline in its employment share between 1967 and 2008, while most service industries, as well as the construction industry, realized gains in their share of employment.

[12]For reference purposes, the minimum wage in 1982 was \$3.36.

[13]There are no observations for 1977, 1978, or 1979 due to a lack of data on firm tenure.

[14]The size of the PSID grows as descendants of individuals in the original SRC sample enter the panel.

5.4 Auxiliary Model of Wage Dynamics

Allowing for inter-industry mobility in my theoretical model leads to self selection – agents who switch industries are those who have received negative productivity shocks. Controlling for selection bias, though, in the estimation of wage differentials and wage risk using a reduced form approach requires a valid instrument. Instead, I use my theoretical model to control for self selection and employ a calibration strategy based on the method of indirect inference first introduced by Smith (1993) and later extended by Gourieroux, Monfort, and Renault (1993).[15] I proceed by defining the following auxiliary model which I use as a device for providing a natural set of moments about the actual data:

$$\ln \tilde{w}_{i,j,t} = \xi_t + x_{i,j,t}\psi + f(a_{i,t}) + \Omega_j + z_{i,j,t} + e^b_{i,j,t}, \tag{19}$$

where

$$z_{i,j,t} = z_{i,j,t-2} + \zeta^b_{i,j,t}, \tag{20}$$

$\tilde{w}_{i,j,t}$ is the real wage for individual i employed in industry j at time t, ξ_t denotes a time fixed-effect, $x_{i,j,t}$ is a vector of individual-level controls including years of education, union membership status, occupation, firm tenure, occupational tenure, and industry tenure, $f(a_{i,t})$ is a quartic in age, Ω_j is the fixed-effect of employment in industry j, $\zeta^b_{i,j,t} \sim N(0, \sigma^b_{\zeta,j})$ is a biennial permanent wage shock, and $e^b_{i,j,t} \sim N(0, \sigma^b_{e,j})$ is a biennial transitory wage shock.[16] I assume $\mathbb{E}[z_{i,j,t}|x_{i,j,t}, a_{i,t}] = 0$ which is a necessary condition for identification. If my theoretical model is the true data generating process, though, this condition will certainly not hold due to endogenous selection effects. Misspecification, however, is not a problem for indirect inference as the auxiliary model is merely a lens through which to view both

[15] See Smith (2008) for an overview of indirect inference and more recent applications.

[16] Given that the PSID transitioned from an annual to biennial survey after 1997, I focus on two-year wage changes in order to maintain consistency throughout my entire sample period.
Kambourov and Manovskii (2009) find that returns to occupational tenure are substantial, and that when occupational experience is accounted for, the importance of industry tenure and firm tenure decline substantially. In light of this evidence, I include controls for firm tenure, occupational tenure, and industry tenure.

actual data and data generated by my theoretical model. Moreover, I will ultimately use my theoretical model to uncover the true industry-level fixed effects.

Critically, my auxiliary model is chosen to allow for a simple decomposition of wage risk into its persistent and transitory components following the methods of Moffitt and Gottschalk (2002), Meghir and Pistaferri (2004), and Low, Meghir, and Pistaferri (2010). I start by taking first differences of equation (19), after substituting in for $z_{i,j,t}$ using equation (20), for individuals who do not switch industries between dates t and $t-2$ to obtain the following wage growth equation:

$$\Delta \ln \tilde{w}_{i,j,t} = \Delta \left(\hat{\xi}_t + x_{i,j,t}\hat{\psi} + \hat{f}(a_{i,t}) \right) + \left(\zeta^b_{i,j,t} + \Delta e^b_{i,j,t} \right), \tag{21}$$

where $\Delta y_{i,j,t} \equiv y_{i,j,t} - y_{i,j,t-2}$. The left hand side of equation (21) is observed wage growth, while the first term on the right hand side is that which is predicted by the auxiliary model based solely on observable factors. The second term on the right hand side is the unpredicted component of wage growth, or the cumulative wage shock $g_{i,j,t} \equiv \zeta^b_{i,j,t} + (e^b_{i,j,t} - e^b_{i,j,t-2})$. Computing the variance and first-order autocovariance of $g_{i,j,t}$ for individuals employed in industry j at dates t and $t-2$ leads to a system of equations which can be solved for the biennial permanent wage shock volatility for industry j:

$$\sigma^b_{\zeta,j} = \sqrt{\mathbb{E}[g^2_{i,j,t}] + 2\mathbb{E}[g_{i,j,t}g_{i,j,t-2}]}, \tag{22}$$

and the biennial transitory wage shock volatility for industry j:

$$\sigma^b_{e,j} = \sqrt{-\mathbb{E}[g_{i,j,t}g_{i,j,t-2}]}. \tag{23}$$

My calibration strategy is to first choose coefficients for the quartic in age $f(a)$ based on OLS estimation of equation (19) and then to select values for the annual wage shock volatilities $\{\sigma_{\zeta,j}, \sigma_{e,j}\}_{j=1}^J$ such that the estimates $\{\hat{\sigma}^b_{\zeta,j}, \hat{\sigma}^b_{e,j}\}_{j=1}^J$ implied by the sample analogues of conditions (22) and (23) are similar for both actual data and data generated by the model.

5.5 Estimation of Auxiliary Model using Actual Data

A selection of the results from an OLS estimation of equation (19) using the base sample of data from the PSID are presented in column (1) of Table 5. The first four estimates represent the coefficients of the quartic in age $\hat{f}(a)$, while the final twelve represent the industry-level fixed effects $\hat{\Omega}_j$.[17] Nearly all of the estimated coefficients are statistically significant, including the industry-level fixed effects, which confirms that industry affiliation is an important factor in explaining variations in the real wage for observationally equivalent workers employed in different industries.

The inter-industry wage differentials presented in column (1) of Table 6 are computed as the difference between $\hat{\Omega}_j$ for each industry j and the employment weighted average of $\hat{\Omega}_j$ across all industries. The magnitude and pattern of these estimated wage differentials are similar to those previously reported in the literature. In particular, workers employed in the mining, manufacturing, and transportation, communications, and utilities industries earn higher wages on average than observationally equivalent workers employed in the agriculture, forestry, and fisheries, wholesale and retail trade, and personal services industries. A typical worker employed in the mining industry, for example, earns a wage that is, on average, 27% higher than that of an observationally equivalent worker employed in the agriculture, forestry, and fishing industry. Moreover, the weighted standard deviation of these differentials is 0.061, which is roughly equivalent to the effect on wages of 1–2 additional years of education. Hence, wage differentials, as viewed through the lens of the auxiliary model, are large and vary quite substantially across industries.

The estimated volatilities $\hat{\sigma}^b_{\zeta,j}$ and $\hat{\sigma}^b_{e,j}$ reported in column (1) of Table 7 for each industry were obtained using the sample analogues of equations (22) and (23). The employment weighted average and standard deviation of $\hat{\sigma}^b_{\zeta,j}$ are 0.187 and 0.020, respectively. Thus,

[17]Industry-level fixed effects are estimated relative to Public Administration.

through the lens of the auxiliary model, there is also substantial variation in the volatility of biennial permanent shocks to wages across industries. Perhaps surprisingly, it is the manufacturing industry which offers workers the lowest permanent shock volatility of 0.164, which is more than 32% less than that offered to workers by the entertainment and recreation services industry. The employment weighted average and standard deviation of $\hat{\sigma}^b_{e,j}$, on the other hand, are 0.150 and 0.008, respectively. Hence, there is far less variation in the volatility of biennial transitory shocks to wages across industries.

My estimates for the volatility of transitory shocks to wages also captures measurement error in either the reporting or recording of total labor income and hours worked. Given that my empirical strategy does not allow for the disentangling of true transitory wage shocks from measurement error, I rely on external estimates of the magnitude of measurement error in the data. Bound, Brown, Duncan, and Rodgers (1994) conduct a validation study of the PSID data on earnings and conclude that measurement error explains 22 percent of the overall variance in the rate of earnings growth in the PSID. Given that my estimates for the volatility of transitory shocks to wages are relatively constant across industries, I set $\sigma_{e,j} = 0.083$ for each industry $j \in J$, which is equal to 78 percent of the annualized employment weighted average of $\hat{\sigma}^b_{e,j}$.

In order to verify whether or not the results presented here are robust to sample selection, I repeat my analysis of the auxiliary model for the following sub-groups of individuals in the PSID: non-union (those not affiliated with a labor union), unskilled (those with at most a high school diploma), skilled (those with at least a 4 year college degree), 1967–1984 (individual-year observations in the first half of my sample period), and 1985–2008 (individual-year observations in the second half of my sample period). Results for each of these sub-groups are presented in columns (2) – (6) of Tables 5, 6, and 7. While there is some variation in my estimates of the volatility of the permanent shocks across sub-groups, the rank correlation of each subgroup with the base sample is always positive and significant at the 1% level with the notable exception of skilled workers. There is substantially more variation in my estimates of the volatility of the transitory shocks across sub-groups, but the rank correlation of each subgroup with the base sample is still always positive.[18]

5.6 Parameters Selected Inside of the Model

I simulate the model in order to calibrate the island-specific shock volatilities $\{\sigma_{\zeta,j}\}_{j=1}^{J}$, the resource cost of switching islands χ, the transaction cost of issuing debt τ, and the preference parameter ν. The target moments are a combination of those implied by the auxiliary model described above and three additional moments in the data which I describe in detail below.

