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Task Assignment over the Business Cycle

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In this article, I evaluate the hypothesis that firms respond to negative demand shocks by assigning workers to tasks that require less skill than the tasks they normally carry out. Using changes in employment in state-industry cells as a measure of demand conditions facing individual firms, I provide evidence in favor of the hypothesis. Furthermore, the skill requirements of the tasks carried out by workers are procyclical. The results are consistent with a specific capital model where employers move workers between tasks so that layoffs are concentrated on workers with low levels of firm-specific human capital.

I. Introduction

While there has been considerable research on worker mobility between firms, little is known about the determinants of worker mobility between tasks within the firm.¹ However, understanding task assignment within the firm is surely crucial to understanding promotions, human capital development, and turnover behavior. In this article, I investigate whether firms react to cyclical downturns by assigning workers to tasks that would normally be carried out by less-skilled workers. I show that

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¹ There is a small empirical literature about the workings of internal labor markets. It includes contributions from Rosenbaum (1979), Lazear (1992), Baker, Gibbs, and Holmstrom (1994), McCue (1996), Solon, Whatley, and Stevens (1997), and Wilson (1997).

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specific human capital models predict this form of cyclical task adjustment and I use these models as a framework to guide the empirical work.

The cyclical task assignment is of great relevance to the debates about the procyclicality of wages and productivity. Recent research on labor productivity has stressed the importance of accounting for changes in average worker quality over the business cycle.² However, the productivity of a worker within any match will depend on the tasks that the worker is carrying out. Thus, in order to measure changes in labor productivity, one needs to know not only how worker quality varies over the business cycle, but also how the tasks carried out by these workers vary. Cyclical task adjustment is also relevant to wage cyclicality because wages may depend on the tasks carried out by workers.³

The presence of firm-specific human capital is central to many of the models of labor market contracting that have generated implications for the cyclical behavior of employment, hours, and wages for workers of different skill levels.⁴ In this article, I develop a specific capital model that shows how firms may respond to negative demand shocks by assigning workers to tasks that require less skill than the tasks they normally carry out. While other implications of specific capital have been tested and verified, the implications of specific capital for this specific form of labor hoarding have remained unexplored.

Using changes in employment in state-industry cells as a measure of demand conditions facing individual firms, I provide evidence that employers respond to negative demand shocks by assigning workers to tasks that require less skill than the tasks they normally carry out. Furthermore, I show that the task assignment of high-tenure workers is least affected by changes in state-industry employment. Next, I examine the cyclical task assignment using the state unemployment rate as a cyclical measure. The empirical results show that the skill requirements of the tasks carried out by workers are procyclical but wages are quite acyclical. The results are consistent with the specific capital model where employers move workers between tasks so that layoffs are concentrated on workers with low levels of firm-specific capital.

² Recent papers on cyclical productivity include Bils and Cho (1994), Gordon (1990), Shapiro (1993), Basu (1996), and Burnside and Eichenbaum (1996).

³ Recent work has questioned the assumption that wages are sticky within matches. Solon, Barsky, and Parker (1994) have shown that the wages of job stayers display significant procyclicality. McLaughlin (1994) has presented evidence that nominal wage cuts are widespread for job stayers. The extent to which these are spuriously caused by measurement error is still in dispute (Akerlof, Dickens, and Perry 1996; Card and Hyslop 1997; Kahn 1997; Altonji and Devereux 1998).

⁴ Surveys of this literature have been provided by Rosen (1985) and Malcomson (1997).

Despite the importance of these issues, the empirical literature on task assignment over the business cycle in the United States is rather sparse. Using data from the Ford and Byers companies from the 1920s and 1930s, Solon et al. (1997) find that these firms increased hiring standards to job titles in recessions. Furthermore, the bulk of wage cyclicality was a result of workers changing job titles rather than changing wages within a job title. Wilson (1997) uses recent data from two companies to further analyze the issues. She finds no evidence that the wages of position changers are more cyclical than the wages of position stayers and finds mixed evidence for the hypothesis that the rate of position changing is procyclical.

I add to this literature in several ways. Since both of these papers are case studies, the extent to which their results generalize is in some doubt. By using a nationally representative sample of workers, I get results that apply to more than just individual companies. Furthermore, previous analysis focuses on the effects of the business cycle on one outcome measure—wages. I examine how labor market shocks affect the skill requirements of the tasks that workers are assigned and interpret the results using the framework of a specific capital model. Finally, by using disaggregated state-level unemployment rate data and state-industry employment data, I can control for year and state effects that might otherwise bias results.

The layout of this article is as follows: In Section II, I describe the specific capital model that I use as a framework to analyze the data, and in Section III, I describe the estimation methodology. In Section IV, I describe the data, and in Section V the results are presented. Section VI examines the cyclicality of task assignment. In Section VII, I examine the implications of rigid-wage models of job title changes, and Section VIII concludes.

II. The Specific Capital Model

In this section, I develop a specific capital model of task assignment over the business cycle.⁵ The assumptions of the specific capital model are that workers in more senior positions in the firm tend to have more firm-specific human capital and that firms capture some of the rents that result from the accumulation of firm-specific capital. The mechanism works as follows. Suppose the firm experiences a demand shock and so has to reduce output and employment throughout the firm. One strategy is to fire the requisite number of workers from all positions and then hire suitably qualified workers from the outside labor market for these positions when a positive demand shock implies that more workers are optimal. This strategy involves no

⁵ There is a huge literature on specific-capital models and labor hoarding starting with Oi (1962).

changes in the tasks particular workers carry out within the firm. An alternative approach is to fire the workers with the lowest levels of firm-specific capital, who by assumption will be primarily located in the lower-level positions. Then, by assigning some workers to lesser positions, the firm can reduce employment in higher-level positions. Hence, the firm can adjust output while maintaining its most valuable workers. The cost of this strategy is in terms of the temporary mismatch that results from workers being assigned to tasks to which they are not optimally suited. In the appendix, I develop a simple model of this process. I show that this strategy will be more profitable if negative shocks are temporary and the gain from having experienced skilled workers in good times outweighs the cost of these workers being mismatched in bad times. From the perspective of an individual worker, the model implies that workers are assigned to tasks that require less skill in bad times.⁶ For example, in good times an administrator may have a secretary type letters, but in bad times, the administrator may type himself.

This process of quality adjustment is a form of labor hoarding, in that firms are hoarding workers with a lot of specific capital and letting go workers who do not have such capital. Labor hoarding is typically defined as occurring when firms assign workers to nonproduction tasks such as maintenance and training when there is no production work for them to do (Gordon 1990).

