Which workers get insurance within the firm?

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A B S T R A C T

Industry-level time series data suggest that low-skilled workers get less insurance within the firm than high-skilled workers. In particular, wages respond relatively more to productivity shocks in low-skilled industries than high-skilled industries. Our theory is that low-skilled workers get relatively less insurance from their firms because they have relatively lower displacement costs. Under limited commitment, lower displacement costs make the workers’ outside options more attractive, and hence decrease the amount of risk sharing sustainable within the firm. Evidence on average displacement costs by industry support the theory’s predictions.

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1. Introduction

Risk averse individuals value smooth consumption streams over time, but face volatile earnings. A large literature has demonstrated that wage volatility has first order effects on consumption volatility and large effects on welfare more generally (see e.g. Krueger and Perri, 2003, 2004; Heathcote et al., 2005, 2008). This literature has typically focused on ways that agents can insure themselves against uncertain labor earnings, such as through financial markets, risk-sharing within the family, or public insurance programs, and has concluded that these forms of insurance are important components of mitigating earnings volatility.

This paper explores where earnings volatility arises from in the first place, by asking which types of workers tend to get insurance within the firm—and why. Neither question has received much attention in spite of their potential importance (as highlighted by Heathcote et al., 2009). To answer which types of workers get insurance within the firm, the current paper draws on industry-level time series to measure the extent to which worker compensation responds to cyclical fluctuations in worker productivity. Industry-level data, as opposed to worker-level data, have the advantage of offering information over time on payments to workers as well as the value of output produced per worker.

For each industry, we compute the elasticity of the compensation per worker to value added per worker as a measure of “wage smoothing,” or insurance against volatility in the value of labor input. Our main finding is that there is substantially less wage smoothing in industries with low average schooling levels than in industries with high average schooling: wages in the former respond more to productivity shocks than the latter. This suggests that low-skilled workers are those that get relatively least insurance within the firm.

To better understand why some types of workers get more insurance within the firm than others, and in particular why low-skilled workers get relatively less insurance from their employers, we document a second fact. This fact is that...
displacement costs, as measured by the percent loss in wages on average after a mass layoff or plant closing, are higher in industries with higher average schooling levels. In industries with relatively few college graduates, such as retail trade and apparel manufacturing, worker wages on average fall very little after a displacement. This fact serves to motivate our theory of why workers in high-skilled industries get more insurance from their employers.

Our theory is that worker displacement costs reduce the value of the workers’ outside options, and hence lead workers and firms to agree on a compensation scheme in which wages are smooth even when productivity is volatile. Displacement costs, which could arise from specific capital or thin markets for specialized jobs, essentially serve as collateral in the match, and allow for risk sharing even when neither party can commit to stay in the match. Because workers in high-skilled industries have higher displacement costs, their wages respond relatively little to industry productivity shocks. Having lower displacement costs, workers in less skilled industries have wages that more closely resemble spot market contracts, rising more with productivity in peaks and falling more in downturns.

The theory is formalized in a model of wage contracting between a risk-averse worker and risk-neutral firm under limited commitment, based on the work of Thomas and Worrall (1988). The optimal contract specifies wage smoothing: wages move as little as possible after any productivity realization to keep both parties at least indifferent to remaining in the match. The theory predicts that, all else equal, higher displacement costs lead to increased wage smoothing. Intuitively, the more that is lost when the worker leaves, the easier it is for a smooth wage contract to be incentive compatible, and the more both parties will be willing to accept promises of higher future payoffs in exchange for lower payoffs in the present, as is required in order to smooth wages.2

The theory’s predictions are then tested using regression analysis on our industry data. In a series of regressions of the industry wage elasticity of productivity on a set of industry characteristics, industries with higher displacement costs have lower elasticities, all else equal, as the theory predicts. Furthermore, the (multiple) correlation between the wage elasticity of productivity and the industry skill level – proxied by the percent of industry workers that are college graduates – is substantially diminished after controlling for displacement costs. This supports the hypothesis that differences in displacement costs between high and low skilled industries are an important driving force of their differences in wage responses to productivity.

Our findings are complementary to those of Blundell et al. (2008), who show that individuals without college education, and particularly those belonging to poor households, have relatively less external insurance against transitory shocks to their wage earnings than college graduates.3 Their results suggest that low-skilled workers should stand to gain the most from getting insurance within their firms. Instead, as our paper shows, the low-skilled get relatively least within-firm insurance. To the extent that displacement costs are inherently low in low-skilled jobs, our paper implies that low-skilled workers are unlikely to get much insurance within the firm either. Hence, improving public and private insurance mechanisms would seem to be the most promising channels for decreasing consumption volatility for low-skilled individuals. Still, the question of why displacement costs are lower for low skilled workers – be it perhaps less specific capital or relatively thicker markets for low-skilled jobs – is still an open question, beyond the scope of this paper.

Our work also complements an older literature on insurance within the firm, which has been widely recognized as a means of risk-sharing for workers, and even as a justification of the existence of firms (Knight, 1921). The motivation for insurance within the firm is that firm owners can smooth their consumption better than workers by having more access to asset markets (Baily, 1974; Azariadis, 1975). Recently Guiso et al. (2005) use a unique data set of Italian firms and workers to estimate that insurance within the firm accounts for about 15% of overall earnings variability, suggesting that insurance within the firm can be an important vehicle of insurance provision against workers’ productivity shocks. Our work contributes by measuring which types of workers get (relatively more of) this type of insurance, and by identifying displacement costs as a key facilitator of within-firm insurance.4

Finally, our conclusions are supported by survey evidence on why wages do not respond fully to changes in market conditions. For example, Campbell and Kamlani (1997) argue that among U.S. employers, “firm-specific human capital was rated as an important factor in explaining the rigidity of wages, particularly for white-collar workers.” Firm-specific capital is a prime example of what would lead displacement costs to be higher for high skill workers. Franz and Pfeiffer (2006) provide more recent corroborative evidence for our theory, using evidence from a sample of German employers. The authors conclude that “specific human capital and negative signals for new hires are causes of stickiness of wages for the highly skilled,” and that specific capital is not a factor in determining the wage movements of less skilled workers.

2. Wage smoothing: the industry-level facts

This section describes the industry data used in the analysis and lay out the main empirical result, which is that wages are smoothed relatively more in high-skilled industries than low-skilled industries.