In order to reduce the computational burden involved in simulating my general equilibrium model, I set the number of islands J equal to 2. Without loss of generality, let island 1 be the low volatility island and island 2 be the high volatility island. Mapping this simplifying assumption to the data, I divide the twelve 1970 Census one-digit industries into two mutually exclusive groups based on the value of $\hat{\sigma}^b_{\zeta,j}$ for each industry relative to the employment weighted average across all industries. Following this approach, the low volatility group accounts for 48.5% of the individual-year observations in my base sample and includes the following three industries: (1) manufacturing, (2) transportation, communications, and utilities, and (3) public administration. The remaining nine industries then make up the high volatility group which accounts for the remaining 51.5% of the individual-year observations in my base sample. My target moments for the annual permanent shock volatilities $\sigma_{\zeta,1}$ and $\sigma_{\zeta,2}$ are then the within group weighted averages of the estimated volatility of biennial permanent shocks to wages, which are given by $\hat{\sigma}^b_{\zeta,1} = 0.168$ and $\hat{\sigma}^b_{\zeta,2} = 0.204$, respectively.

One of the three remaining model parameters, ν governs the average fraction of time

[18]As an alternative, earnings risk can be estimated using annual income (labor income plus transfers). While there is more variation across industries in the volatility of transitory shocks to income than wages, perhaps due to differences in the frequency and duration of unemployment spells across industries, the correlation between the volatility of transitory shocks to income and wage differentials estimated using the auxiliary model is -0.24. Thus, workers employed in industries that pay relatively high wages suffer from less severe transitory variations in annual income. It follows that controlling for unemployment risk would merely reinforce the results presented above. Furthermore, the correlation between wage differentials and annual income differentials estimated using the auxiliary model is 0.94, while the correlation between the estimated volatility of biennial permanent shocks to wages and biennial permanent shocks to income is 0.87.

agents spend working relative to leisure. Individuals in my base sample worked an average of 2,224 hours per year. Assuming a time endowment of 16 hours per day, individuals worked an average of 38% of their free time. I choose ν to match this moment in the data.

The resource cost of switching industries, χ, directly impacts the option value of inter-industry mobility, which, in turn, affects the equilibrium allocation of workers across industries. Given that young agents have more time before retirement to either realize large productivity gains or exercise the option to switch industries than their older counterparts, their choice of industry is more sensitive to the value of χ. In my base sample, 68% of individuals started their working life in one of the nine high volatility industries. I select χ such that an equivalent fraction of 18 year olds in my model choose to work on the high volatility island.

The final remaining model parameter is the proportional transaction cost, τ, which affects the cost of borrowing in credit markets. Given that credit markets are an important source of insurance against labor market risk, I choose τ to match the ratio of median net worth to median disposable income. According to the 2004 Survey of Consumer Finances, this moment in the data is equal to 1.19.[19]

I look for the set of parameters $\{\sigma_{\zeta,1}, \sigma_{\zeta,2}, \nu, \chi, \tau\}$ which minimize the weighted sum of the square deviations of each moment implied by the model from its target in the data as described above. This procedure yields the following set of model parameters: $\sigma_{\zeta,1} = 0.12$, $\sigma_{\zeta,2} = 0.15$, $\nu = 0.33$, $\chi = 1.4$, and $\tau = 0.020$.

6 Characterizing the Stationary Equilibrium

In this section, I explore the predictions of my calibrated theoretical model for the risk-return trade-off across industries, patterns of inter-industry mobility, and expected wage growth. I then quantify the effects of the observed decrease in the degree of credit market imperfections since the early 1980's for the risk-return trade-off across industries and allocative efficiency.

[19] See Mitman (2011).

6.1 The Risk-Return Trade-off across Industries

Table 8 lists the prices that characterize the stationary equilibrium of my baseline model. The true underlying wage differential implied by the model, $\ln(w_1/w_2)$, is equal to 0.060, from which we can immediately infer that the option value of mobility dominates the risk premium effect, as in the simple two-period example. The true risk-return trade-off, expressed as the wage differential per unit of excess annual wage volatility, is given by:

$$\frac{\ln(w_1/w_2)}{\sigma_{\zeta,1} - \sigma_{\zeta,2}} = -2.00.$$

Thus, in the calibrated theoretical model, for every 1.0% increase in the volatility of annual permanent shocks to wages that a worker accepts, their expected wage falls by 2.0%.

Alternatively, we can view simulated data generated by the calibrated theoretical model through the lens of the auxiliary model described in the section above. This approach facilitates a direct comparison between the model-implied risk-return trade-off and that which is present in the actual PSID data. Re-estimating the auxiliary model on simulated data yields a measured wage differential, $\hat{\Omega}_1^m - \hat{\Omega}_2^m$, of 0.106, and risk-return trade-off:

$$\frac{\hat{\Omega}_1^m - \hat{\Omega}_2^m}{\hat{\sigma}_{\zeta,1}^b - \hat{\sigma}_{\zeta,2}^b} = -2.89,$$

which is expressed as the wage differential per unit of excess biennial wage volatility. Using actual data from the PSID, the measured wage differential, $\hat{\Omega}_1 - \hat{\Omega}_2$, is 0.081, where $\hat{\Omega}_1$ is the employment weighted average of $\hat{\Omega}_j$ for industries in the low volatility group and $\hat{\Omega}_2$ is the employment weighted average of $\hat{\Omega}_j$ for industries in the high volatility group. The risk-return trade-off present in the actual data is thus given by:

$$\frac{\hat{\Omega}_1 - \hat{\Omega}_2}{\hat{\sigma}_{\zeta,1}^b - \hat{\sigma}_{\zeta,2}^b} = -2.19.$$

While the measured risk-return trade-off implied by the theoretical model is steeper than that which is present in the actual data, both convey a similar negative relationship between the volatility of persistent shocks to wages and inter-industry wage differentials.

In order to verify whether or not the results presented here are robust to sample selection, I re-estimate the auxiliary model on the following sub-groups of individual-year observations in the PSID: non-union (those not affiliated with a labor union), unskilled (those with at most a high school diploma), skilled (those with at least a 4 year college degree), 1967–1984 (individual-year observations in the first half of my sample period), and 1985–2008 (individual-year observations in the second half of my sample period). Results for each of these sub-groups, along with the base sample, are presented in Table 9. While there is modest variation across sub-groups, the measured wage differential is always positive and the risk-return trade-off is always negative. Thus, the qualitative nature of my estimates from the auxiliary model using the base sample of individual-year observations from the PSID are robust to sample selection. Moreover, they are also fully consistent with the results obtained by estimating the auxiliary model on data generated by the calibrated theoretical model.

Figure 2 (a) plots the inter-industry wage differentials versus the volatility of permanent biennial shocks to wages, both of which are estimated using the auxiliary model on actual data from the PSID. Each data point in the figure represents the risk-return trade-off offered by one of the twelve 1970 Census one-digit industries. The solid blue line depicts the risk-return trade-off between the low and high volatility industry groups present in the actual data, while the dashed red line represents that which is implied by the theoretical model. Thus, through the lens of the auxiliary model, there exists a strong negative relationship between the volatility of persistent idiosyncratic shocks to wages and inter-industry wage differentials. Moreover, the theoretical model captures this feature of the data quite well.

For comparison, Figure 2 (b) depicts the relationship between the volatility of transitory biennial shocks to wages and inter-industry wage differentials, both of which are estimated using the auxiliary model on actual data from the PSID. As in the previous figure, each data point represents the risk-return trade-off offered by one of the twelve 1970 Census one-digit industries. Aside from the personal services industry, which is the lone data point to the right in the figure, there is little variation across industries in this measure of wage risk. This supports my assumption that the estimated transitory shocks to wage growth predominantly represent measurement error in the data.

6.2 Patterns of Inter-industry Mobility

The frequency with which workers move between industries at the one-digit level is substantial. Moreover, the majority of these movements represent switches between the low and high volatility groups defined above. In particular, between 1967 and 1996, the average annual inter-industry mobility rate at the one-digit level in my sample was 11.1%, nearly 60% of which is accounted for by the movement of workers between the high and low volatility industry groups.[20] If the movement of workers between industries was random, then roughly half of all industry switches at the one-digit level should have occurred between these volatility groups since each contains about half of the individual-year observations in my sample.

In addition, the net flow of workers between these volatility groups over the life cycle is far from random. In the first 5 years of their working life, individuals in the PSID were 14.3% more likely to transition from a high volatility industry to a low volatility industry than vice versa.[21] Examining the average fraction of workers employed in a high volatility industry by age conveys a similar story. On average, 68% of workers enter the workforce in a high volatility industry, while only 45% of workers are still employed in a high volatility industry at age 50.[22]

[20] In order to identify genuine industry switches in the PSID data, I count only those changes in industry affiliation that are accompanied by a concurrent change of employer. This procedure, when combined with using the 1968–1980 Retrospective Occupation-Industry Files, has been shown by Kambourov and Manovskii (2012) to greatly reduce the impact of industry affiliation coding errors in the PSID data.

[21] I assume unskilled workers enter the workforce at age 18, while skilled workers enter the workforce at age 23. This approach is intended to eliminate the influence of individuals who both entered the workforce and were employed while in college during the same sample year.