The specific capital model has no strong implication for wage adjustment. As I show in the appendix, the conclusion of the simple specific-capital model is that the wage may be greater than productivity while the worker is being hoarded and less than productivity at other times. Thus, movement in wages may not fully reflect movement in the type of tasks performed. More generally, there is a huge literature on contracting that argues that wages are likely to be invariant to labor market shocks for long periods of time (see Rosen [1985] for a survey). Thus, short-term reassignments of tasks are unlikely to lead to wage changes. Therefore, to test for cyclical changes in task assignment, it is necessary to look beyond wage changes and to see how direct measures of task quality vary over the business cycle. The specific capital model implies that within a worker-firm match the quality of the tasks carried out by the worker will be higher in good times.

III. Empirical Implications and Estimation Methodology

The model predicts that when firms are laying off workers, they will tend to assign remaining workers to tasks that require less skill. Since the data set I use has no measure of firm-level employment changes, I use

⁶ If turnover and hiring costs are higher for workers who are at higher levels in the firm, a similar rationale for hoarding workers at high levels in the firm exists.

employment by state industry as a measure of demand conditions facing the firm. The model implies that when employment in the state industry is lower than usual, the skill requirements of the tasks carried out by employed persons will also be lower than usual.

The specification to be estimated is

$$z_{ijt} = \beta_1 + \beta_2'x_{it} + \beta_3E_t + \beta_4'YEAR_t + \beta_5'STATE + f_{ij} + f_i + \varepsilon_{ijt}. \quad (1)$$

The variable z_{ijt} refers to task quality, E_t is employment at t in the state-industry cell, $YEAR_t$ is a vector of year dummies, and $STATE$ is a vector of state dummies. The vector x_{it} is a vector of worker characteristics. The subscript i refers to person, j refers to match with employer, and t refers to time. I have modeled task quality as having a match-specific component (f_{ij}) because the tasks a worker is likely to be assigned depend on the employer for whom he works. Since workers are likely to be in worse jobs in loose labor markets, the match-specific component is likely to be negatively related to state-industry employment. However the individual-specific effect is likely to be negatively correlated with state-industry employment, because better workers are in the labor market in recessions (Solon, Barsky, and Parker 1994). Intuitively, the direction of the bias on β_3 with ordinary least squares (OLS) is ambiguous. Thus, I estimate the model by fixed effects, taking deviations of all variables from match means. This procedure washes both of the fixed components from the regression and leaves the error term uncorrelated with state-industry employment. By definition, this procedure involves omitting jobs that are present in the data for one period.⁷ Because I use fixed effects, I limit the controls to time-varying variables. These are experience, experience squared, experience cubed, tenure, tenure squared, and indicator variables for married and college degree.

Tenure Interactions

The task adjustment model in most circumstances implies that workers with higher tenure, which is a proxy for firm-specific capital, should have task assignment within matches that is less correlated with state-industry employment.⁸ More highly tenured workers will experience less task

⁷ Random effects estimation gives very similar coefficient values for state-industry employment. However, Hausman tests reject the hypothesis that all the coefficient values in the random effects models equal the coefficients in the fixed effects models.

⁸ This statement must be qualified by acknowledging that tenure may also proxy for unobservable characteristics of the worker and of the position held. Indeed, my maintained assumption is that workers with more specific capital tend to be at higher levels in the firm. Workers with high tenure may tend to be in

quality adjustment than less tenured workers. The following example demonstrates this point. Consider a firm with 1,000 employees that is partitioned into 10 departments of 100 workers.⁹ The departments are ranked hierarchically by skill requirement. The requirement is 1 in the lowest department and 10 in the highest. Now, assume that this firm is hit by a demand shock and decides it must lay off 1% of its workers, one from each department. If it decides to lay off only workers from the lowest department, and demote workers to make up the numbers in all departments, then one can easily calculate that the average remaining worker is placed in a department that is 0.8% less skilled than the department he was previously in. In the process, the firm has maintained all of its upper-level workers. Workers who were in the second lowest department are now, on average, in departments that require 5% less skill than the departments they were in. However, workers that were in department 10 are now, on average, in departments that are 0.1% less skilled than the departments they were in. Hence, the model predicts that workers at higher levels in the firm will have task assignment that is less affected by demand conditions facing the firm.¹⁰ Assuming that workers at higher levels in the firm also have greater tenure on average gives the result that the task assignment of high-tenure workers should be less affected by demand conditions.¹¹ Thus, the second specification I estimate adds interactions of tenure and state-industry employment to the task assignment equations (eq. [1]).

positions that are not cyclically sensitive and experience less cyclical wage and quality adjustment for this reason. Also, if average tenure levels vary widely across firms, workers with relatively high tenure may not have relatively high tenure compared with other workers within their firms. Despite this problem, both Raisian (1983) and Keane and Prasad (1993) have used tenure as a proxy for specific capital in studying whether workers with specific capital have more cyclical wages than other workers.

⁹ If, instead, I assume that the firm is shaped like a triangle rather than a rectangle, the conclusions remain unchanged. In the triangular firm, I assume that there are 100 workers at the lowest level and that each level has 10 fewer workers than the level just below. Thus, the tenth level has 10 workers.

¹⁰ In this example, the shocks hit all levels of the firm to the same extent. If shocks hit lower levels of the firm more than higher levels, the conclusions of the specific example are strengthened. At the other extreme, if the shocks only affect position 10, then on average workers in all positions will be equally affected by the shocks.

¹¹ In my data, the correlation between tenure and job quality is positive and very significant. Baker et al. (1994) show that for one particular firm the probability of being hired from outside the firm decreases with level of entry for people starting new positions within the firm. This implies that tenure is positively correlated with quality of position.

IV. The Data

The data used throughout this article come from the 1981–92 survey years of the Panel Study of Income Dynamics (PSID).¹² This data set is chosen because it extends over a long time period and is representative of the working-age population of the United States. Also, its panel structure is useful as the analysis requires observations on the same individuals over time. The PSID is composed of both a random sample and a poverty subsample. I restrict the analysis to the random sample and I use the following sample selection criteria: Respondents must be hourly or salaried workers between the ages of 18 and 64 who are not self-employed. They must live in the mainland United States, not including Alaska and Hawaii. Furthermore, I exclude 791 cases with missing values for wages, 265 cases with missing values for college degree, high school diploma, married, disabled, or tenure, and 560 cases for which occupation data are missing. After excluding these 1,578 cases, there remains a data set of 38,541 observations.

There are two wage measures in the PSID: the reported hourly wage rate and annual average hourly earnings. I have chosen to use the reported wage as it is specific to the current job. Wages are deflated by the gross domestic product (GDP) consumption deflator. For hourly workers, the reported wage is the hourly straight-time wage the worker receives. For workers paid weekly, monthly, or annually, the reported wage is equal to earnings divided by a fixed number of hours. For example, for weekly workers, the reported wage equals weekly earnings divided by 40 hours, irrespective of the number of hours actually worked during the week.