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2 For brevity, proofs of all results are available in an online Appendix.
3 Our findings are also consistent with those of Parker and Vissing-Jorgensen (2009, 2010), who find that the cyclicality of wages is higher for low-income households than for high-income households at all levels of the income distribution except for the top 1%, whose wages are much more cyclical than average. They find that these top 1% of earners are widely dispersed across industries, however, which makes it unlikely to expect they would affect the industry-level patterns which are the focus of the current paper.
4 The role of displacement costs for workers in determining risk sharing between workers and firms also features prominently in the work of Lustig et al. (2011), who study how the portability of organizational capital by managers affects their compensation dynamics.
2.1. Why industry-level data?

Why should one use industry-level data, as opposed to individual-level, occupation-level, or firm-level data? The answer is that industry-level data provide independent time series of both the compensation received and the output produced by category of worker, for a set of worker categories that comprise the aggregate. While in principle individual-level time series could provide such data, in practice no broad sample of workers does. For example the Panel Study of Income Dynamics (PSID) and Current Population Survey (CPS) provide data on worker wages over long time periods, but not the value of output produced by those workers. Occupation-level data do not solve the problem either, as there is no available data to our knowledge on the value of output produced by occupation categories. While firm-level data coming from matched worker and firm data would be ideal in principle, in practice there no are publicly available data sets for the United States with both value added and wage data for broad sections of the workforce over long time horizons.\(^5\)

2.2. Description of industry data

The industry data on labor productivity and wages come from the GDP-by-Industry Accounts, constructed by the US Bureau of Economic Analysis (BEA). Our main analysis employs the longest set of industry time series available, which contains annual industry-level measures of value added, labor hours, and compensation of labor between 1947 and 1987. Industries are classified according to 2-digit 1972 Standard Industrial Classification (SIC) codes. Excluded are the public sector, agriculture industries, and others for which market prices are not readily measured, ending up with 48 industries.

The measure of wages used is the total compensation of labor, including all salaries, bonuses, contributions to medical and pension plans, and any other compensation that is not in-kind. Average wages are computed by dividing total industry wages by full-time-equivalent (FTE) employees, which provide a measure of hours worked. The measure of labor productivity used is value added divided by FTE employees. Both the wage and productivity series are deflated by the Consumer Price Index. To capture the relatively high-frequency component in our variables productivity and wages in each industry are deflated using a Hodrick–Prescott (HP) filter with smoothing parameter \(\lambda = 100\).

Other industry-level variables come from the Current Population Survey (CPS). The skill level of an industry is proxied by the percent of employees that have completed college in 1987, which is the last year in our time series.\(^6\) Our study also makes use of measures of unionization rates by industry, which are calculated from the 1987 CPS, and median job tenure, which is compiled by the Bureau of Labor Statistics (BLS) using CPS data.

The measures of displacement costs come from the Displaced Workers Survey (DWS), which is a supplement to CPS. The data come from 1986, which is the most recent survey conducted during our sample period. Our baseline definition of displaced workers is all workers who were separated from their employers due to (i) insufficient demand for the worker’s services, (ii) the worker’s position being abolished, or (iii) the worker’s plant closing.\(^7\) Displacement costs in an industry are measured by computing, for each full-time displaced worker, the log of the weekly wage in the worker’s new job minus the log of the weekly wage in her previous wage, and then averaging across workers. The resulting displacement-cost measures represent the fraction of a typical worker’s wage that would be lost if she were exogenously removed from her current match and left to find a new job.

2.3. Summary statistics of industry data

Table 1 displays some simple summary statistics of our industry data. All statistics are weighted by industry employment. The basic observation in the table is that there is a lot of heterogeneity across industries for most characteristics. While in the average industry 67% of workers are college graduates, the range runs from 59% to 84%. Thus, the average worker skill level varies substantially across industries. Median job tenure averages just above 3 years, and ranges from 2.4 to 4.7 years. Unionization rates vary enormously across industries, with an average of 15%, but a standard deviation of 12%, and a range running from just 1% to 42%.

Next, the table reports the cyclical properties of the time series of wages and productivity. One measure of the persistence of productivity shocks is the autocorrelation of the productivity series. The average autocorrelation is 0.48, with a range running from 0.36 to 0.65. The volatility of wages, computed as the standard deviation of the log deviation of wages from trend, averages just under 2%, with a standard deviation of 0.6%, and a range that runs from 1.4% to 2.8%. Interestingly, the volatility of productivity is higher on average than the volatility of wages, and exhibits much more

\(^5\) Guiso et al. (2005) use matched worker and firm data from a unique sample of Italian firms. Their findings at the firm level are consistent with our findings at an industry level. For the U.S., the Longitudinal Research Database has matched worker-firm data available, but only for a sample of firms in the manufacturing industry, which constitutes less than 15% of aggregate employment. Compustat has some firm-level data on worker compensation, but it does not have data on value added.

\(^6\) Industries in the CPS for 1987 closely (but not exactly) correspond to 2-digit 1972 SIC codes. Industries are matched follow the NBER’s suggested industry bridge described in the Merged Outgoing Rotation Group (MORG) documentation.

\(^7\) Two narrower alternative definitions of displaced workers are also considered: (1) those workers who lost their job due to insufficient demand for their services or their plant closing, and (2) those workers who lost their job due to a plant closing. As shown in Section 2.6 below, our results hold for all three of these measures.
variation across industries. The volatility of productivity is 4% in the average industry, with a standard deviation of 3.2%, and a range running from 2.4% to 7%. As one frame of reference, the volatility of aggregate wages and productivity for this period are 1.1% and 1.5%, respectively. The fact that productivity is so much more volatile on average than wages suggests that workers in most industries are receiving wages that are smoothed relative to productivity. The next section presents a more formal measure of the degree of wage smoothing present in each industry.

2.4. Our measure of wage smoothing

The amount of wage smoothing in industry \( j \) is measured as \( \varepsilon_j \) in the linear model:

\[ w_{jt} = \varepsilon_j p_{jt} + u_{jt}, \tag{1} \]

where \( w_{jt} \) and \( p_{jt} \) are average wages and labor productivity in industry \( j \) at time \( t \), each expressed in log deviation from trend, and \( u_{jt} \) is an error term. Eq. (1) is estimated for each industry using OLS. Our wage-smoothing measure \( \varepsilon_j \) has the interpretation of the elasticity of wages in deviation from trend with respect to productivity in deviation from trend. This elasticity is referred to as the wage-productivity elasticity throughout the paper. Industries with lower wage-productivity elasticities are those with relatively more wage smoothing, and industries with higher elasticities have less smoothing.