[22] These patterns of inter-industry mobility are reminiscent of Miller (1984) who argues that because young workers are less experienced than their older counterparts, they are more willing to try out jobs for which success is rare. This notion of "young and foolish" was also put forth by Adam Smith who wrote "The contempt of risk and the presumptuous hope of success, are in no period of life more active than at the age

The calibrated model has sharp predictions for patterns of inter-industry mobility that can be compared directly with the data. To start, I consider the implications of the model for inter-industry mobility over the life cycle. Figure 3 depicts the average fraction of agents working in a high volatility industry by age in the model and in the actual data from the PSID for both unskilled and skilled workers, respectively. The slope and asymptotic behavior generated by the model match the patterns observed in the data quite well. The delay in inter-industry mobility predicted by the model for agents younger than 22 years old results from the resource cost of switching islands – given that agents enter the model with zero assets, those who receive negative shocks face a trade-off between borrowing to finance switching islands and biding their time to see if their island-specific productivity improves. Since the resource cost of switching islands in my baseline calibration represents about 2.2 times median annual income, it is perfectly reasonable that young agents prefer to wait before borrowing in credit markets against their future income.[23]

On average, 1.3% of agents in the model move between islands each period compared with the 6.6% of individuals in the data who move between the broad volatility groups defined above. Thus, the model generates about 20% of the mobility between volatility groups observed in the data. Given that productivity shocks are only one of many reasons for which individuals might choose to switch industries of employment, it would be quite troubling if the calibrated model generated the same level of mobility observed in the data.

6.3 Expected Wage Profiles

Young agents will only be willing to work a low paying job today if they can credibly expect to earn more in the future than they otherwise would. Figure 4 (a) depicts the expected log wage as a function of age generated by the model conditional on the agent's initial island of employment. While the expected wage profile for agents who initially select the high

at which young people choose their professions." (Smith (2009))

[23] Artuç and McLaren (2012) structurally estimate a model of occupational and industry mobility and find that industry switching costs of 1.0–1.5 times average annual income are needed to explain the patterns of inter-industry mobility observed in CPS data.

volatility island ($j = 2$) starts out lower than that for agents who initially select the low volatility island ($j = 1$), eventually the wage profiles cross. In other words, young agents who choose the high volatility island do so knowing that their expected wage will initially be lower than that of their peers, but that exposure to higher wage volatility offers the opportunity for large productivity gains with limited downside risk. Given that agents always have the option to switch to another island in which they are more productive, those who remain on the high volatility island can expect to earn higher wages on average than agents of the same age who are employed on the low volatility island.

Critically, this implication of the model is corroborated by the data. Figures 4 (b) and (c) depict the average log wage as a function of age for unskilled and skilled workers, respectively, in the PSID conditional on the individual's initial industry of employment (either the low or high volatility group).[24] Both figures depict a similar single-crossing pattern in which the expected wage profile for individuals who initially select a high volatility industry starts off lower but eventually exceeds that for individuals who initially select a low volatility industry. Models which abstract from inter-industry mobility will fail to generate these same systematic patterns, and thus are firmly rejected by the data.

6.4 Sensitivity Analysis

In this section, I explore the robustness of my results to changes in the resource cost of switching industries χ. Figure 5 depicts the average fraction of agents working on the high volatility island by age for various values of χ relative to median annual income, where 2.2 represents the baseline calibration. The pattern in the figure is clear – increasing χ results in less risk-taking by young workers and less net inter-industry mobility over the life

[24] Unskilled workers are classified based on their first industry of employment before age 20, while skilled workers are classified based on their first industry of employment between ages 23 and 25. I allow for a range of ages so that individuals who enter the PSID at age 19, for example, can still be included in my analysis. To construct these figures, I first divide my base sample into skilled and unskilled workers, and then again by first industry of employment. Finally, I regress log wages on a set of year dummies, years of education, union membership status, and a quartic in age, the latter of which is depicted in the figures for each stratification of the data.

cycle. Figures 6 (a) and (b) plot the inter-island wage differential and risk-return trade-off, respectively, as functions of χ relative to median annual income. The solid black lines represent the true values implied by the theoretical model, while the dashed blue lines represent those measured by estimating the auxiliary model on simulated data. The higher is χ, the more expensive it is to exercise the option to switch islands and the lower is the value of exposure to wage volatility. Thus, as χ rises, working on the high volatility island becomes relatively less attractive for any given inter-island wage differential. In equilibrium, the wage on the high volatility island must rise relative to that on the low volatility island, which reduces the inter-island wage differential. For sufficiently high values of χ, inter-island mobility is prohibitively expensive and the option value of mobility goes to zero. As long as χ is less than 3.5 times median annual income, both the true and measured risk-return trade-offs are negative, implying that the qualitative results of my theoretical model are robust to reasonable alternative parameterizations of χ.

7 The Option Value of Inter-island Mobility

Individuals in my model have three ways in which they can insure themselves against labor market risk in addition to precautionary savings. First, they can borrow in credit markets using one-period uncontingent bonds. Second, they can adjust their labor supply. Third, they can switch islands of employment. I compute the stationary equilibrium in which these three insurance channels are shut-down (no borrowing, no labor supply decision, no inter-island mobility) and find that the resulting risk-return trade-off is 0.56, meaning that for every 1.0% increase in wage volatility that a worker accepts, they can expect to see their wage rise by 0.56%. Thus, when the only available insurance channel against labor market risk is precautionary saving, risk-averse agents demand a wage premium in exchange for exposure to higher wage volatility.

In order to quantify the relative importance of each of these insurance channels in determining the equilibrium relationship between wage differentials and wage risk in my baseline calibration, I decompose the total change in the risk-return trade-off across islands (from -2.00 to 0.56) by sequentially eliminating insurance channels and computing the resulting stationary equilibrium. Since the order in which each channel is removed may influence the magnitude of its incremental effect, I consider all possible permutations in order to obtain upper and lower bounds on the relative importance of each. The results of this exercise are reported in Table 10, where each case represents one of the six unique orderings in which the three alternative insurance channels can be removed from the model.

I first consider the role of borrowing in credit markets. Young agents who receive positive permanent productivity shocks respond by borrowing heavily against the increase in their expected future income. Moreover, this effect is increasing in the volatility of the permanent productivity shocks that agents face. In my baseline calibration, for example, agents employed on the high volatility island have amassed 40% more debt by age 22, on average, than agents employed on the low volatility island. Conversely, agents who receive negative permanent productivity shocks tend to save in order to offset the resource cost of switching islands, if necessary, in the future. Any remaining resources required to switch islands are then financed by borrowing in credit markets. The attractiveness of seeking employment on the high volatility island when young thus depends critically on an agent's ability to borrow in credit markets. I find that when agents have the option to switch islands, removing their ability to borrow in credit markets accounts for between 38.7% and 55.6% of the total increase in the risk-return trade-off across islands. When the option to switch islands is eliminated, however, being able to borrow in credit markets has a markedly diminished effect. In these cases it accounts for merely 0.1% to 1.6% of the total increase in the risk-return trade-off across islands. Thus, the importance of borrowing in credit markets as an insurance channel against labor market risk depends critically on whether or not agents are also allowed to switch islands of employment.

I find that removing the ability of agents to vary their labor supply in response to productivity shocks has a relatively large impact on the risk-return trade-off across islands, accounting for up to 32.2% of the total change. The intuition for this effect is rather straightforward. Agents employed on the high volatility island value the ability to adjust their labor supply in response to productivity shocks more than their counterparts employed on the low volatility island. Eliminating this insurance channel thus reduces the relative attractiveness of employment on the high volatility island, which in turn increases the risk-return trade-off across islands. The importance of labor supply decisions, however, is significantly diminished in the absence of inter-island mobility. In these cases, the labor supply channel accounts for only 0.3% to 1.8% of the total change in the risk-return trade-off across islands.

While the relative importance of being able to borrow in credit markets and adjust labor supply vary widely across cases, the ability of agents to switch islands of employment consistently accounts for a significant fraction of the total change in the risk-return trade-off across islands. As documented in Table 10, this insurance channel against labor market risk accounts for between 29.2% and 98.1% of the total change in the risk-return trade-off across industries, depending on the order in which it is eliminated from the model. Moreover, the risk-return trade-off across islands is always negative if agents are allowed to switch islands. When this option is removed, the risk-return trade-off across islands is always positive, indicating that agents demand a wage premium in exchange for exposure to higher wage volatility. It is not hard to understand why inter-island mobility is an important insurance channel against labor market risk. When agents are restricted to their initial industry of choice, they are then fully exposed to the risk of realizing adverse permanent productivity shocks. This effect is particularly acute for agents employed on the high volatility island which decreases the relative attractiveness of employment on this island. The net result is an unambiguous and large change in the risk-return trade-off across industries, regardless of the order in which this insurance channel is eliminated. We can infer from these results that the option value of inter-industry mobility is important for understanding the negative correlation between wage volatility and wage differentials observed in data from the PSID.

8 Changes in Credit Markets Since the Early 1980's

There is overwhelming evidence that access to consumer credit in the U.S. has increased significantly over the past 30 years. Although there is still vigorous debate in the literature regarding the factors responsible for this dramatic change, there is wide consensus that the spread between borrowing and lending rates has decreased since the early 1980's. Livshits, MacGee, and Tertilt (2010), for example, estimate that this spread would have had to decline by about 3% in order to explain the near doubling in the consumer unsecured debt-to-income ratio between 1984 and 2000. From Table 9, we can see that between the pre–1984 and post–1985 periods, the risk-return trade-off across industries steepened by 43%. The fraction of individuals entering the workforce in a high volatility industry also increased by 25%, rising from 62.9% in the pre–1984 period to 78.6% in the post–1985 period. Given the relative importance of borrowing as an insurance channel against labor market risk (when agents are free to switch islands of employment), in this section I explore to what extent a decrease in the transaction cost of issuing credit can account for these patterns in the data.