The analysis in this article requires the identification of employer changes. The following tenure question is asked in the data: How long have you worked for your current employer? These data allow one to determine when employer changes occur. I partition the data into spells with employers using the method recommended by Brown and Light (1992). An individual is assumed to have started a spell with a new employer when tenure with the employer is less than the elapsed time since the survey date. As noted earlier, I exclude matches that appear in the data only once. I am left with 33,357 observations for 6,716 matches. The means of selected variables are presented in table 1.

The state-industry data series I use is provided by the Bureau of Labor Statistics (BLS). Specifically, it is annual employment by state and 2-digit industry. Because the scale of employment varies radically by state in-

¹² I restrict the analysis to the 1981–92 period because I need the 3-digit occupation data that are available from 1981.

Table 1
Means of Selected Variables in the Panel Study
of Income Dynamics (SDs in Parentheses)

Variable	Mean
Years of education	13.27 (2.39)
College degree	.33 (.47)
High school diploma	.86 (.35)
Female	.47 (.50)
White	.91 (.28)
Years of experience	17.33 (9.73)
Government employee	.22 (.42)
Salaried employee	.49 (.50)
Years of tenure with employer	7.44 (7.18)
Married	.82 (.39)
Log wage	2.24 (.51)
No. of observations	33,357

dustry, I normalize the employment figures by dividing by the average employment level in that state industry.¹³

Measuring Task Quality

To get a measure of task quality, I use the PSID 3-digit occupation codes. Each year the respondent gives a description of the tasks he/she carries out. The PSID coder then uses this description to assign one of over 400 3-digit occupation codes. Even within matches, the occupation code changes quite frequently (35% of workers report a different 3-digit occupation from one year to the next). I match information from the 1977 fourth edition of the *Dictionary of Occupational Titles (DOT)* and the Current Population Survey (CPS) on the skill requirements of the 3-digit occupation to the occupational code. In this way, I create proxies for the quality of the tasks the worker is carrying out in each year.

Differences in occupation coding represent differences in the descriptions given by workers about the tasks they carry out. Hence, the

¹³ State-industry employment information is missing for approximately 18% of observations. I simply exclude these observations from the analysis that uses the state-industry employment data.

occupation codes have the advantage of measuring the workers' own perceptions about the nature of their current duties. The disadvantage of these measures is that many of the occupation changes represent coding error where the worker gives a similar description of his tasks in both years but the coders assign different codes. If such measurement error is uncorrelated with cyclical conditions, it will not bias the estimates of the coefficients of interest.

I create a set of task quality measures from information in the PSID, the DOT, and the CPS. These measures are designed to capture the skill requirements of the occupations. I aggregate *DOT* measures up to the 3-digit 1970 census occupation level that is used in the PSID by taking the mean of the *DOT* measures across the detailed occupations within each 3-digit occupation code. I use measures of specific vocational preparation (SVP) and general educational development in mathematics (GEDM). The SVP measure represents the amount of time required to learn the skills required for average performance in the occupation. It is a 9-level variable ranging from level 1 (short demonstration) to level 9 (over 10 years). The GEDM measure relates to the required level of mathematical skills. This is an ordinal variable with 6 levels ranging from level 1 (ability to add and subtract) to level 6 (mean value theorems and implicit function theorems).¹⁴ These variables have been widely used as job characteristics in previous studies.¹⁵

I also calculate characteristics of 3-digit occupations using the Annual Demographic Files of the CPS for the years 1971–82. I chose these years as they were the years that the CPS used the 1970 census codes for occupation and industry. The total number of CPS observations used was 287,395. I have constructed variables for average education, proportion with college degree, and proportion with high school diploma for each 3-digit occupation cell. All measures are merged with the PSID data.

I have also created a predicted log wage variable that is predicted by regressing the log wage on 2-digit industry, 2-digit occupation, union, salaried, government, and year and state dummies using the full PSID sample that includes observations on matches that only last one period as well as matches that last for longer. I use the coefficients on the occupation dummy variables to create a variable for wage predicted by occupation.¹⁶ One can think of this measure as being the mean wage in the occupation conditional on industry, state, and year. In general, one would expect that occupations with higher wages also have higher skill requirements.¹⁷

¹⁴ For further details on these variables, see U.S. Department of Labor (1981).

¹⁵ A recent example is Gittleman and Howell (1995).

¹⁶ I use the 2-digit level for calculating the predicted wages because the cell sizes in the PSID can become very small at the 3-digit level.

¹⁷ Some occupations may pay well as a compensating differential for particu-

If there is measurement error in my categorization of when spells with employers begin and end, then a finding of quality adjustment within matches may be actually caused by workers changing employers. As a check for this possibility, I have reestimated the equations on a sample that omits any spell with an employer in which the reported 2-digit industry or state of residence changed at any point. While there will still be some measurement error present in this sample, the extent of the problem should be much less than before.

V. Results of Task Quality Regressions

In this section, I examine how the skill requirements of the tasks workers are assigned vary with state-industry employment. I expect a positive relationship between state-industry employment and the skill requirements of the tasks workers carry out. The results from estimating equation (1) by match fixed effects are presented in table 2. In column 1, I present the coefficients on state-industry employment (β_3 in eq. [1]) for various specifications of task quality. Each row represents the coefficient on state-industry employment from a different regression. The dependent variable in each regression is listed in the left-hand column of table 2. The results indicate that the tasks performed when state-industry employment is high are tasks that generally pay more and that require higher educational qualifications. Also, the wage regression shows that wages are higher when state-industry employment is high. The estimates in column 1 of table 2 imply that a 10% increase in state-industry employment increases the actual wage workers earn by 0.7%. Similarly, a 10% increase in state-industry employment is associated with workers being in an occupation with a predicted log wage that is 0.4% higher and average years of education in the occupation that is 0.014 years (0.1%) higher.¹⁸ Thus, the results imply that when the state industry is doing well, workers do more demanding tasks and get paid more for doing them.

In column 2, I present the results when the sample is restricted to matches where the same 2-digit industry is reported in all years. The results are essentially the same as for the full sample, indicating that measurement error does not spuriously cause the skill requirements of the

larly unpleasant work. This is one reason for using the measures of occupational skill from the CPS and *DOT* as well as the average wage measure.

¹⁸ The results using the *DOT* measures are harder to interpret because they are both ordinal scales. One can crudely translate the specific vocational preparation scores into months of required training and the general educational development in mathematics scores into years of required education (see Burris 1983). When I carry out this exercise, I find that a 10% increase in state-industry employment increases required education by 0.023 years and months of required training by 0.25 months.