To illustrate our measure, Fig. 1 plots de-trended wages and productivity in two select US industries. Each plot in the figure shows value added per worker (green dotted lines) and average wages (blue solid lines) expressed in log deviations from trend. For expositional purposes the figure plots two industries that display clear differences in their degrees of wage smoothing. The wage-productivity elasticity in rubber and plastics manufacturing is 0.19, indicating a high degree of wage smoothing, while that in apparel manufacturing is 0.51, indicating a lower degree of wage smoothing.

Table 1

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Mean</th>
<th>Median</th>
<th>Std</th>
<th>5th</th>
<th>95th</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent college graduate</td>
<td>67</td>
<td>63</td>
<td>8</td>
<td>59</td>
<td>84</td>
</tr>
<tr>
<td>Median tenure (years)</td>
<td>3.3</td>
<td>2.7</td>
<td>1.4</td>
<td>2.4</td>
<td>4.7</td>
</tr>
<tr>
<td>Unionization rate (%)</td>
<td>15</td>
<td>8</td>
<td>12</td>
<td>1</td>
<td>42</td>
</tr>
<tr>
<td>Autocorrelation of productivity</td>
<td>0.48</td>
<td>0.48</td>
<td>0.08</td>
<td>0.36</td>
<td>0.65</td>
</tr>
<tr>
<td>Volatility of wages (%)</td>
<td>1.9</td>
<td>1.9</td>
<td>0.6</td>
<td>1.4</td>
<td>2.8</td>
</tr>
<tr>
<td>Volatility of productivity (%)</td>
<td>4.0</td>
<td>3.1</td>
<td>3.2</td>
<td>2.4</td>
<td>7.0</td>
</tr>
</tbody>
</table>

Note: The statistics are for the cross-section of U.S. industries using data from the BLS (tenure and unionization), the CPS (percent college graduate), and BEA’s value added by industry accounts for 1947–1987 (the rest).
of smoothing, while in apparel manufacturing, the wage-productivity elasticity is 0.51. As is apparent in the figure, wages in apparel manufacturing are considerably more responsive to a change in productivity than in rubber and plastics.

Table 2 presents summary statistics for these elasticities for all industries, as well as for just service industries and just manufacturing industries. Services are defined to be all industries in our data set that do not constitute manufacturing, mining, or mining-related industries. The statistics are again weighted by industry employment. The first thing to take away from the table is that the mean and median elasticities are roughly comparable across manufacturing and services, with the overall average elasticity equal to 0.40, compared to 0.27 in manufacturing and 0.44 in services. The second finding, and perhaps the more interesting one, is that both services and manufacturing exhibit large variation in elasticities, with standard deviations of around 0.15 and 90-percentile ranges from 0.05 to 0.50 in manufacturing and from 0.06 to 0.59 in services. These results show that there have been vast differences in wage smoothing across industries of all types over the post–war period. The next section turns to the question of which types of industries tend to have the highest degrees of smoothing.

2.5. High-skilled industries have the most wage smoothing

This section details our main empirical finding with regard to wage-productivity elasticities, namely that elasticities tend to be lower in industries with higher average skill levels.

Fig. 2 plots the industry wage-productivity elasticities against our measure of the skill level: the percent of industry workers completing college. Each “bubble” represents one industry, and the size of each bubble is proportional to industry employment. The main feature of the graph is the strong negative relationship between the percent of workers that finished college and the elasticity, demonstrating that industries with higher skill levels tend to get the most smoothing. The employment-weighted correlation across industries is −0.58, with a P-value of 0.01.

The negative correlation between the wage-productivity elasticity and skill level shows up in two other prominent industry-level data sets as well. The first is for BEA industries defined according to the SIC 1987 classification of industries, available from 1987 to 1997. The second is for ISIC industries available in the OECD’s Structural Analysis database (STAN), for 1970 through 2000. Table 3 shows the correlations between the wage-productivity elasticity and percent graduating college in each data set. For comparability the results are reported for our main set of industry time series, namely 1947–1987 using 1972 SIC codes. The table shows that in all cases the correlation between the wage productivity elasticity and the skill level is negative. The correlation is −0.66 in the OECD STAN database, with a P-value of 0.01, and −0.38 in the BEA data from 1987 to 1997, with a P-value of 0.04. For comparison, the correlation in our primary data set, the BEA data from 1947 to 1987, is −0.58 with a P-value of 0.01. These results allow us to conclude that the correlation is measured fairly precisely and not particular to our main industry data.

2.6. High-skilled industries have higher displacement costs

This section documents an additional fact which will be useful in understanding the relationship between industry wage smoothing and average skill level. In particular, industries with more skilled workers on average have higher costs of job displacement than other industries.

Table 4 shows the cross-industry correlations of average skill level, again defined as percent of workers that are college graduates, with average displacement costs. Correlations are weighted by industry size, defined by FTE employees. The first row of Table 4 shows that the correlation of our baseline displacement cost measure and the average skill level is 0.41, meaning that workers in industries with higher average education levels have higher percent drops in wages after an exogenous displacement. The P-value is 0.004, showing the correlation is statistically significant from zero. The second and third rows shows that the correlation between skill level and two alternative measures of displacement costs. These are

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Notes:

8 The standard errors of the elasticity estimates are small in most cases: on the order of 0.05 or less, without substantial variation across industries.

9 Section 4 to follow presents (multiple) correlations of wage-productivity elasticities and other industry characteristics.

10 Other calculations show that this correlation is present in industry-level data in several other OECD countries, and using alternative measures of the skill level, such as the average wage or percent of industry workers that are high-school graduates. The correlation is also present in the U.S. data when not weighting, and when de-trending with alternative smoothing parameters. For brevity these calculations are omitted from the paper, but can provide them upon request.

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the wage loss of (1) workers who lost their jobs due to either insufficient demand for the worker’s services or a plant closing, and (2) workers who lost their job due to a plant closing. The correlation from these two alternate measures are 0.31 and 0.28, with $P$-values of 0.01 and 0.06. This suggests that by any of these measures, workers in industries with higher skill levels have higher displacement costs.\(^\text{11}\)

Table 3
Correlation of wage-productivity elasticity and skill level.