Given that my theoretical model is calibrated to match the average state of the U.S. economy during my entire sample period, I compare the stationary equilibrium of the model for proportional transaction costs of issuing credit, τ, 2% higher and 1% lower than my baseline calibration and quantify the resulting differences in the employment decisions of young workers, wage differentials, the risk-return trade-off, and measured productivity.[25] Figures 7 (a) – (d) depict the results of this exercise. As τ declines from 4% to 1%, the cost of borrowing against future income declines which raises the relative attractiveness of employment on the high volatility island. This leads to a 10.8% increase in the fraction of young workers employed on the high volatility island. As a result, the wage rate on the high volatility island falls relative to that on the low volatility island, causing the true model-implied inter-island wage differential to rise by 41.5%. Given that the volatility of permanent

[25] The results are nearly identical if I compare the stationary equilibrium of the model for proportional transaction costs of issuing credit, τ, 1% higher and 2% lower than my baseline calibration.

productivity shocks is held fixed across simulations, this results in a 40.6% decline in the risk-return trade-off across islands as measured through the lens of the auxiliary model. Changes in the allocation of workers across industries also has important implications for measured productivity which rises by 1.4%.[26] Thus, the model predicts that a decrease in the transaction cost of issuing credit since the early 1980's can account for 43% of the observed increase in risk-taking by individuals entering the labor market and 94% of the steepening in the risk-return trade-off across industries as measured through the lens of the auxiliary model. In addition, the model implies that this improvement in credit market conditions contributed meaningfully to the rise in measured productivity.

9 Conclusion

In this paper, I document the existence of a strong negative relationship between wage risk and inter-industry wage differentials. I then demonstrate that this counter-intuitive feature of the data can be quantitatively rationalized by a general equilibrium, incomplete markets, life cycle model in which risk-averse workers are allowed to optimally select their industry of employment each period. Inter-industry wage differentials arise in equilibrium as young agents are willing to accept a relatively low wage today in exchange for the possibility of rapid wage growth in the future. The resulting wage differentials depend on the size of the option value of mobility relative to the risk premium effect, which, in turn, are determined by both the resource cost of switching industries and the ability of agents to borrow in credit markets. My quantitative results suggest the option value of mobility is an important insurance channel against labor market risk, which generates a negative trade-off between risk and return across industries on the order of that which is observed in the data. In addition, I find that a decrease in the spread between borrowing and lending rates since the early 1980's

[26]Measured productivity, or the Solow residual, is computed assuming the aggregate production function is Cobb-Douglas in capital and labor. Specifically, measured productivity is given by the ratio $Y/(K^{\alpha}L^{1-\alpha})$, where Y is output of the final consumption good, K is capital rented by the final goods producer, and L is aggregate hours worked.

contributed to increased risk taking in the labor market by young workers, a steepening of the risk-return trade-off across industries, and the rise in measured productivity.

The natural question which then follows is what factors are responsible for variations in wage risk across industries? Lagakos and Ordoez (2011) take a step in this direction by showing that under limited commitment, lower skill workers receive less insurance from their employers against productivity shocks as a result of their relatively low displacement cost. Differences in the amount of risk sharing between firms and workers might thus be a useful starting point for understanding why the volatility of persistent, uninsurable, idiosyncratic shocks to wages vary systematically across industries for both high and low skill workers.

During the recent financial crisis, consumer credit markets exhibited a sharp and protracted contraction.[27] Given that the allocation of workers across industries in my model depends critically on the spread between borrowing and lending rates, a shock to the transaction cost of issuing credit may have a long-lasting impact on allocative efficiency. Understanding the empirical relevance of this channel during the recent financial crisis and quantifying its aggregate implications may prove a fruitful avenue for future research.

Ultimately, jobs are defined by both an occupation and an industry affiliation. Given the positive relationship between earnings risk and expected lifetime earnings across occupations documented by Dillon (2012), a natural question to explore is how wage volatility and wage differentials vary across occupation-industry cells. The answer to this question will likely hinge on the magnitude of variations in wage risk across occupations relative to that across industries, as well as the relative costs of switching between occupation-industry cells.

10 Appendix

In this section, I derive the formulas presented in Section 2 of the paper.

[27]See Chatterjee and Eyigungor (2012) for an analysis of the effects of the financial crisis on mortgage markets. See Luzzetti and Neumuller (2012) for a study of its implications for unsecured credit markets.

10.1 Case 1: No Mobility

The value of choosing island 1 can be simplified as follows:

$$V_1 = \frac{w_1^{1-\gamma}}{1-\gamma} + \beta \frac{w_1^{1-\gamma}}{1-\gamma} = \frac{w_1^{1-\gamma}}{1-\gamma}(1+\beta),$$

while the value of selecting island 2 can also be simplified as follows:

$$V_2 = \mathbb{E}_{z_2}\left[\frac{(w_2 e^{z_2})^{1-\gamma}}{1-\gamma} + \beta \frac{(w_2 e^{z_2})^{1-\gamma}}{1-\gamma}\right] = \frac{w_2^{1-\gamma}}{1-\gamma}(1+\beta)\mathbb{E}_{z_2}\left[e^{z_2(1-\gamma)}\right]$$

Equating V_1 and V_2 yields:

$$\frac{w_1^{1-\gamma}}{1-\gamma} = \frac{w_2^{1-\gamma}}{1-\gamma}\mathbb{E}_{z_2}\left[e^{z(1-\gamma)}\right]$$

$$\left(\frac{w_1}{w_2}\right)^{1-\gamma} = \mathbb{E}_{z_2}\left[e^{z_2(1-\gamma)}\right]$$

Taking logs, and recognizing that $e^{z_2(1-\gamma)}$ is log normally distributed with mean $-\frac{\sigma_2^2}{2}(1-\gamma)$ and variance $\sigma_2^2(1-\gamma)^2$, yields the following expression the log wage differential:

$$\ln\left(\frac{w_1}{w_2}\right) = \frac{1}{1-\gamma}\ln\left(\mathbb{E}_{z_2}\left[e^{z_2(1-\gamma)}\right]\right) = \frac{1}{1-\gamma}\ln e^{-\frac{\sigma_2^2}{2}(1-\gamma)+\frac{\sigma_2^2}{2}(1-\gamma)^2} = -\gamma\frac{\sigma_2^2}{2}$$

which is strictly negative for any $\gamma > 0$ and $\sigma_2 > 0$.

10.2 Case 2: With Mobility

The value of choosing island 1 is given by:

$$V_1 = \frac{w_1^{1-\gamma}}{1-\gamma} + \beta \max\left\{\frac{w_1^{1-\gamma}}{1-\gamma}, \mathbb{E}_{z_2}\left[\frac{(w_2 e^{z_2})^{1-\gamma}}{1-\gamma}\right]\right\}$$

while the value of selecting island 2 is given by:

$$V_2 = \mathbb{E}_{z_2}\left[\frac{(w_2 e^{z_2})}{1-\gamma}^{1-\gamma} + \beta \max\left\{\frac{w_1^{1-\gamma}}{1-\gamma}, \frac{(w_2 e^{z_2})}{1-\gamma}^{1-\gamma}\right\}\right]$$

First, note that if $V_1 \geq V_2$, it follows that

$$\frac{w_1^{1-\gamma}}{1-\gamma} \geq \mathbb{E}_{z_2}\left[\frac{(w_2 e^{z_2})}{1-\gamma}^{1-\gamma}\right]$$

and therefore any worker who chooses island 1 in period 1 will never find it optimal to switch to island 2 in period 2. Hence, the value of choosing island 1 can be simplified as follows:

$$V_1 = \frac{w_1^{1-\gamma}}{1-\gamma} + \beta \frac{w_1^{1-\gamma}}{1-\gamma} = \frac{w_1^{1-\gamma}}{1-\gamma}(1+\beta),$$

Second, for every $\{w_1, w_2\}$ there exists a threshold productivity shock z_2^* such that workers who choose island 2 in period 1 decide to stay on island 2 in period 2 if $z_2 \geq z_2^*$ and decided to switch to island 1 in period 2 otherwise. Note that this threshold value is precisely that for which $w_1 = w_2 e^{z_2^*}$, and hence $z_2^* = \ln(w_1/w_2)$. Equating V_1 and V_2 and substituting in for w_1 inside of the max operator yields:

$$\frac{w_1^{1-\gamma}}{1-\gamma}(1+\beta) = \mathbb{E}_{z_2}\left[\frac{(w_2 e^{z_2})}{1-\gamma}^{1-\gamma} + \beta \max\left\{\frac{(w_2 e^{z_2^*})}{1-\gamma}^{1-\gamma}, \frac{(w_2 e^{z_2})}{1-\gamma}^{1-\gamma}\right\}\right]$$

$$\frac{w_1^{1-\gamma}}{1-\gamma}(1+\beta) = \frac{w_2^{1-\gamma}}{1-\gamma}\mathbb{E}_{z_2}\left[e^{z_2(1-\gamma)} + \beta \max\left\{e^{z_2^*(1-\gamma)}, e^{z_2(1-\gamma)}\right\}\right]$$

$$\left(\frac{w_1}{w_2}\right)^{1-\gamma}(1+\beta) = \mathbb{E}_{z_2}\left[e^{z_2(1-\gamma)}\right] + \beta \mathbb{E}_{z_2}\left[\max\left\{e^{z_2^*(1-\gamma)}, e^{z_2(1-\gamma)}\right\}\right]$$