Table 2
Effect of State-Industry Employment Level on Characteristics of Tasks
Performed by Workers within Worker-Firm Matches (Match Fixed Effects)

Dependent Variable	Coefficient on State-Industry Employment	
	Matches That Last at Least 2 Years (1)	Matches That Last at Least 2 Years with Constant 2-Digit Industry (2)
No. of observations	27,445 (5,709 matches)	18,232 (4,027 matches)
Quality measures:*		
Predicted log wage in occupation	.0376 (.0087)	.0453 (.0120)
Log of actual wage	.0704 (.0132)	.1033 (.0180)
Occupation means from CPS:		
Years of education	.1380 (.0546)	.1846 (.0729)
College degree	.0260 (.0086)	.0363 (.0116)
High school diploma	.0038 (.0052)	.0028 (.0069)
DOT characteristics:		
GEDM	.1234 (.0406)	.1035 (.0531)
SVP	.1710 (.0668)	.2679 (.0903)

NOTE.—Values are means, with SEs below in parentheses. CPS, current population survey; DOT, *Dictionary of Occupational Titles*; GEDM, general educational development in mathematics; SVP, specific vocational preparation. All specifications include year and state dummies, experience squared, experience cubed, tenure squared, married, and college degree. The state-industry employment has been normalized by dividing employment by average employment in that state-industry cell.

* These variables are described in the text.

tasks carried out to vary with state-industry employment. These findings support the implication of the specific capital model that workers are assigned to tasks that require more skill when employment is high.

Results of Tenure Interactions

I now turn to the implication of the specific capital model that the correlation between task quality and state-industry employment is greater for low-tenure workers than for high-tenure workers. In table 3, I present the coefficients on state-industry employment and the coefficients on the tenure interactions when equation (1) is estimated allowing interactions between tenure and state-industry employment. The model suggests that the coefficients on the tenure interactions should be negative. Indeed, the coefficients on the interactions of tenure with the state-industry employment are generally negative and significant. For example, with the results from column 4, a 10% increase in employment in the state industry increases the predicted wage in the occupation by 0.84% for a worker

Table 3

Effect of State-Industry Employment Level on Characteristics of Tasks Performed by Workers within Worker-Firm Matches: Tenure Interactions (Match Fixed Effects)

Dependent Variable	Matches That Last at Least 2 Years (1)		Matches That Last at Least 2 Years with Constant 2-Digit Industry (2)	
	Coefficient on State-Industry Employment	Coefficient on State-Industry Employment: Tenure Interaction*	Coefficient on State-Industry Employment	Coefficient on State-Industry Employment: Tenure Interaction*
Quality measures: [*]				
Predicted log wage in occupation	.0625 (.0139)	-.0025 (.0011)	.0842 (.0195)	-.0038 (.0015)
Log of actual wage	.0561 (.0212)	.0015 (.0017)	.0997 (.0293)	.0003 (.0023)
Occupation means from CPS:				
Years of education	.3039 (.0874)	-.0170 (.0070)	.3979 (.1187)	-.0208 (.0091)
College degree	.0589 (.0138)	-.0034 (.0011)	.0750 (.0189)	-.0035 (.0015)
High school diploma	.0098 (.0084)	-.0006 (.0007)	.0164 (.0113)	-.0013 (.0009)
DOT characteristics:				
GEDM	.2373 (.0650)	-.0117 (.0052)	.2364 (.0864)	-.0130 (.0067)
SVP	.2993 (.1069)	-.0131 (.0085)	.5178 (.1471)	-.0244 (.0113)

NOTE.—Values are means with SEs below in parentheses. The number of observations for column 1 is 27,445 (5,709 matches); for column 2, the number of observations is 18,232 (4,027 matches). CPS, current population survey; DOT, *Dictionary of Occupational Titles*; GEDM, general educational development in mathematics; SVP, specific vocational preparation. All specifications include year and state dummies, experience squared, tenure squared, married, and college degree. The state-industry employment has been normalized by dividing employment by average employment in that state-industry cell.

*These variables are described in the text.

with no tenure and by only 0.46% for a worker with 10 years of tenure. Workers with higher tenure have task assignment that is less dependent on demand conditions. This is as predicted by the specific capital model. The interaction of tenure with state-industry employment is not negative in the equation for the actual wage. This result is consistent with the findings of Keane and Prasad (1993) and the findings of Raisian (1983) that workers with higher tenure do not have less cyclical wages.

VI. Task Assignment over the Business Cycle

In Section V, I provided evidence that task assignment is correlated with state-industry employment. An important issue is whether this form of labor-hoarding behavior is procyclical. Empirical work by Oi (1962), Becker (1975), and Fay and Medoff (1985), among others, has established the existence of labor hoarding at the firm level. Horning (1994) has pointed out that none of these studies have characterized this phenomenon at the aggregate level and that in a model with both firm-specific and aggregate shocks the productivity effects of labor hoarding need not be procyclical. Thus, the result that task quality is positively related to state-industry employment does not imply that task quality is procyclical. Therefore, to examine the cyclicality of task assignment, it is necessary to use cyclical measures such as the state unemployment rate.

The BLS provides the unemployment rate by state. I match the unemployment rates to the data by month, so that if a worker reports a wage in March 1980, the unemployment rate during that month is used as the relevant unemployment rate. To minimize the effects of measurement error in the monthly state unemployment rates, I have calculated a 3-month moving average of the unemployment rate, and I use this variable in the analysis.¹⁹ The unemployment rate data I use are not seasonally adjusted, but using adjusted data gives similar results.

I have chosen to use unemployment rates as cyclical measures for several reasons. First, it is fairly standard to use the unemployment rate as a cyclical measure in the labor economics literature and it is widely accepted that recessions are associated with high unemployment. Second, unemployment rates are measures of excess supply of labor. Other possible measures, such as employment growth rates, need not reflect excess supply or excess demand for labor. Finally, unemployment rates are strongly correlated with wages. For example, in a wage regression, the state unemployment rate has a strong negative effect on real wages, while the employment growth rate of the state has no significant effect on wages.

I prefer the state unemployment rate to the national rate for two reasons. First, it is a much stronger determinant of wages. When I control

¹⁹ Using the unsmoothed state unemployment rate gives very similar results.

for the state unemployment rate in a wage equation, the national unemployment rate does not have a negative coefficient. This indicates that the relevant labor market facing firms is a state labor market rather than a national labor market. Second, the state unemployment rate allows me to control for year effects that may result from annual questionnaire or coding differences in the PSID or from other economy-wide changes that may be correlated with the unemployment rate. The identification of the effects of the business cycle comes from state-year variation. I first examine whether the assignments of workers within matches show a cyclical pattern. The specification to be estimated is

$$z_{ijt} = \beta_1 + \beta_2'x_{it} + \beta_3U_t + \beta_4'YEAR_t + \beta_5'STATE + f_{ij} + f_i + \varepsilon_{ijt}. \quad (2)$$

The variable z_{ijt} refers to a particular occupation characteristic, U_t is the state unemployment rate, $YEAR_t$ is a vector of year dummies, and $STATE$ is a vector of state dummies. The vector x_{it} includes experience, experience squared, experience cubed, tenure, tenure squared, married, and college degree. The subscript i refers to person, j refers to match with employer, and t refers to time. As before, I estimate the model by fixed effects, taking deviations of all variables from match means. I expect the coefficient on the unemployment rate to be negative.