<table>
<thead>
<tr>
<th>Data source</th>
<th>Industry definition</th>
<th>Industries</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>OECD STAN, 1970–2000</td>
<td>ISIC, Rev 3.</td>
<td>51</td>
<td>$-0.66 (0.01)$</td>
</tr>
<tr>
<td>US BEA, 1947–1987</td>
<td>SIC 1972 definition</td>
<td>48</td>
<td>$-0.58 (0.01)$</td>
</tr>
<tr>
<td>US BEA, 1987–1997</td>
<td>SIC 1987 definition</td>
<td>49</td>
<td>$-0.38 (0.04)$</td>
</tr>
</tbody>
</table>

Note: Correlations are between the percent of the industry’s workers that graduate college and the industry wage-productivity elasticity, defined as the elasticity of industry average wages to value added per worker, and is calculated using the BEA’s value added by industry accounts for 1947–1987.

Table 4
Industry correlations of average displacement costs and skill levels.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation with average skill level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement costs (baseline)</td>
<td>0.41 (0.004)</td>
</tr>
<tr>
<td>Displacement costs (alternative 1)</td>
<td>0.31 (0.01)</td>
</tr>
<tr>
<td>Displacement costs (alternative 2)</td>
<td>0.28 (0.06)</td>
</tr>
</tbody>
</table>

Note: Correlations are between the percent of the industry’s workers that graduate college and the percent wage loss for industry workers after a displacement using the three definitions of displaced workers.

The existing literature has drawn similar conclusions. Carrington and Zaman (1994) and Jacobson et al. (1993) use earlier data to study displacement costs in different sets of U.S. industries. They both find that industries with higher average wages are those where workers face higher average displacement costs after separations.

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3. Simple model of risk sharing within the firm

This section builds a simple model of risk sharing within the firm. Risk sharing in the model occurs when a worker receives a wage that is less volatile, or smoother, than the value of their output. The model predicts more wage smoothing when displacement costs for workers upon separation are higher. Thus, given the fact laid out in Section 2.6, the model helps understand why industries with more skilled workers tend to receive smoother wages. Our model is based on that of Thomas and Worrall (1988), who study risk sharing between a worker and firm under two-sided limited commitment. Proofs for all results are available in Appendix.

3.1. Environment

A risk-averse worker and risk-neutral firm are matched. The worker prefers higher values of expected discounted utility:

$$U_0 = E_0 \sum_{t=0}^{\infty} \beta^t u(c_t)$$

(2)

where $E_0$ is the expected value operator at time 0, $c_t$ is consumption, and $\beta \in (0, 1)$ is the worker’s discount factor. Workers are endowed with one unit of labor each period which they supply inelastically to the firms for a wage $w_t$. There are no asset markets or storage possibilities, and so the worker’s consumption each period equals her wage: $c_t = w_t$. Workers have constant relative risk aversion (CRRA) preferences: $u(c_t) = c_t^{1-\sigma}/(1-\sigma)$, where $\sigma$ captures the degree of relative risk aversion.

The assumption of two sided limited commitment is made to deliver the desirable property that wages increase in response to higher productivity and decrease when productivity falls over the business cycle, as observed in the data. Alternatively, assuming one-sided limited commitment in which only the worker can walk away from the contract (as in Harris and Holmstrom, 1982; Beaudry and DiNardo, 1991), generates the feature that wages only increase over time.\(^\text{13}\)

The firm operates a constant-returns technology that uses labor as the sole input to produce output $y_t$. The firm keeps the output, which it sells for a (normalized) price of 1, and pays the worker a wage $w_t$. The firm prefers higher values of expected discounted profits

$$\Pi_0 = E_0 \sum_{t=0}^{\infty} \beta^t (y_t - w_t).$$

(3)

At the beginning of each period $t$ the worker’s productivity $p_t$ is realized. Productivity values live in the set $\mathcal{P} = \{p^1, p^2, \ldots, p^n\}$ where $p^i < p^j$ for $i < j$. Productivity evolves as a first-order Markov chain, where $x_{p, p'}$ is the probability of transition to state $p$ from state $p'$. The production function is

$$y = F(p; \theta, d) = p(1 - d(1 - \theta))$$

where $\theta \in [0, 1]$ represents whether the worker has been displaced or not and $d \in [0, 1]$ is the worker’s displacement cost in the form of lost productivity for one period. Hence, the worker productivity is $p$ when she has not been displaced and $p(1 - d)$ when she has been displaced. If both parties decide to stay in the match then output $y$ is produced, and the worker gets wage $w$. Either party may leave the match after $p$ realizes, however, in which case they both get their respective outside options. Let $\Pi(p)$ denote the value of the firm’s outside option in productivity state $p$. If the firm breaks the match it can match up with a new worker, but the new worker does not trust the firm and will only accept a wage equal to her output in each period. Thus, $\Pi(p) = 0$ for any state $p$.

The worker’s outside option is to join another firm. Let $V(p)$ denote the worker’s outside option in state $p$. In addition to the displacement costs “paid” by the worker who leaves, the new firm will not trust the worker and will pay her a wage each period exactly equal to her output (as in Thomas and Worrall, 1988).\(^\text{14}\) Her outside utility can be expressed in state $p_t$, as:

$$V(p) = u(p(1 - d)) + \beta \sum_{p'} x_{p, p'} V(p')$$

(4)

\(^{12}\) Mortensen and Pissarides (1994) type search models have been used extensively to model long term relationships between workers and firms, but these models typically do not incorporate a theory of wage change in ongoing matches, making them less useful for understanding our empirical findings. One notable exception is the work of Rudanko (2009), who embeds the Thomas and Worrall (1998) model into a Mortensen–Pissarides search model. In her paper and ours, the elasticity of wages to productivity arises endogenously because of a limited commitment problem between workers and firms.

\(^{13}\) An exception is the model of Krueger and Uhlig (2006), who assume that the firm’s discount factor is larger than that of the worker.

\(^{14}\) This “extreme” outside option is assumed for expositional purposes since it provides the most transparent link between outside option values and size of displacement costs. The comparative statics relating wage smoothing to displacement costs are present with “less extreme” punishments, such as a single period of punishment on spot markets followed by risk sharing in the next match, as long as displacement costs lower the worker’s value of working on spot markets.
3.2. Wage contracting problem

One can now state and solve the optimal wage contracting problem in this environment. To do so, it helps to formulate the firm’s profit maximization problem recursively and characterize its solution. For now assume that at the initial period the worker is entitled to a particular utility promise \( v \). Following Thomas and Worrall (1988), the contracts considered only are those that are self-enforcing, in the sense that in no state of the world does either party have incentive to break the contract.