$$= e^{-\frac{\sigma_2^2}{2}(1-\gamma)+\frac{\sigma_2^2}{2}(1-\gamma)^2} + \beta \mathbb{E}\left[e^{z_2(1-\gamma)} | e^{z_2(1-\gamma)} > e^{z_2^*(1-\gamma)}\right] \Pr\left[e^{z_2(1-\gamma)} > e^{z_2^*(1-\gamma)}\right]$$

$$+\beta e^{z_2^*(1-\gamma)} \Pr\left[e^{z_2(1-\gamma)} \leq e^{z_2^*(1-\gamma)}\right]$$

$$= e^{-\frac{\sigma_2^2}{2}(1-\gamma)+\frac{\sigma_2^2}{2}(1-\gamma)^2} + \beta e^{-\frac{\sigma_2^2}{2}(1-\gamma)+\frac{\sigma_2^2}{2}(1-\gamma)^2} \Phi\left[\left(\frac{1}{2}-\gamma\right)\sigma_2 - \frac{z_2^*}{\sigma_2}\right] + \beta e^{z_2^*(1-\gamma)} \Phi\left(\frac{z_2^*}{\sigma_2} + \frac{\sigma_2}{2}\right)$$

$$\vdots$$

$$\ln\left(\frac{w_1}{w_2}\right) = \underbrace{-\gamma\frac{\sigma_2^2}{2}}_{\text{Risk Premium}} + \cdots$$

$$\cdots + \underbrace{\frac{1}{1-\gamma}\ln\left\{\frac{1}{1+\beta}\left[1+\beta\Phi\left[\left(\frac{1}{2}-\gamma\right)\sigma_2 - \frac{z_2^*}{\sigma_2}\right] + \beta e^{(1-\gamma)\left[z_2^*+\frac{\sigma_2^2}{2}-\frac{\sigma_2^2}{2}(1-\gamma)\right]}\Phi\left(\frac{z_2^*}{\sigma_2}+\frac{\sigma_2}{2}\right)\right]\right\}}_{\text{Option Value of Mobility}}$$

The first term on the right hand side is the risk premium effect while the second term on the right hand side is the option value of mobility. This final equation can be expressed as the following fixed point problem by subtracting $z_2^* = \ln(w_1/w_2)$ from both sides: $f(z_2^*) = 0$. Suppose $\gamma > 1$. When $z_2^* \to +\infty$, $f(z_2^*) \to -\infty$. Alternatively, when $z_2^* \to -\infty$, $f(z_2^*) \to +\infty$. Given that $f(z_2^*)$ is continuous, there must exist a threshold $z_2^* \in \mathbb{R}$ such that $f(z_2^*) = 0$.

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Table 1: 1970 Census One-digit Industry Classification System

Code	Industry Description
01	Agriculture, forestry, and fisheries
02	Mining
03	Construction
04	Manufacturing
05	Transportation, communications, and utilities
06	Wholesale and retail trade
07	Finance, insurance, and real estate
08	Business and repair services
09	Personal services
10	Entertainment and recreation services
11	Professional and related services
12	Public administration

Table 2: 2000 Standard Occupational Classification System

Code	Industry Description
11	Management
13	Business and financial operations
15	Computer and mathematical
17	Architecture and engineering
19	Life, physical, and social science
21	Community and social services
23	Legal
25	Education, training, and library
27	Arts, design, entertainment, sports, and media
29	Healthcare practitioners and technical
31	Healthcare support
33	Protective services
35	Food preparation and serving related
37	Building and grounds cleaning and maintenance
39	Personal care and services
41	Sales and related
43	Office and administrative support
45	Farming, forestry, and fishing
47	Construction and extraction
49	Installation, repair, and maintenance
51	Production
53	Transportation and material moving

Table 3: Sample Summary Statistics

Year	Observations	Age	Years of Education	Union Members	Hours Worked	Real Wage*
1967	1,093	37.3	12.0	0.349	2,311	$11.13
1968	1,127	37.5	12.0	0.358	2,283	$11.47
1969	1,184	36.9	12.2	0.354	2,260	$11.73
1970	1,232	36.7	12.2	0.348	2,209	$11.95
1971	1,308	36.1	12.3	0.333	2,225	$11.72
1972	1,374	35.2	12.4	0.322	2,244	$12.03
1973	1,442	34.9	12.5	0.316	2,224	$12.20
1974	1,501	34.6	12.6	0.322	2,189	$11.82
1975	1,472	34.5	12.7	0.314	2,175	$11.54
1976	1,484	34.4	12.7	0.309	2,210	$12.00
1980	1,618	34.5	12.9	0.297	2,171	$11.75
1981	1,598	34.6	13.0	0.274	2,143	$11.73
1982	1,570	34.7	13.2	0.267	2,130	$11.58
1983	1,613	34.6	13.2	0.241	2,142	$11.62
1984	1,624	34.8	13.4	0.243	2,222	$11.52
1985	1,659	34.9	13.5	0.225	2,206	$11.70
1986	1,668	35.3	13.5	0.234	2,218	$12.06
1987	1,682	35.4	13.5	0.220	2,232	$12.11
1988	1,711	35.7	13.6	0.208	2,247	$12.03
1989	1,725	36.0	13.6	0.211	2,271	$11.89
1990	1,715	36.3	13.6	0.209	2,269	$11.99
1991	1,711	36.5	13.6	0.212	2,237	$12.03
1992	1,736	36.8	13.6	0.200	2,221	$12.41
1993	1,579	37.5	13.7	0.215	2,203	$13.08
1994	1,435	37.2	13.6	0.194	2,235	$12.34
1995	1,193	37.9	13.7	0.200	2,235	$12.48
1996	1,430	38.1	13.7	0.202	2,227	$12.82
1998	1,318	38.7	13.7	0.187	2,235	$13.74
2000	1,349	39.0	13.6	0.197	2,217	$14.27
2002	1,999	38.8	13.7	0.190	2,270	$12.78
2004	1,990	38.3	13.8	0.177	2,283	$12.52
2006	2,014	38.2	13.8	0.171	2,251	$12.65
2008	1,905	38.1	13.8	0.160	2,176	$13.38

*The agerage real wage is expressed in 1982 dollars.

Table 4: Distribution of Individual-Year Observations across 1970 Census One-Digit Industries

Year	Agriculture, forestry, and fisheries	Business and repair services	Const-ruction	Entertain-ment and recreation services	Finance, insurance, and real estate	Mining	Manufact-uring	Personal services	Professional and related services	Public admin-istration	Transport-ation, comm-unications, and utilities	Wholesale and retail trade
1967	0.024	0.038	0.087	0.004	0.036	0.011	0.382	0.005	0.114	0.078	0.096	0.125
1968	0.022	0.033	0.087	0.003	0.035	0.008	0.397	0.008	0.119	0.075	0.092	0.122
1969	0.016	0.035	0.085	0.003	0.043	0.014	0.386	0.008	0.120	0.079	0.090	0.122
1970	0.015	0.028	0.088	0.003	0.040	0.012	0.367	0.007	0.119	0.088	0.092	0.140
1971	0.015	0.029	0.089	0.005	0.050	0.011	0.351	0.009	0.120	0.091	0.094	0.135
1972	0.023	0.028	0.089	0.007	0.047	0.014	0.352	0.009	0.116	0.086	0.088	0.142
1973	0.020	0.030	0.091	0.007	0.048	0.011	0.343	0.011	0.112	0.092	0.096	0.140
1974	0.025	0.023	0.087	0.006	0.043	0.016	0.341	0.015	0.116	0.099	0.093	0.136
1975	0.020	0.028	0.079	0.010	0.047	0.016	0.334	0.013	0.115	0.106	0.094	0.139
1976	0.021	0.028	0.078	0.007	0.042	0.016	0.337	0.014	0.114	0.102	0.096	0.145
1980	0.017	0.040	0.085	0.006	0.042	0.015	0.331	0.009	0.109	0.095	0.110	0.142
1981	0.016	0.039	0.078	0.006	0.035	0.019	0.335	0.014	0.111	0.088	0.114	0.145
1982	0.025	0.039	0.076	0.005	0.037	0.012	0.300	0.008	0.118	0.104	0.125	0.150
1983	0.020	0.040	0.084	0.006	0.036	0.014	0.306	0.011	0.112	0.095	0.126	0.149
1984	0.021	0.044	0.075	0.007	0.033	0.015	0.305	0.012	0.111	0.099	0.126	0.153
1985	0.019	0.048	0.091	0.006	0.034	0.012	0.291	0.011	0.116	0.101	0.116	0.155
1986	0.015	0.050	0.083	0.007	0.038	0.011	0.292	0.013	0.113	0.100	0.118	0.161
1987	0.020	0.046	0.078	0.011	0.040	0.011	0.297	0.009	0.121	0.096	0.105	0.165
1988	0.017	0.051	0.075	0.008	0.043	0.009	0.285	0.015	0.122	0.098	0.119	0.157
1989	0.016	0.055	0.083	0.008	0.046	0.009	0.289	0.012	0.121	0.096	0.110	0.155
1990	0.019	0.055	0.087	0.008	0.038	0.008	0.290	0.006	0.128	0.093	0.107	0.159
1991	0.016	0.054	0.094	0.007	0.040	0.011	0.281	0.012	0.126	0.096	0.110	0.153
1992	0.017	0.060	0.085	0.010	0.038	0.010	0.263	0.008	0.145	0.100	0.103	0.161
1993	0.015	0.064	0.091	0.007	0.044	0.006	0.251	0.007	0.135	0.100	0.110	0.170
1994	0.022	0.062	0.086	0.010	0.045	0.008	0.253	0.006	0.129	0.097	0.107	0.176
1995	0.018	0.065	0.076	0.006	0.045	0.008	0.260	0.006	0.138	0.095	0.118	0.164
1996	0.018	0.077	0.091	0.013	0.049	0.008	0.243	0.008	0.133	0.101	0.113	0.146
1998	0.020	0.076	0.093	0.011	0.049	0.007	0.266	0.010	0.127	0.097	0.107	0.138
2000	0.019	0.078	0.085	0.009	0.043	0.010	0.243	0.007	0.134	0.110	0.103	0.159
2002	0.015	0.051	0.101	0.076	0.052	0.011	0.210	0.017	0.157	0.083	0.086	0.143
2004	0.017	0.053	0.106	0.069	0.054	0.006	0.210	0.019	0.165	0.073	0.077	0.151
2006	0.015	0.049	0.114	0.071	0.055	0.010	0.195	0.020	0.174	0.077	0.077	0.143
2008	0.013	0.047	0.115	0.080	0.061	0.012	0.175	0.020	0.182	0.083	0.072	0.139