Results

The results are presented in table 4. In column 1, I present the coefficients on the state unemployment rate for various specifications of task quality. They indicate that the tasks performed in recessions are tasks that generally pay less and that require lower educational qualifications. However, the second row shows that wages are countercyclical. Thus, the results seem to imply that, in recessions, workers do less demanding tasks but get paid more for doing them. To examine whether this anomalous result is due to the timing of the cyclical variable, I reestimate the regressions using the state unemployment rate lagged one period instead of the contemporaneous state unemployment rate. As shown in the second column, the timing here does appear to be more appropriate as the skill requirements of the tasks carried out by workers are now more procyclical and the wage is no longer countercyclical. Columns 3 and 4 present the results when the sample is restricted to those matches where the same 2-digit industry is reported in all years. The results are essentially the same as for the full sample, indicating that measurement error is not spuriously causing tasks to appear countercyclical.

The results are qualitatively consistent with cyclical changes in task assignment within firms. However, it is not obvious that these coefficients are large enough to imply that changes in task assignment are of any economic

Table 4
Effect of State Unemployment Rate on Characteristics of Tasks Performed
by Workers within Worker-Firm Matches (Match Fixed Effects)

Dependent Variable	Matches That Last at Least 2 Years		Matches That Last at Least 2 Years with Constant 2-Digit Industry	
	Coefficient on Unemployment Rate (1)	Coefficient on Unemployment Rate Lagged 1 Period (2)	Coefficient on Unemployment Rate (3)	Coefficient on Unemployment Rate Lagged 1 Period (4)
Quality measures:*				
Predicted log wage in occupation	-.0020 (.0006)	-.0025 (.0007)	-.0025 (.0008)	-.0024 (.0008)
Log of actual wage	.0038 (.0010)	.0005 (.0010)	.0034 (.0013)	-.0006 (.0013)
Occupation means from CPS:				
Years of education	-.0100 (.0040)	-.0182 (.0043)	-.0162 (.0048)	-.0192 (.0050)
College degree	-.0023 (.0006)	-.0030 (.0007)	-.0032 (.0008)	-.0029 (.0008)
High school diploma	.00005 (.0004)	-.0011 (.0004)	-.0004 (.0004)	-.0012 (.0005)
DOT characteristics:				
GEDM	-.0057 (.0030)	-.0093 (.0031)	-.0081 (.0034)	-.0096 (.0035)
SVP	-.0063 (.0048)	-.0118 (.0050)	-.0106 (.0058)	-.0123 (.0060)

NOTE.—Values are means, with SEs below in parentheses. The number of observations for columns 1 and 2 is 33,357 (6,716 matches); for columns 3 and 4, the number of observations is 21,034 (4,530 matches). CPS, current population survey; DOT, *Dictionary of Occupational Titles*; GEDM, general educational development in mathematics; SVP, specific vocational preparation. All specifications include year and state dummies, experience squared, experience cubed, tenure squared, married, and college degree.

* These variables are described in the text.

significance. The following example suggests that they are. Once again, consider a firm with 1,000 employees that is partitioned into 10 departments of 100 workers. The departments are ranked hierarchically by skill requirement, with 1 being the lowest department and 10 the highest. Now, assume this firm is hit by a demand shock and decides it must lay off 1% of its workers, one from each department. If it decides to lay off only workers from the lowest department, and demote workers to make up the numbers in all departments, then one can easily calculate that the average worker that remains is placed in a department that is 0.8% less skilled than the department he or she was in previously. In the process, the firm has maintained all of its upper-level workers. The coefficient of -0.0025 when the predicted wage is used as the quality measure (table 4, col. 2) implies that, if the state unemployment rate rises by one point, the average worker is carrying out a

task that is 0.25% less skilled than the department he or she was in previously. A 1-point increase in the state unemployment rate is roughly equivalent to a 1% reduction in employment in the average firm.²⁰ Thus, if all firms in the economy were like this firm, the amount of cyclical task adjustment is approximately 30% $((0.25/0.8) \times 100)$ of what it would be if all cyclical employment changes were being achieved by firing the workers in the lowest-level position. Obviously, this is merely an example. It is, however, difficult to identify the structure of a typical firm.²¹ My goal is merely to suggest that the coefficient values may have substantive importance.

In table 5, I present the results when the state unemployment rate and employment in the state-industry cell are both included in the regression. I do this to check whether the two variables are measuring different aspects of the shocks affecting firms. The interesting result is that the coefficients on both the state-unemployment rate and state-industry employment are very similar here to their values when each is included separately. It appears that shocks at the level of the state industry and shocks at the general state level have independent effects on task assignment within matches. In columns 3 and 4 of table 5, I restrict the sample to matches where the worker reported the same 2-digit industry each period. As with the earlier state unemployment rate results, the coefficients are rather robust across samples, indicating that the task procyclicality is not a result of measurement error in the determination of the starting and ending dates of matches.

VII. An Alternative Model of Cyclical Task Changes

An alternative model of cyclical task assignment has been developed by Reynolds (1951), Reder (1955), and Hall (1974). The maintained assumption of this hypothesis is that wage levels within job titles are unresponsive to the demand conditions faced by firms. Therefore, employers respond to the business cycle by transferring workers between job titles so as to adjust labor costs appropriately. For example, in expansions firms lower promotion and hiring standards and hence lower the average quality of worker in each job title. Consequently, real wages per quality

²⁰ Research by Davis and Haltiwanger (1992) suggests that 80% of employment reductions in the economy arise from firms downsizing rather than plants closing down. Therefore, a 5% reduction in employment, should lead to the average firm reducing employment by about 4%. A 5% reduction in employment is roughly equivalent to a 4-point increase in the unemployment rate.

²¹ Once again, if I assume that the firm is shaped like a triangle rather than a rectangle, the conclusions remain unchanged. In the triangular firm, I assume that there are 100 workers at the lowest level and that each level has 10 fewer workers than the level just below. Thus, the tenth level has 10 workers. In this firm a 10% reduction in employment in each rung leads to the average worker being in a position that is approximately 8% worse.