Let \( \Pi(v,p) \) be the firm’s value function given a promised utility \( v \) for a worker in productivity state \( p \), which represents the maximized expected discounted profits from the match. The firm’s problem can be written as

\[
\Pi(v,p) = \max_{w \in \Omega(p)} \left\{ p - w + \beta \sum_{p'} P_{pp'} \Pi(v'(p'),p') \right\}
\]

subject to a promise-keeping constraint:

\[
v = u(w) + \beta \sum_{p'} P_{pp'} v(p')
\]

to worker self-enforcement constraints for every future state:

\[
v'(p') \geq \bar{V}(p') \quad \forall p'
\]

and to firm self-enforcement constraints:

\[
\Pi(v'(p'),p') \geq \Pi(p') \quad \forall p'
\]

The self-enforcement constraints guarantee that neither party ever wants to leave the contract.\(^{15}\) As in Thomas and Worrall, the optimal wages in the contract will be functions of current and one-period-prior productivities \((p,p_{-1})\), and the optimal wages will move as little as possible to satisfy the self-enforcing constraints.

**Proposition 1 (Thomas and Worrall, 1988).** Let \((p_{-1},p,p')\) be any productivity history in \( \mathbb{P} \times \mathbb{P} \times \mathbb{P} \), and let \( w = w(p,p_{-1}) \) and \( w' = w(p',p) \) be the optimal wage after history \((p,p_{-1})\) and \((p',p)\). Then

1. if \( w' > w \) then \( v'(p') = \bar{V}(p') \)
2. if \( w' = w \) then \( v'(p') \geq \bar{V}(p') \) and \( \Pi(v',p') \geq \Pi(p) \)
3. if \( w' < w \) then \( \Pi(v',p') = \Pi(p) \).

The proposition says that if wages rise from one period to the next, they do just so to the point where the worker is indifferent between staying in the match or not. Similarly, if wages fall they do so until the firm is indifferent. Finally, if wages stay the same then it must be the case that both parties at least weakly prefer the match to their respective outside options. In short, wages are smoothed as much as possible such that both parties are willing to stay in the match. This result highlights the fact that the amount of wage smoothing will depend in large part on the outside options for each party.

A useful implication of this proposition (also from Thomas and Worrall, 1988) is that optimal wages must lie in a particular interval for each productivity state. Formally, this can be written as:

**Proposition 2.** For all \( p \in \mathbb{P} \) there exists an interval \([w_w, w_p]\) such that

1. \( w(p,p_{-1}) \in [w_w,w_p] \) \( \forall p_{-1} \)
2. when \( w(p,p_{-1}) = w_w \) then \( v = \bar{V}(p) \), and
3. when \( w(p,p_{-1}) = w_p \) then \( \Pi(v,p) = \Pi(p) \).

This result says that the range of optimal wage always lives in an interval where the worker is indifferent between staying in the contract or not at the lowest wage in the interval, and the firm is indifferent at the highest wage in the interval.

3.3. Two-state environment

Consider a simple and transparent version of the model with two possible states: high productivity and low productivity. Later in Section 5, a version of the model with a richer productivity process is presented.

Let there be two states, high and low, with productivity \( p_h \) and \( p_l \) satisfying \( p_l < p_h \). Let \( x \in (0,1) \) be the probability that tomorrow’s state is the same as today’s, i.e. the persistence parameter in the transition matrix. Given some initial productivity state and a worker utility promise, it must be that there is one optimal wage for each state – independent

\(^{15}\) Section 5 presents and solves a richer version of the model in which separations occur endogenously.
of past history – once the productivity realization differs from the initial state the first time. Let \( w_H \) and \( w_L \) denote these history-independent optimal wages in the high and low states, respectively, and let the two intervals described in Proposition 2 be denoted \([w_L, w_H]\) and \([w_H', w_H]\) in states \( p_L \) and \( p_H \).

Then the following two cases are possible for wages, depending on whether or not the two intervals \([w_L, w_H]\) and \([w_H', w_H]\) overlap or not.

**Corollary 1.** If \( w_L \geq w_H \) then \( w_H = w_L \).

**Corollary 2.** If \( w_L < w_H \) then \( w_L = w_L \) and \( w_H = w_H \).

**Corollary 1** illustrates the case of perfectly smooth wages. To see this result, let \( w_L > w_H \) and take an arbitrary initial state (for exposition say \( p_L \)) and an arbitrary initial wage \( w_0 \) that satisfies Proposition 2. Once the state switches to \( p_H \), it is true by Proposition 1 that if \( w_0 < w_H \) then the wage rises until the worker’s self-enforcement constraint binds, i.e. until \( w = w_H \). But this wage is now incentive compatible in both states, and hence by Proposition 1 it remains constant for all future periods. If on the other hand \( w_0 \geq w_H \), then it is incentive compatible to both parties in both states to begin with, and hence it remains constant. Hence, if \( w_0 \in [w_H, w_L] \), it remains constant at all future periods. If \( w_0 < w_H \), as soon as productivity rises to \( p_H \), then wages are \( w_H \) forever after. Similarly, if \( w_0 > w_L \), as soon as productivity falls to \( p_L \), then wages are \( w_L \) forever after.

**Corollary 2** illustrates the case of imperfectly smooth wages. The intuition is as follows. Take an arbitrary initial state (for exposition again say \( p_L \)) and an arbitrary wage that satisfies Proposition 2. Once the state switches to \( p_H \), it is again true by Proposition 1 that the wage rises until the worker’s constraint binds, i.e. until \( w = w_H \). By Proposition 1 again it must be that while at \( p_H \) the wage remains constant. When \( p_L \) realizes the wage must fall until the firm’s constraint binds, i.e. until \( w = w_L \). Similarly, wages remain constant while in \( p_L \). When \( p_H \) realizes again, then \( w = w_H \).

Let \( V_L(w_L, w_H) \in \mathbb{R}^+ \) and \( V_H(w_H, w_H) \in \mathbb{R}^+ \) be the worker’s expected discounted utilities in states \( p_L \) and \( p_H \) under wages \((w_L, w_H)\). Similarly, let \( P_L(w_L, w_H) \in \mathbb{R}^+ \) and \( P_H(w_H, w_H) \in \mathbb{R}^+ \) be the firm’s expected discounted profits in the optimal contract in states \( p_L \) and \( p_H \). The optimal contract can then be pinned down by the following system of two equations and two unknowns, \( w_L \) and \( w_H \):

\[
\begin{align*}
V_L(w_L, w_H) &= \bar{V}(p_H) \\
V_H(w_H, w_H) &= \bar{V}(p_L) = 0
\end{align*}
\] (9)

Eq. (9) says that the worker is indifferent between the contract and her outside option in the high state. Eq. (10) says that the firm is indifferent between the contract and its outside option in the low state. From the definition of the elasticity in Eq. (1), the elasticity of wages to productivity in this two-state environment can be conveniently expressed as 

\[
e_{w,p} = (w_H - w_L)/(p_H - p_L).
\]

The next section analyzes how changes to the parameters of the productivity process affect this elasticity, and hence the extent of wage smoothing, in the optimal contract.