Table 5: Estimation Results for Auxiliary Model on Actual Data

	(1)	(2)	(3)	(4)	(5)	(6)
	Base Sample	Non-union	Unskilled	Skilled	1967-1984	1985-2008
VARIABLES	log(w)	log(w)	log(w)	log(w)	log(w)	log(w)
age	0.170***	0.107*	0.387***	0.206	0.294***	0.142**
	(0.0473)	(0.0559)	(0.0557)	(0.150)	(0.0628)	(0.0702)
age^2/10^2	-0.446**	-0.184	-1.418***	-0.307	-1.069***	-0.254
	(0.201)	(0.239)	(0.239)	(0.612)	(0.269)	(0.297)
age^3/10^4	0.525	0.0600	2.320***	-0.0540	1.817***	0.0603
	(0.369)	(0.440)	(0.443)	(1.082)	(0.497)	(0.542)
age^4/10^6	-0.244	0.0537	-1.421***	0.273	-1.184***	0.127
	(0.248)	(0.296)	(0.299)	(0.702)	(0.334)	(0.362)
years of education	0.0464***	0.0448***	0.0468***	0.000648	0.0566***	0.0418***
	(0.00435)	(0.00515)	(0.00163)	(0.00217)	(0.00130)	(0.00654)
union member	0.199***		0.230***	0.100***	0.167***	0.216***
	(0.00442)		(0.00539)	(0.0115)	(0.00617)	(0.00642)
Agriculture, forestry, and fisheries	-0.133***	-0.0974***	-0.112***	-0.0487	-0.112***	-0.133***
	(0.0274)	(0.0302)	(0.0321)	(0.0663)	(0.0416)	(0.0366)
Mining	0.142***	0.160***	0.102**	0.262***	0.166***	0.110**
	(0.0302)	(0.0395)	(0.0416)	(0.0690)	(0.0407)	(0.0466)
Construction	0.0401***	0.0176	0.0644***	0.00367	0.0674***	0.0201
	(0.0145)	(0.0175)	(0.0190)	(0.0402)	(0.0223)	(0.0205)
Manufacturing	0.0566***	0.0845***	0.0612***	0.0752***	0.0958***	0.0443**
	(0.0122)	(0.0150)	(0.0170)	(0.0217)	(0.0173)	(0.0179)
Transportation, communications, and utilities	0.0468***	0.0512***	0.0433**	0.142***	0.0721***	0.0459**
	(0.0138)	(0.0175)	(0.0191)	(0.0274)	(0.0204)	(0.0197)
Wholesale and retail trade	-0.0947***	-0.0927***	-0.0237	-0.127***	-0.0163	-0.128***
	(0.0133)	(0.0156)	(0.0180)	(0.0265)	(0.0198)	(0.0189)
Finance, insurance, and real estate	-0.0281	-0.0213	0.0599*	-0.0441	0.00363	-0.0241
	(0.0188)	(0.0209)	(0.0322)	(0.0281)	(0.0274)	(0.0263)
Business services	0.0273*	0.0426**	0.0186	0.0821**	0.0584**	0.0188
	(0.0166)	(0.0187)	(0.0228)	(0.0325)	(0.0265)	(0.0218)
Personal services	-0.0799***	-0.0988***	0.0721	-0.292***	-0.115**	-0.0581
	(0.0296)	(0.0326)	(0.0494)	(0.0520)	(0.0478)	(0.0374)
Entertainment and recreation services	-0.131***	-0.121***	-0.108**	-0.0692	-0.150***	-0.103***
	(0.0252)	(0.0292)	(0.0436)	(0.0530)	(0.0539)	(0.0299)
Professional services	-0.0351**	-0.0144	-0.0118	-0.0107	-0.0161	-0.0373*
	(0.0146)	(0.0173)	(0.0229)	(0.0223)	(0.0210)	(0.0206)
Constant	-0.983**	-0.446	-2.653***	-1.549	-1.941***	-0.871
	(0.398)	(0.467)	(0.471)	(1.353)	(0.533)	(0.597)
Observations	51,024	38,573	25,707	14,201	21,223	29,801
R-squared	0.424	0.446	0.377	0.373	0.440	0.424

Standard errors in parentheses. Other regressors include year dummys, occupation dummys, industry tenure, firm tenure, and occupational tenure.
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Employment Weighted Inter-industry Wage Differentials Estimated using the Auxiliary Model on Actual Data

	(1) Base Sample	(2) Non-union	(3) Unskilled	(4) Skilled	(5) 1967-1984	(6) 1985-2008
Industry	Ω_j	Ω_j	Ω_j	Ω_j	Ω_j	Ω_j
Agriculture, forestry, and fisheries	-0.1349	-0.1042	-0.1423	-0.0561	-0.1538	-0.1210
	(0.0274)	(0.0302)	(0.0321)	(0.0663)	(0.0416)	(0.0366)
Business and repair services	0.0251	0.0358	-0.0115	0.0748	0.0166	0.0306
	(0.0166)	(0.0187)	(0.0228)	(0.0325)	(0.0265)	(0.0218)
Construction	0.0379	0.0108	0.0343	-0.0037	0.0256	0.0319
	(0.0145)	(0.0175)	(0.0190)	(0.0402)	(0.0223)	(0.0205)
Entertainment and recreation services	-0.1335	-0.1283	-0.1380	-0.0766	-0.1917	-0.0910
	(0.0252)	(0.0292)	(0.0436)	(0.0530)	(0.0539)	(0.0299)
Finance, insurance, and real estate	-0.0303	-0.0282	0.0298	-0.0515	-0.0381	-0.0123
	(0.0188)	(0.0209)	(0.0322)	(0.0281)	(0.0274)	(0.0263)
Manufacturing	0.0544	0.0776	0.0310	0.0679	0.0540	0.0560
	(0.0122)	(0.0150)	(0.0170)	(0.0217)	(0.0173)	(0.0179)
Mining	0.1395	0.1533	0.0715	0.2547	0.1244	0.1217
	(0.0302)	(0.0395)	(0.0416)	(0.0690)	(0.0407)	(0.0466)
Personal services	-0.0821	-0.1056	0.0419	-0.2992	-0.1569	-0.0463
	(0.0296)	(0.0326)	(0.0494)	(0.0520)	(0.0478)	(0.0374)
Professional and related services	-0.0373	-0.0213	-0.0419	-0.0181	-0.0578	-0.0255
	(0.0146)	(0.0173)	(0.0229)	(0.0223)	(0.0210)	(0.0206)
Public Administration	-0.0022	-0.0068	-0.0301	-0.0073	-0.0417	0.0118
	(0.0142)	(0.0173)	(0.0229)	(0.0223)	(0.0210)	(0.0206)
Transportation, communications, and utilities	0.0447	0.0444	0.0132	0.1346	0.0304	0.0577
	(0.0138)	(0.0175)	(0.0191)	(0.0274)	(0.0204)	(0.0197)
Wholesale and retail trade	-0.0969	-0.0995	-0.0538	-0.1339	-0.0581	-0.1157
	(0.0133)	(0.0156)	(0.0180)	(0.0265)	(0.0198)	(0.0189)
Employment Weighted Standard Deviation	0.0614	0.0680	0.0446	0.0797	0.0582	0.0640
Rank Correlation with Base Sample	1.0000	0.9510	0.7448	0.8881	0.9580	0.9860
p-value	0.0000	0.0000	0.0047	0.0001	0.0000	0.0000

Standard errors in parentheses.