Table 5
Effect of State Unemployment Rate and State-Industry Employment Level on Characteristics of Tasks Performed by Workers within Worker-Firm Matches (Match Fixed Effects)

Dependent Variable	Matches That Last at Least 2 Years (1)		Matches That Last at Least 2 Years with Constant 2-Digit Industry (2)	
	Coefficient on Unemployment Rate	Coefficient on State-Industry Employment	Coefficient on Unemployment Rate	Coefficient on State-Industry Employment
Quality measures:*				
Predicted log wage in occupation	-.0023 (.0007)	.0344 (.0087)	-.0029 (.0009)	.0415 (.0120)
Log of actual wage	.0041 (.0011)	.0763 (.0133)	.0033 (.0013)	.1077 (.0180)
Occupation means from CPS:				
Years of education	-.0108 (.0045)	.1226 (.0550)	-.0180 (.0052)	.1610 (.0732)
College degree	-.0024 (.0007)	.0225 (.0087)	-.0033 (.0008)	.0343 (.0117)
High school diploma	.00003 (.0004)	.0039 (.0053)	-.0006 (.0005)	.0020 (.0069)
DOT characteristics:				
GEDM	-.0078 (.0033)	.1123 (.0409)	-.0111 (.0038)	.0888 (.0533)
SVP	-.0097 (.0055)	.1572 (.0673)	-.0153 (.0065)	.2479 (.0907)

NOTE.—Values are means, with SEs below in parentheses. The number of observations for column 1 is 27,445 (5,709 matches); for column 2, the number of observations is 18,232 (4,027 matches). CPS, current population survey; DOT, *Dictionary of Occupational Titles*; GEDM, general educational development in mathematics; SVP, specific vocational preparation. All specifications include year and state dummies, experience squared, experience cubed, tenure squared, married, and college degree. The state-industry employment has been normalized by dividing employment by average employment in that state-industry cell.

* These variables are described in the text.

unit of labor rise even if real wages within job titles are rigid. Similarly, in a recession, firms increase promotion and hiring standards and thus reduce the wage per unit quality. I refer to this as the Reynolds Reder Hall (RRH) hypothesis. In this section I assess the ability of the RRH to explain wage changes in the data.

This distinguishing feature of this hypothesis is that it refers to job titles rather than tasks. There is no one-to-one relationship between tasks and job titles. Workers frequently change tasks with no change in job title; it is also possible that workers change job titles but the tasks they carry out do not change. Indeed, it is perfectly consistent with the RRH hypothesis for an employer to change a worker's job title and pay but for the worker's tasks to remain unchanged. However, since changes in job title

will most likely involve changes in tasks, this model is consistent with the empirical findings of procyclical task quality.²²

The model predicts that a significant proportion of overall wage cyclicity results from workers changing job titles rather than wage changes within job titles. This arises either because the rate of job title changing is procyclical or because the wage changes of workers who change job titles are more responsive to changes in cyclical conditions than the wage changes of workers who do not change job titles. Since demotions are rare, one would expect the bigger impact to come from procyclical job title changing.

In the PSID, respondents are asked, In what month and year did you start working in your present (position or work situation)? If an individual does not change employer, I assume a change in job title when tenure in the present position or work situation is less than the elapsed time since the survey date. One reason to believe that respondents are referring to changes in job title is that the majority of these changes are labeled as promotions. Also, in the data, workers who report changes in work situation have greater wage increases and wage change variances than other workers. However, it is possible that some of the reported changes in position or work situation merely involve changes in tasks rather than changes in job title and pay.

It is standard in the wage cyclicity literature to estimate how the yearly change in the log wage depends on changes in cyclical conditions. I will use this specification here because it allows me to calculate the wage cyclicity of job title changers separately from the cyclicity of non-changers. The specification involves regressing the change in the log wage on the change in the state unemployment rate:

$$\Delta \ln w_{it} = \alpha_1 + \alpha_2 \Delta U_t + \alpha_3' x_{it} + \alpha_4' YEAR_t + \alpha_5' STATE + v_t. \quad (3)$$

By differencing, one nets out unobserved individual and firm heterogeneity that may be correlated with the error term. The control variables in x_{it} are a cubic in experience, a quadratic in tenure, female, black, other nonwhite, years of education, high school diploma, college degree, married, and disabled. The principal wage measure I use here is the reported hourly wage. However, because this wage measure does not capture wage cyclicity due to greater access to overtime in expansions, I also carry out the analysis with the average hourly earnings measure. While this measure includes income from all jobs, for job stayers it should be a reasonably

²² It is possible for cyclical effects to occur in within-firm assignment in the absence of any formal policy to achieve this goal. If more vacancies are available in expansions, then workers do not have to be as highly qualified to win a tournament for one of these positions.

good measure of average hourly earnings on the main job we are studying. I estimate the equations for the 1981–92 period.²³

As noted by Moulton (1986), the standard errors from the OLS estimates of equation (3) may be underestimated in the presence of a state/time specific error (v_{st}) because the change in the state unemployment rate is the same for all workers in the same state at the same time. To correct the estimates for this form of grouping, I estimate the following two-step model. In the first step, I estimate the OLS equation

$$\Delta \ln w_{it} = \gamma_1' STATE/YEAR + \gamma_2' x_{it} + v_{it}, \quad (4)$$

where $STATE/YEAR$ is a vector of a complete set of dummies for each state/year combination. In the second step, I estimate the following equation using generalized least squares (GLS):²⁴

$$\hat{\gamma}_1 = \beta_1 + \beta_2' STATE + \beta_3' YEAR_t + \beta_4 \Delta U_t + v. \quad (5)$$

I use this two-step procedure in this section to account for grouping in the state unemployment rate. The coefficient of interest is β_4 , the coefficient on the change in the state unemployment rate.

Results

The results are presented in table 6. The first row of data for each portion provides the cyclical estimates for workers who do not switch job titles. The estimates suggest that the wages of workers who do not change job title are quite acyclical. Hence, it is reasonable to believe that the RRH assumption of within-job-title wage acyclicity is valid within this time period. However, as the results of the second rows of each portion indicate, the sample composed of all firm stayers, including those who changed job titles, exhibits very similar levels of wage procyclicality. Thus, there is no evidence that employers move workers between job titles to adjust wages to the business cycle.²⁵

The reasons for this result are threefold. First, there are not very many

²³ The average hourly earnings variable is unavailable for 1992 in my sample. Therefore, when average hourly earnings is the dependent variable, only data from 1981–1991 are used. The sample sizes differ for the two wage measures for this reason and also because of missing values of the two wage variables.

²⁴ Amemiya (1978) showed that if GLS is used in the second stage, this procedure is equivalent to GLS in one stage.

²⁵ I have also experimented with asymmetric effects of the business cycle by allowing the effect of the change in the unemployment rate on wages to depend on whether the change in the unemployment rate is positive. I find no evidence for any asymmetry in the response of wages to the unemployment rate.