### 3.4. The average productivity does not affect wage smoothing

The first result of note is that the average productivity level does not affect the amount of wage smoothing in the optimal contract. Formally,

**Proposition 3.** Wage smoothing is independent of the average level of productivity.

To see this, imagine that \( w_L \) and \( w_H \) are the wages in the optimal contract under productivity values \( p_L \) and \( p_H \). Now imagine what happens under a productivity process that is scaled up by a factor \( x > 1 \), to \( x p_L \) and \( x p_H \). In this case, the value of the outside option, represented by the right-hand side of Eq. (9), is scaled up by a factor \( x^{1-\sigma} \) because of the assumption of CRRA preferences. In order to keep Eq. (9) satisfied, therefore, the left-hand side must be scaled up by a factor \( x^{1-\sigma} \). Because of CRRA preferences, this happens when the wages in the high and low state are each scaled up by a factor of \( x \). Thus, smoothing is unaffected by the change in average productivity.

**Proposition 3** implies that for standard representations of preferences, the productivity level alone is unable to account for the correlation between wage smoothing and the skill level, which captures (among other things) a level effect on worker productivity. One must therefore look for other characteristics of workers in higher skilled industries that could be associated with more wage smoothing. The next section considers one such candidate, which is the displacement costs of workers.

### 3.5. Higher displacement costs increase wage smoothing

The model’s main prediction of interest is that higher displacement costs lead to smoother wages in the equilibrium contract. Formally,

**Proposition 4.** Wage smoothing increases in displacement costs, \( d \).

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The intuition for this result is that higher displacement costs reduce the value of the worker’s outside option in either state. Thus, smoother wages are incentive compatible for the worker and firm and allow higher profits for the firm. In this two-state example, one can see from Eq. (9) that a rise in $d$ must lead to a reduction in the worker’s value in the high state. Thus, the optimal contract when $d$ rises will prescribe lower wages in the high state, and, to keep the firm indifferent in the low state, higher wages in the low state.

### 3.6. Characteristics of the productivity process and wage smoothing

Other components of the environment which could affect smoothing are the autocorrelation and volatility of the productivity process. This section characterizes the effect of the autocorrelation of productivity on the extent of smoothing, and then studies the role of productivity volatility on wage smoothing.

**Proposition 5.** Wage smoothing decreases in the autocorrelation of productivity, $\alpha$.

The intuition for Proposition 5 is as follows. When the productivity process is more persistent it is more tempting for workers to renege in high states and for firms to renege in low states. In high states, workers expect to be in the high state for a long time, and thus wages should be relatively high in high states to convince workers to stay in the contract rather than go to spot markets. Similarly, in low states, firms expect to be in the low state for a long time. Thus wages should be relatively low in low states to convince firms to stay in the contract. This implies that wages respond more to productivity in both high and low states, reducing wage smoothing.

**Proposition 6.** Consider a mean-preserving increase in the volatility of productivity, such that $p_t^b = p_t - z$ and $p_t^h = p_t + z$ for some $z > 0$. Wage smoothing increases if the discount factor is sufficiently high ($\beta > \overline{\beta}(z)$), and decreases if the discount factor is sufficiently low ($\beta < \overline{\beta}(z)$), for some $\overline{\beta}(z) \in (0, 1)$.

Intuitively, Proposition 6 says that higher volatility will increase wage smoothing if workers are sufficiently patient. The basic intuition is that for high discount factors, the higher volatility of the productivity process reduces the value of the workers’ outside option, and decreases the workers’ incentives to renege on the contract, allowing more smoothing. For low discount factors, in contrast, the higher productivity in the high state increases the value of the outside option, and decreases smoothing. The reason is that, with lower discount factors, workers place relatively higher value on the short-term benefits of reneging on the contract in the (now higher) high state, and relatively lower value on the long-term costs of having a more volatile consumption stream on spot markets.

### 4. Testing the model

This section returns to the industry-level data in order to test the model’s main prediction that higher displacement costs lead to smoother wages, helping explain the negative correlation observed between the industry skill level and wage-productivity elasticity. Specifically, it examines the extent to which the correlation between the percent of workers that are college graduate and the wage-productivity elasticity can be explained by industry differences in displacement costs. Finally, it asks how industry differences in productivity autocorrelation and volatility further explain the correlation.

#### 4.1. Regression results

Table 5 presents the results of cross-industry regressions of industry characteristics on the elasticity of wages to productivity. Each column represents one regression, and the observations are the 48 U.S. industries for which comparable data are available. Industries are once again weighted by their total number of employees, and $P$-values are reported beneath each coefficient in parentheses.

The first column shows, as a baseline, the results of a regression with just percent college graduate and a constant. The coefficient on percent college graduate is negative ($-1.122$) and statistically significant from zero, implying that industries with a higher fraction of workers that are college graduates have lower elasticities of wages to productivity. The coefficients suggest that a 10 percentage point increase in the percent of workers that are college graduates leads to a decrease in the wage-productivity elasticity of around $0.112$. This negative multiple correlation is consistent with the simple correlation of Section 2.

The second regression adds the measure of industry average displacement costs described in Section 2. As the model predicts, in Proposition 4, the coefficient on displacement costs is negative, meaning that industries with higher displacement costs have smoother wages (controlling for schooling level.) In spite of the potential noisiness of the displacement costs measures, the coefficient is statistically significant at the 1% level. Furthermore, the coefficient on percent college graduate drops from $-1.122$ down to $-0.797$ once displacement costs are added. The coefficient suggests that a 10 percentage point increase in the college graduate percent is associated with a decrease in the elasticity of around $0.078$. This suggests that higher displacement costs in higher skilled industries are an important determinant of their less elastic wages.
The third regression adds the volatility and autocorrelation of productivity as regressors. The coefficient on the autocorrelation suggests that industries with more autocorrelated productivity shocks (all else equal) have less wage smoothing. This is consistent with Proposition 5, which argues that more autocorrelated productivity shocks lead in the theory to less smoothing. The coefficient on volatility suggests that industries with more volatile productivity shocks (all else equal) have more smoothing. This is consistent with Proposition 6 for workers that are sufficiently patient such that an increase in the volatility of productivity means that working on spot markets is less attractive. Both coefficients are statistically significant at the 5% level, and the sign and significance of the displacement costs coefficient is largely unchanged. Interestingly, the coefficient on percent college graduate drops further to $0.581$, suggesting that higher productivity volatility, less autocorrelated productivity processes, and higher displacement costs in high skilled industries are important factors in explaining the simple correlation between skill level and wage elasticities across industries.