Table 7: Biennial Permanent and Transitory Shock Volatilities Estimated Using the Auxiliary Model on Actual Data

	(1) Base Sample		(2) Non-union		(3) Unskilled		(4) Skilled		(5) 1967-1984		(6) 1985-2008	
Industry	$\sigma_{\zeta,j}$	$\sigma_{e,j}$	$\sigma_{\zeta,j}$	$\sigma_{e,j}$	$\sigma_{\zeta,j}$	$\sigma_{e,j}$	$\sigma_{\zeta,j}$	$\sigma_{e,j}$	$\sigma_{\zeta,j}$	$\sigma_{e,j}$	$\sigma_{\zeta,j}$	$\sigma_{e,j}$
Agriculture, forestry, and fisheries	0.2360	0.1573	0.2385	0.1581	0.2675	0.1340	0.2333	0.1532	0.2794	0.1409	0.2165	0.1670
	(0.0246)	(0.0124)	(0.0263)	(0.0125)	(0.0265)	(0.0143)	(0.0803)	(0.0490)	(0.0330)	(0.0201)	(0.0432)	(0.0178)
Business and repair services	0.2033	0.1554	0.2153	0.1496	0.2095	0.1537	0.1898	0.1378	0.2324	0.1336	0.1905	0.1570
	(0.0177)	(0.0080)	(0.0177)	(0.0087)	(0.0282)	(0.0126)	(0.0281)	(0.0134)	(0.0268)	(0.0159)	(0.0245)	(0.0106)
Construction	0.1995	0.1462	0.1981	0.1427	0.1982	0.1362	0.1929	0.1454	0.2140	0.1376	0.2094	0.1384
	(0.0108)	(0.0050)	(0.0130)	(0.0067)	(0.0118)	(0.0058)	(0.0471)	(0.0181)	(0.0170)	(0.0093)	(0.0134)	(0.0069)
Entertainment and recreation services	0.2419	0.1514	0.2579	0.1377	0.2107	0.1671	0.1855	0.1895	0.2805	0.1046	0.2411	0.1557
	(0.0271)	(0.0148)	(0.0288)	(0.0173)	(0.0962)	(0.0333)	(0.0539)	(0.0278)	(0.0523)	(0.0467)	(0.0315)	(0.0167)
Finance, insurance, and real estate	0.2067	0.1583	0.2052	0.1579	0.1699	0.1531	0.2122	0.1583	0.1662	0.1538	0.2344	0.1582
	(0.0151)	(0.0070)	(0.0152)	(0.0070)	(0.0356)	(0.0161)	(0.0201)	(0.0087)	(0.0310)	(0.0120)	(0.0185)	(0.0092)
Manufacturing	0.1640	0.1413	0.1651	0.1409	0.1742	0.1362	0.1417	0.1346	0.1571	0.1392	0.1644	0.1499
	(0.0056)	(0.0023)	(0.0069)	(0.0030)	(0.0070)	(0.0031)	(0.0118)	(0.0050)	(0.0088)	(0.0038)	(0.0089)	(0.0036)
Mining	0.1903	0.1480	0.1908	0.1424	0.1653	0.1611	0.1984	0.1026	0.1495	0.1631	0.1997	0.1456
	(0.0324)	(0.0146)	(0.0334)	(0.0199)	(0.0376)	(0.0197)	(0.0492)	(0.0426)	(0.0692)	(0.0218)	(0.0551)	(0.0227)
Personal services	0.2057	0.1972	0.1820	0.2100	0.2453	0.1749	0.2141	0.2104	0.2705	0.1452	0.1821	0.2146
	(0.0503)	(0.0180)	(0.0632)	(0.0201)	(0.0502)	(0.0280)	(0.0834)	(0.0328)	(0.0488)	(0.0282)	(0.0871)	(0.0241)
Professional and related services	0.2001	0.1484	0.2062	0.1426	0.1825	0.1389	0.1963	0.1510	0.1941	0.1394	0.2125	0.1521
	(0.0082)	(0.0037)	(0.0094)	(0.0045)	(0.0193)	(0.0093)	(0.0102)	(0.0045)	(0.0149)	(0.0077)	(0.0106)	(0.0049)
Public Administration	0.1783	0.1496	0.1914	0.1485	0.1711	0.1561	0.1670	0.1480	0.1573	0.1522	0.1887	0.1493
	(0.0100)	(0.0041)	(0.0127)	(0.0055)	(0.0170)	(0.0066)	(0.0184)	(0.0075)	(0.0196)	(0.0075)	(0.0131)	(0.0057)
Transportation, communications, and utilities	0.1685	0.1535	0.1766	0.1562	0.1439	0.1568	0.2261	0.1413	0.1478	0.1519	0.1757	0.1627
	(0.0099)	(0.0039)	(0.0147)	(0.0056)	(0.0144)	(0.0054)	(0.0187)	(0.0100)	(0.0197)	(0.0071)	(0.0144)	(0.0055)
Wholesale and retail trade	0.2038	0.1567	0.2098	0.1576	0.1934	0.1533	0.2168	0.1545	0.1891	0.1560	0.2084	0.1609
	(0.0087)	(0.0040)	(0.0093)	(0.0043)	(0.0119)	(0.0054)	(0.0183)	(0.0102)	(0.0157)	(0.0071)	(0.0119)	(0.0054)
Employment Weighted Average	0.187	0.150	0.193	0.149	0.182	0.145	0.187	0.148	0.177	0.145	0.194	0.154
Employment Weighted Standard Deviation	0.020	0.008	0.022	0.010	0.023	0.010	0.028	0.012	0.030	0.008	0.022	0.010
Rank Correlation with Base Sample	1.000	1.000	0.776	0.860	0.671	0.266	0.336	0.643	0.811	0.245	0.769	0.874
p-value	0.000	0.000	0.003	0.000	0.015	0.402	0.284	0.022	0.001	0.442	0.003	0.000

Bootstrap Standard Errors in Parentheses.

Table 8: Equilibrium Statistics

Statistic	Value
r	4.25%
w_1	1.55
w_2	1.46
$\ln(w_1/w_2)$	0.060
$\ln(w_1/w_2) / (\sigma_1 - \sigma_2)$	-2.00
$\Omega_1^m - \Omega_2^m)$	0.106
$(\Omega_1^m - \Omega_2^m) / (\sigma_1^b - \sigma_2^b)$	-2.89
Average Inter-industry Mobility Rate	1.26%
Measured Productivity	1.39

Table 9: Wage Differential and Risk-return Trade-off Estimated Using the Auxiliary Model

	(1) Base Sample	(2) Non-union	(3) Unskilled	(4) Skilled	(5) 1967-1984	(6) 1985-2008
$\Omega_1 - \Omega_2$	0.081	0.096	0.048	0.056	0.071	0.086
$(\Omega_1 - \Omega_2) / (\sigma_{\zeta,1}^{b} - \sigma_{\zeta,2}^{b})$	-2.19	-2.58	-1.41	-1.06	-1.54	-2.20

Table 10: Quantitative Significance of Insurance Channels

Insurance Channel and Order Removed	$\ln(w_1/w_2)$ $(\sigma_1 - \sigma_2)$	Percentage of Total Change
Case 1		
1) Borrowing	-0.58	55.6%
2) Inter-industry Mobility	0.55	44.1%
3) Labor Supply	0.56	0.3%
Case 2		
1) Borrowing	-0.58	55.6%
2) Labor Supply	-0.19	15.2%
3) Inter-industry Mobility	0.56	29.2%
Case 3		
1) Labor Supply	-1.18	32.2%
2) Borrowing	-0.19	38.7%
3) Inter-industry Mobility	0.56	29.2%
Case 4		
1) Labor Supply	-1.18	32.2%
2) Inter-industry Mobility	0.56	67.8%
3) Borrowing	0.56	0.1%
Case 5		
1) Inter-industry Mobility	0.51	98.1%
2) Labor Supply	0.56	1.8%
3) Borrowing	0.56	0.1%
Case 6		
1) Inter-industry Mobility	0.51	98.1%
2) Borrowing	0.55	1.6%
3) Labor Supply	0.56	0.3%

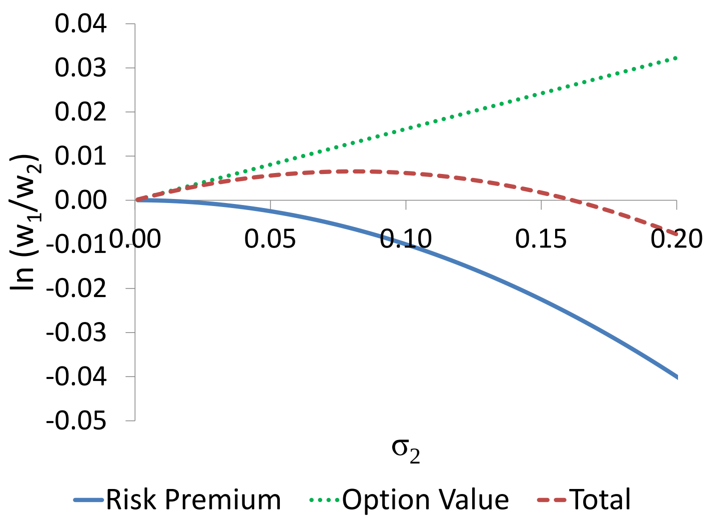
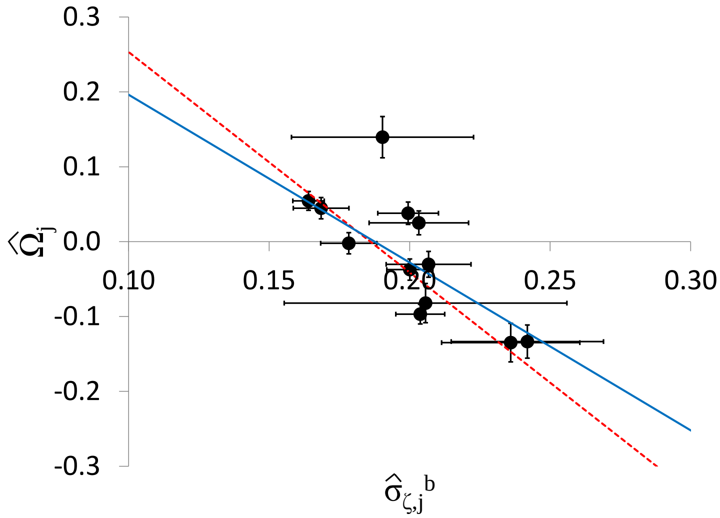
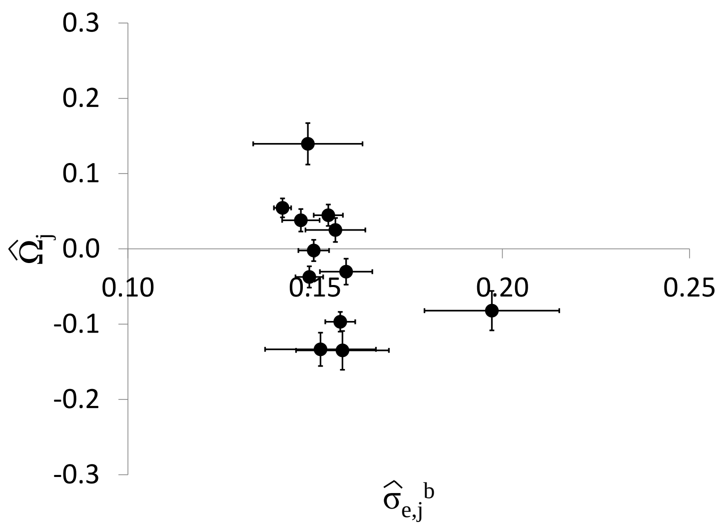