Table 6
Wage Cyclicalities of Workers Who Do Not Switch Employers
(Generalized Least Squares Estimates)

Sample	Coefficient on Change in State Unemployment Rate	No. of Observations
Reported hourly wage, male and female, 1981–1992:		
Job title stayers	–.0008 (.0015)	25,369
All firm stayers	–.0013 (.0027)	28,416
Job title changers	.0006 (.0053)	3,047
Average hourly earnings, male and female, 1981–1991:		
Job title stayers	–.0048 (.0023)	24,258
All firm stayers	–.0034 (.0022)	27,312
Job title changers	.0065 (.0067)	3,054

NOTE.—Values are means, with SEs below in parentheses. Also included are year and state dummies, experience, experience squared, experience cubed, tenure, tenure squared, female, black, other nonwhite, years of education, high school diploma, college degree, married, and disabled.

respondents who report changing work situation. Second, as can be seen in the third row of each portion, workers who change job title experience wage cyclicalities that are not significantly different from those experienced by workers who do not change job title. Third, the probability of changing job title is not very procyclical. In estimates not reported here, I find that changes in the state unemployment rate have a small and statistically insignificant negative effect on the probability of changing job title. Hence, even if many changes in job title go unreported, it is unlikely that this is the reason for the lack of evidence for the hypothesis.²⁶

The results in table 6 are not supportive of the RRH hypothesis. Unlike the analysis of Solon et al. (1997), who used firm-level data from the 1920s and 1930s, I do not find evidence that the wage changes of job title changers are significantly more procyclical than the wage changes of workers who report no change in job title. One reason for the differing results is that the incidence of demotions that involve cuts in pay is much lower in the 1980s than in the Great Depression era. The results are consistent with those of Wilson (1997), who used more recent case study data.

The generally low levels of wage cyclicalities here are also apparently at odds with the wage cyclicalities study of Solon et al. (1994). They used

²⁶ When I use the national unemployment rate as a cyclical measure, I get very similar results.

PSID data from 1968 to 1987 on males aged 16 and older and found that the average hourly earnings of workers who did not switch employer were very procyclical (the coefficient on the national unemployment rate was -0.0124). My investigation indicates that the differences between their estimates and mine are largely due to different sample periods. Also, average hourly earnings are more cyclical than the reported hourly wage.²⁷ Thus, it appears that the estimated cyclicalities of wages of workers who do not switch employer is sensitive to choice of sample period and to the choice of wage measure.

VIII. Conclusions

In this article, I evaluate the hypothesis that firms respond to negative demand shocks by assigning workers to tasks that require less skill than the tasks they normally carry out. Using changes in employment in state-industry cells as a measure of demand conditions facing individual firms, I provide evidence in favor of the hypothesis. Furthermore, I show that it is the task assignment of high-tenure workers that is least affected by changes in state-industry employment. Next, I examine the cyclicalities of task assignment using the state unemployment rate as a cyclical measure. The empirical results show that the skill requirements of the tasks carried out by workers are procyclical but that wages are quite acyclical. The results are consistent with a specific capital model where employers move workers between tasks so that layoffs are concentrated on workers with low levels of firm-specific capital. I find no evidence for rigid-wage models that imply that employers use changes in job titles as a means of adjusting wages to the business cycle.

It is well known that measured labor productivity exhibits considerable variation over the business cycle. In particular, productivity is generally found to be procyclical. The specific capital model has no unambiguous prediction for productivity. It implies that while workers are engaged in suboptimal tasks in recessions, the average quality of the workers remaining employed is higher. Attempts to control for labor quality when calculating labor input need to take into account the fact that the tasks

²⁷ Unfortunately, I cannot replicate Solon et al.'s sample because I have constructed tenure data only from 1971 onward. However, I have estimated their empirical specification for the change in average hourly earnings for men for the years 1971–1987. The coefficient on the change in the national unemployment rate is -0.010 , which is close to their estimate of -0.012 . For the 1981–1991 period, the coefficient on the change in the national unemployment rate is -0.006 . With women included, the coefficient falls to -0.005 . When I replace the change in average hourly earnings with the change in the reported hourly wage for the 1981–1991 period, the coefficient on the change in the national unemployment rate becomes 0.001 . See Devereux (1998) for further analysis of the wage cyclicalities of workers who do not change employers.

being carried out also vary over the business cycle. The effects of cyclical differences in task assignment for the measured procyclicality of productivity is a topic for future research.

Appendix

The Specific-Capital Model

I assume that the firm has two possible positions. Position 1 is the low-skill position and position 2 is the high-skill position. There are two types of workers. Type a workers are low skill and best suited to working in position 1, and type b workers are high skill and best suited to working in position 2. The productivity of each worker type in position 2 depends on his or her experience in that position. Workers in their first period in position 2 are considered inexperienced and produce less output than experienced workers. Workers are considered experienced if they were employed in position 2 in that firm in any previous period. Experience is firm-specific. Experience has no effect on productivity in position 1.

There are two possible states of nature. The state changes by a Markov transition matrix λ , where λ_{lh} is the probability of transition from state l (the low state) to state h (the high state):

$$\lambda = \begin{bmatrix} \lambda_{ll} & \lambda_{lh} \\ \lambda_{hl} & \lambda_{hh} \end{bmatrix}.$$

In the high state, productivity is high in both slots, so that there is one position in each slot; in the low state, productivity is zero in position 2, so there is only one position in slot 1. The firm discounts the future using the discount factor β .

For each combination of worker with position in each state there is a 1-period surplus that accrues to the firm. These profits are exogenous to the firm as the firm operates in a competitive market. The possible per-period profits in the high state are as follows:

$$[\pi_{1a}^h \quad \pi_{1a^*}^h \quad \pi_{1b}^h \quad \pi_{1b^*}^h] \quad \text{in position 1,}$$

and

$$[\pi_{2a}^h \quad \pi_{2a^*}^h \quad \pi_{2b}^h \quad \pi_{2b^*}^h] \quad \text{in position 2,}$$

where π_{1a}^h is the firm's per-period profit from employing worker type a in position 1 in the high state, and $\pi_{1a^*}^h$ refers to the profit from employing a type a worker who is experienced (has previously worked in position 2) in position 1. The actual per-period profit in each position depends on the type of worker that is in the position. In the low state, there is only one position in slot 1, so the matrix of possible profits looks as follows:

$$[\pi_{1a}^l \quad \pi_{1a^*}^l \quad \pi_{1b}^l \quad \pi_{1b^*}^l].$$

Profits depend on the state of nature. I make the following assumptions about per-period profits. The first assumption is that the firm makes more per-period profit when a type a worker fills slot 1 and slot 2 is filled by a type b worker. The following inequalities apply:

$$\pi_{1a}^j \geq \max(\pi_{1b}^j, \pi_{1b^*}^j) \quad j = \{b, l\}$$

and

$$\pi_{2b}^j \geq \max(\pi_{2a}^j, \pi_{2a^*}^j) \quad j = \{b, l\}.$$

These inequalities formalize the notion that type a workers are best suited to job 1 and type b workers are best suited to job 2. The second assumption is that the firm gains from having an experienced type b worker in slot 2. Since experience is firm-specific, there are monopoly rents to be shared by employer and experienced employee. I assume that the firm attains some of these rents so that the profit from employing an experienced worker is greater than the profit from employing an inexperienced worker. This implies the inequality

$$\pi_{2b^*}^b > \pi_{2b}^b.$$

PROPOSITION. When the state of nature is such that the firm has one position, the firm fills position 1 with an experienced type b worker if and only if $(\pi_{1b^*}^l - \pi_{1a}^l) + \beta \lambda_{lb}(\pi_{2b^*}^b - \pi_{2b}^b) \geq 0$.