All in all, the coefficient on percent college graduate drops roughly in half from the first to third regressions, and the $R$-squared rises from 0.32 to 0.61. Two conclusions emerge from these regressions. First, this parsimonious set of industry characteristics explain the majority of the cross-industry variance in the responsiveness of wages to productivity. Second, roughly half the observed correlation between wage-productivity elasticities and skill levels are explained by industry variation in displacement costs and properties of industry productivity.

4.2. Robustness

Appendix A presents several additional regressions used to assess several alternative hypotheses about what drives the industry variation in wage smoothing. These regressions focus on the role of unionization, capital intensity of an industry, and differences between manufacturing and service industries. The results suggest that higher unionization leads, all else equal, to more smoothing, but the effects are small in magnitude and statistically insignificant one controlling for industry skill level. The same is true for the industry’s labor share in production, meant to capture capital intensity, and a manufacturing dummy, meant to capture potential quality differences in value added data between manufacturing and service industries (Bosworth and Triplett, 2004).

5. Richer model of risk sharing

This section introduces a richer model that allows for separations between the worker and firm and a more general productivity process. The richer model serves two purposes. First, it allows us to show that the model’s main prediction – that wage smoothing increases in displacement costs – holds under more general circumstances. Second, it provides an additional way of testing the model, using median tenure as a proxy for displacement costs.

5.1. Environment

As before, the worker preferences are given by (2) and the firm’s profits are given by (3). Differently than before, the production function is now stochastic:

\[ y = \max \left\{ p(x, \theta; d) = (p + \epsilon)(1-d(1-\theta)) \right\} \]

Table 5
Wage smoothing, schooling, and displacement costs.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Regression #</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td>Percent college graduate</td>
<td>-1.122 ***</td>
</tr>
<tr>
<td></td>
<td>(3.01e-05)</td>
</tr>
<tr>
<td>Displacement costs</td>
<td>-0.733 ***</td>
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<tr>
<td></td>
<td>(0.00187)</td>
</tr>
<tr>
<td>Volatility of productivity</td>
<td>0.363 **</td>
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<td></td>
<td>(0.0195)</td>
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<tr>
<td>Autocorrelation of productivity</td>
<td>0.733 nnn</td>
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<tr>
<td></td>
<td>(0.00187)</td>
</tr>
<tr>
<td>Constant</td>
<td>1.161 ***</td>
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<td></td>
<td>(7.68e-09)</td>
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<tr>
<td>Observations</td>
<td>48</td>
</tr>
<tr>
<td>$R$-squared</td>
<td>0.318</td>
</tr>
</tbody>
</table>

Note: Dependent variable is the wage-productivity elasticity; observations are U.S. industries. P-values are in parentheses: *$p < 0.1$, **$p < 0.01$, ***$p < 0.05$. 

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where \( p \) is the current realization of an “industry” productivity shock and \( \epsilon \in \mathbb{R}^+ \) is the current realization of an “idiosyncratic” productivity of the match. Here \( \theta \in \{0, 1\} \) represents whether the worker has been displaced or not, so that the worker’s productivity is \( p + \epsilon \) when she has not been displaced, and \( (p + \epsilon)(1 - \theta) \) when she has been displaced.

As before, aggregate productivity \( p \) follows a first-order Markov chain. Idiosyncratic productivity \( \epsilon \) is i.i.d. across matches and across time, following a distribution with mean 0 and standard deviation \( \sigma_\epsilon, \epsilon \sim f(0, \sigma_\epsilon) \). At the beginning of each period \( t \), productivity states \( p_t \) and \( \epsilon_t \) are realized. If both the worker and the firm decide to stay in the match then output \( y_t \) is produced, and the worker gets wage \( w_t \).

As before, denote \( \mathcal{P}_t(p) \) as the firm’s outside option when the aggregate productivity is \( p \), and assume that \( \mathcal{P}_t(p) = 0 \) \( \forall p \in \mathbb{P} \). Denote \( \mathcal{V}_t(p) \) as the worker’s outside option when the aggregate productivity is \( p \). Either party may leave the match after \( p + \epsilon \) realizes, in which case they both get their respective outside options (\( \mathcal{P}_t(p) = 0 \) and \( \mathcal{V}_t(p) \)). The worker knows \( p \) at the moment of separating, he does not know the idiosyncratic productivity \( \epsilon \) he will have in the new match.

Hence, the worker’s outside option in state \( p \) is
\[
\mathcal{V}_t(p) = E_v[u((p + \epsilon)(1 - \theta)) + \beta \sum_{p'} P_{p|p'} \mathcal{V}_t(p')]
\]

Let \( \Pi_t(v, p, \epsilon, s) \) be the firm’s value function from the match that represents the maximized expected discounted profits. This depends on the utility promised to a worker in case of continuation \( v \), the aggregate productivity \( p \), the idiosyncratic productivity \( \epsilon \) and a (previously chosen) separation decision \( s \in \{0, 1\} \). Let \( s = 1 \) denote the state when the match today was chosen to be separated in the current state, and \( s = 0 \) the state when the match today was chosen to continue in the current state. The firm’s problem can be written as
\[
\Pi_t(v, p, \epsilon, s) = \max_{s \in \{0, 1\}} \{v + (1 - s)[p + \epsilon - w + \beta E_{p, \epsilon} \Pi_t(v', p', \epsilon')] \}
\]

subject to a promise-keeping constraint:
\[
v = u(w) + \beta E_{p, \epsilon} V_t(p', \epsilon')
\]
to worker self-enforcement constraints for every future state:
\[
V_t(p', \epsilon') = s(p', \epsilon') \mathcal{V}_t(p') + (1 - s(p', \epsilon'))v(p', \epsilon') \geq V_t(p') \quad \forall (p', \epsilon')
\]
and to firm self-enforcement constraints:
\[
\Pi_t(v', p', \epsilon', s) \geq \mathcal{P}_t(p') \quad \forall (p', \epsilon')
\]

5.2. Wage smoothing and separation

Thus the firm chooses a wage for the current period, plus continuation values and separation decisions for the worker in all future states, in order to maximize profits. As before, wages in the optimal contract are smoothed:

**Proposition 7** (Thomas and Worrall, 1988). Let \( (h_{-1}, h, h') \) be any history of aggregate and idiosyncratic productivities and let \( w \equiv w(h, h_{-1}) \) and \( w' \equiv w(h', h) \) be the optimal wage after history \( (h, h_{-1}) \) and \( (h, h') \). Then, in case of continuation (i.e., \( s(p', \epsilon') = 0 \))

1. if \( w' > w \) then \( V_t(p', \epsilon') = \mathcal{V}_t(p') \)
2. if \( w' = w \) then \( V_t(p', \epsilon') \geq \mathcal{V}_t(p') \) and \( \Pi_t(p', \epsilon') \geq \mathcal{P}_t(p') \)
3. if \( w' < w \) then \( \Pi_t(p', \epsilon') = \mathcal{P}_t(p') \)

There are also states of the nature \( (p', \epsilon') \) in which it is better for the match to separate \( (s(p', \epsilon') = 1) \). This happens when both participation constraints (15) and (16) bind given promises \( v(p', \epsilon') \) and separation rules \( s(p', \epsilon') \). For an aggregate productivity \( p' \), there may be idiosyncratic productivities \( \epsilon' \) low enough such that \( \Pi_t(V_t(p', \epsilon')) < \mathcal{P}_t(p') \). In this case the firm’s profits are lower than the firm’s outside option, even when the worker just his outside option. This defines an \( \epsilon^*_p \) for each aggregate productivity level \( p' \), below which the match will separate. Then \( F(\epsilon^*_p) \) defines the ex-ante probability of separation for each aggregate productivity level \( p \).

In the model, displacement costs increase average tenure in the match. Formally:

**Proposition 8.** As displacement costs increase, the probability of separation, \( F(\epsilon^*_p) \), decreases for all aggregate states \( p \).

The intuition for Proposition 8 is that higher displacement costs reduces the worker’s outside options in all possible productivity states and all idiosyncratic shocks, which reduces the set of states in which a separation is desirable. With this proposition in hand, one can now characterize how displacement costs affect wage smoothing under the optimal contract in this more general setting with many possible productivity levels and positive separation probabilities.

**Proposition 9.** Wage smoothing is increasing in \( d \), i.e., \( \partial \epsilon_{w, p, \epsilon}/\partial d < 0 \).
Higher displacement costs increase wage smoothing for two reasons. First, they reduce the value of the worker’s outside option, \(V(p')\), for all possible future productivity levels \(p'\). With poorer outside options, the worker’s constraints bind less. Second, they increase the expected tenure in the match, as demonstrated in Proposition 8. With a higher expected length of the match, both parties are willing to exchange future shares of the expected match surplus in exchange for current payments, as is required for risk sharing.

6. Testing the richer model

This section uses the richer model to ask whether the tests of the model in Section 4 are robust to an alternative measure of displacement costs, namely median job tenure. Median job tenure is worth considering for two reasons. First, the richer model above predicts that higher displacement costs lead to lower separation rates and hence higher tenure. Second, the measures of median tenure are plausibly more precisely estimated than the displacement cost measures coming from the DWS, since the median job tenure estimates available (from the BLS) are constructed from the full CPS sample, which has a larger sample sizes.

Table 6 shows the results of our regressions with median industry tenure as proxies for displacement costs. Regression 1 shows, for reference, the results of a regression with just percent college graduate and a constant. Regression 2 adds median tenure, and shows that higher tenure is, as the theory predicts, associated with lower expected wage-productivity elasticity. An additional year of median tenure implies an expected elasticity that is lower by 0.038, and the coefficient estimate is statistically significant. Once tenure is added, the coefficient on percent college graduate falls from 1.122 to 0.857, and the \(R^2\)-squared on the regression rises from 0.32 to 0.43. As before, the displacement cost measure substantially weakens the correlation between skill level and wage elasticity of productivity.

Regression 3 adds volatility and autocorrelation of productivity to the set of independent variables. The estimates show that higher volatility of productivity is associated with lower elasticities, higher autocorrelation is associated with higher elasticities, and tenure is again associated with a lower expected elasticity. Compared to the baseline (Regression 1), the coefficient on percent college graduate drops to 0.714, and the \(R^2\)-squared rises to around 0.55. This finding is consistent with those of Section 2.4.

Columns 4 and 5 redo the results with both the direct measure of displacement costs and median job tenure. When both measures are included with a constant, then both show up as having a negative effect on the wage-productivity elasticity, as the theory predicts. The coefficient on percent college graduate falls to 0.675. Column 5 adds volatility and autocorrelation of productivity. While the signs of the coefficients remain unchanged, the coefficient on median tenure is now smaller in magnitude and statistically insignificant. Nevertheless, the coefficient on displacement costs remains large in magnitude and significant. The coefficient on college graduate falls further to 0.544, which is roughly half its size in Regression 1, and the \(R^2\)-squared rises to 0.62. These results suggest that the test of Section 4 are robust to this alternate measure of displacement costs.16

### Table 6

<table>
<thead>
<tr>
<th>Variable</th>
<th>Regression #</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>Displacement costs</td>
<td>(3.01e–05)</td>
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<tr>
<td>Median tenure</td>
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<td>(R^2)-squared</td>
<td>0.318</td>
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</table>

Note: Dependent variable is the wage-productivity elasticity; observations are U.S. industries. P-values are in parentheses.

*** \(p < 0.01\).
** \(p < 0.05\).
* \(p < 0.1\).

16 Another important testable implication of the model is that higher skilled workers have higher average tenure at their jobs, since their separation rates are lower. In fact evidence from industry and other data strongly supports this prediction. Using our data, the cross-industry correlation of percent college graduates and average tenure is 0.61 with a \(P\)-value of 0.01. Fallick and Fleischman (2004) show that these patterns are also corroborated using the CPS job turnover data.
7. Conclusion

Which types of workers tend to get the most insurance within the firm? We argue that high-skilled workers get relatively more than low-skilled workers. As evidence, we document that average wages in industries with low average levels of schooling tend to respond relatively more to industry productivity shocks than they do in higher skilled industries. Why? Our hypothesis is that low skilled jobs are associated with lower displacement costs, which leads, under limited commitment, to less risk sharing between workers and their employers. Industry data supports the idea that lower displacements costs for low-skilled workers are an important factor in their relative lack of insurance coming from within the firm.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jmoneco.2011.11.009.

References