Figure 1: Simple model with mobility



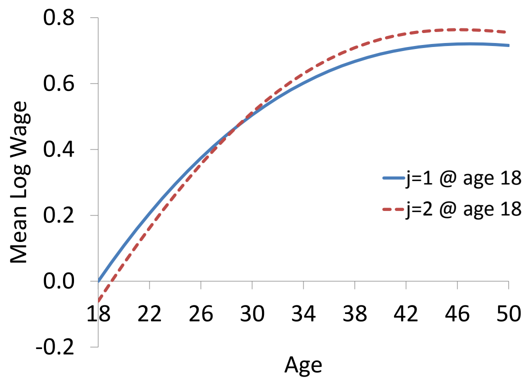
(a) Permanent Shock



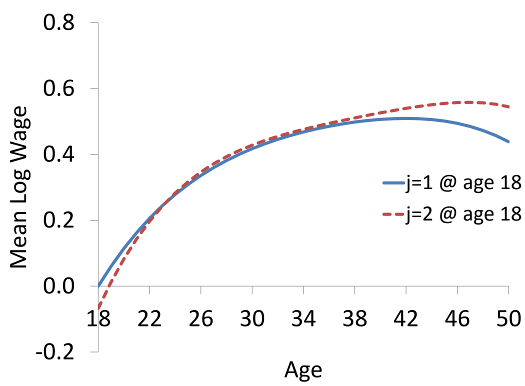
(b) Transitory Shock

Figure 2: The empirical relationship between wage differentials and measures of wage risk as viewed through the lens of the auxiliary model. Error bars depict standard errors. In panel (a), the red dashed line depicts the model-implied risk-return trade-off while the blue solid line depicts that implied by actual data.

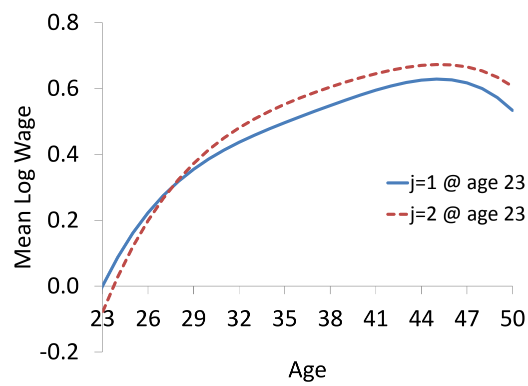
Figure 3: Fraction of individuals employed in a high volatility industry by age.



(a) Model



(b) Data: Unskilled Workers



(c) Data: Skilled Workers

Figure 4: Expected wage profiles conditional on initial industry of employment.

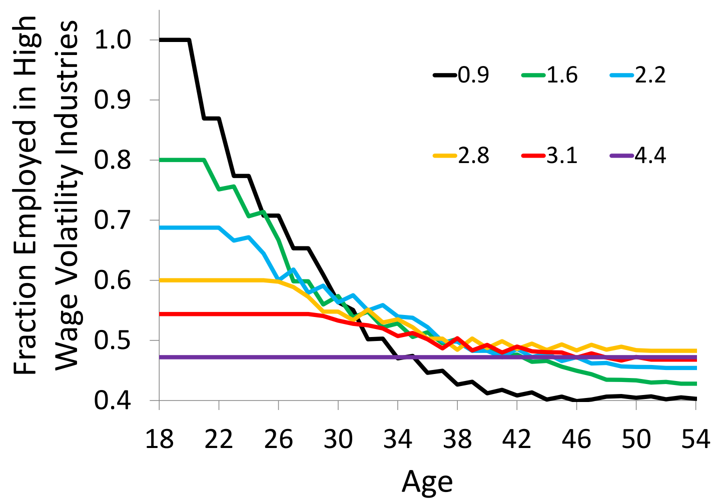
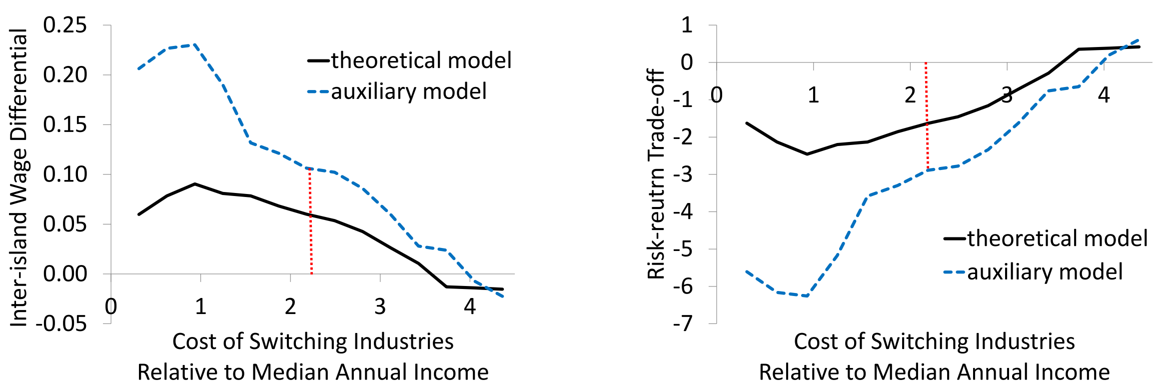


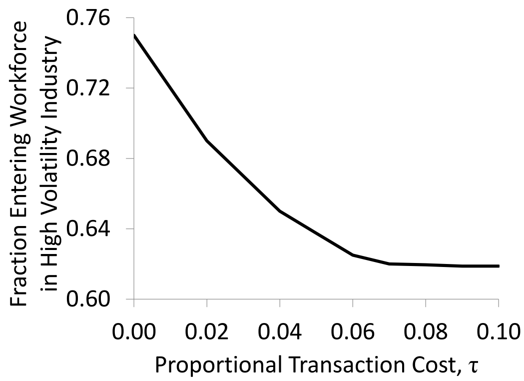
Figure 5: Fraction of agents employed on the high volatility island by age as a function of the resource cost of switching industries.



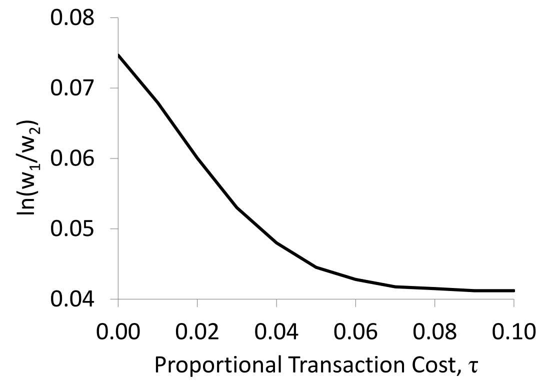
(a) Wage differential

(b) Risk-return trade-off

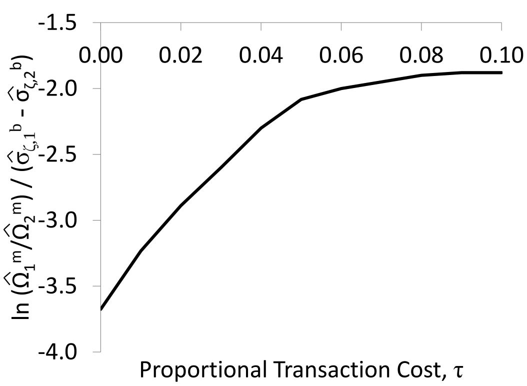
Figure 6: Sensitivity to changes in the resource cost of switching industries.



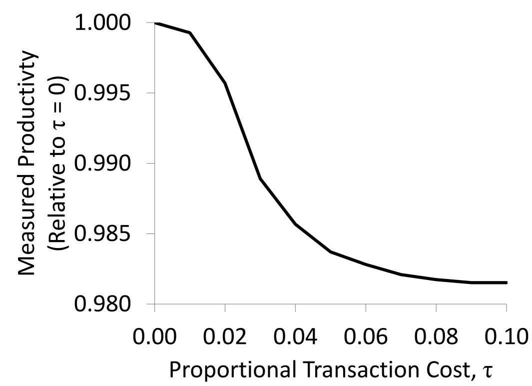
(a) Risk taking by young workers



(b) Wage differential



(c) Risk-return trade-off



(d) Measured productivity

Figure 7: Effects of varying degrees of credit market imperfections.