To see this, note that when the state is such that there are two positions, the firm will employ a type a worker in slot 1 and a type b worker in slot 2. Since there is no future gain from employing either two type a workers or two type b workers, the firm will maximize current profit by employing a type a worker in position 1 and a type b worker in position 2. There are thus four possible histories that may arise at time t : (a) there were two slots at $t - 1$ with a type a worker in position 1 and a type b worker in position 2; (b) There was one slot at $t - 1$ and it was filled by a type a worker; (c) There was one slot at $t - 1$ and it was filled by a type b worker who had previously worked in slot 2; or (d) there was one slot at $t - 1$ and it was filled by a type b worker who had not previously worked in slot 2. The only element of the history that affects the firm's decision making is whether or not an experienced type b worker is available. Thus, history a and history c are equivalent and history b and history d are equivalent. Hence, we need only consider two histories as well as the two possible states that arise at t . I will refer to histories b and d as history type 1 and histories a and c as history type 2. For each history at t , and each of the 2 possible states that arises at t , the firm has a value function that depends on who it employs. Let $V(\phi, \mu)$ refer to the value function

when there is history type ϕ and there are μ slots at time t . The question of having a type b worker in slot 1 arises only when in the low state and having only one position. The value of having only one slot and having no experienced type b worker available can be written as follows:

$$V(1, 1) = \max\{\pi_{1b}^l + \beta\lambda_{lb}V(1, 2) + \beta(1 - \lambda_{lb})V(1, 1), \\ \pi_{1a}^l + \beta\lambda_{lb}V(1, 2) + \beta(1 - \lambda_{lb})V(1, 1)\}. \quad (A1)$$

For example, the first term in the maximum in equation (1) is the value of employing a type b worker in position 1, the second term in the maximum is the value of employing a type a worker in the position. Likewise, one can write the value function for the situation where there is only one slot but there is an experienced type b worker available:

$$V(2, 1) = \max\{\pi_{1b^*}^l + \beta\lambda_{lb}V(2, 2) + \beta(1 - \lambda_{lb})V(2, 1), \\ \pi_{1a}^l + \beta\lambda_{lb}V(1, 2) + \beta(1 - \lambda_{lb})V(1, 1)\}. \quad (A2)$$

Equation (A1) implies that the firm will never have a type b worker in slot 1 at t if at $t - 1$ it employed no experienced type b worker. Because π_{1a}^l is greater than π_{1b}^l , $V(1, 1)$ is equal to the second argument in the maximum:

$$V(1, 1) = \pi_{1a}^l + \beta\lambda_{lb}V(1, 2) + \beta(1 - \lambda_{lb})V(1, 1). \quad (A3)$$

Thus, the only case in which the firm may have a type b worker in slot 1 is if an experienced type b worker is employed at $t - 1$ and there is one position at t . From equation (A2), we see this is the case when

$$(\pi_{1b^*}^l - \pi_{1a}^l) + \beta\lambda_{lb}(V(2, 2) - V(1, 2)) \\ + \beta(1 - \lambda_{lb})(V(2, 1) - V(1, 1)) \geq 0. \quad (A4)$$

In the good state, the following value functions apply:

$$V(1, 2) = \pi_{1a}^b + \pi_{2b}^b + \beta\lambda_{bb}V(2, 2) + \beta(1 - \lambda_{bb})V(2, 1) \quad (A5)$$

and

$$V(2, 2) = \pi_{1a}^b + \pi_{2b^*}^b + \beta\lambda_{bb}V(2, 2) + \beta(1 - \lambda_{bb})V(2, 1). \quad (A6)$$

Equations (A5) and (A6) imply that

$$V(2, 2) - V(1, 2) = \pi_{2b^*}^b - \pi_{2b}^b. \quad (A7)$$

Equations (A1) and (A2) imply that

$$V(2, 1) - V(1, 1) = \max\{0, (\pi_{1b}^l - \pi_{1a}^l) + \beta\lambda_{lb}(V(2, 2) - V(1, 2)) + \beta(1 - \lambda_{lb})(V(2, 1) - V(1, 1))\}. \quad (A8)$$

By substituting equation (A8) and equation (A7) into equation (A4), we get the result that the firm has a type b worker in slot 1 in the bad state if $(\pi_{1b}^l - \pi_{1a}^l) + \beta\lambda_{lb}(\pi_{2b}^b - \pi_{2b}^l) \geq 0$.

Thus, the firm has a type b worker in slot 1 if the probability of going from the bad state to the good state, and the benefit of having an experienced type b worker in the good state, is high enough to offset the cost of having an experienced type b worker in position 1 when in the bad state. From the perspective of an individual worker, the model implies that workers of type b are in slot 2 in the good state and slot 1 in the bad state. Thus, the skill requirements of the tasks performed by type b workers depend positively on the state.²⁸

Wages

Since one possible rationale for cyclical task adjustment within the firm is to enable the firm to cut wages in bad states, it is interesting to inquire what the model implies for wages in each of the positions. The profit from any worker-slot combination depends on both the productivity of the match and the wage paid to the worker.

I assume that firms make zero expected profit when they begin by hiring a type a worker and a type b worker in the good state. I further assume that type a workers are paid their marginal product because the market is competitive for these workers. Therefore, π_{1a}^l is zero and π_{1a}^b is zero. Since, by assumption, π_{1a}^l is at least as great as π_{1b}^l and π_{1b}^l is zero, this implies that π_{1b}^l is no greater than zero. If one further assumes that new firms can enter and exit the market at any time, then this implies that π_{2b}^b cannot be greater than zero. If π_{2b}^b was greater than zero then firms could enter for one period and earn positive profit of π_{2b}^b . For it to be optimal to have a type b worker in slot 1, π_{2b}^b must be greater than zero. Thus, when a worker of type b moves from position 1 in the low state to position 2 in the high state, he or she goes from earning more than productivity ($\pi_{1b}^l \leq 0$) to earning less than productivity ($\pi_{2b}^b > 0$).

²⁸ In the model only the higher-level position is cyclically sensitive. In reality, productivity in all positions may be sensitive to cyclical shocks. This type of generalization should not change the model's results. It would still be optimal in some circumstances to place experienced high-skill workers in low-skill positions and to fire low-skill workers in the process.

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