

Making Do With Less: Working Harder During Recessions

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Abstract

There are two obvious possibilities that can account for the rise in productivity during recent recessions. The first is that the decline in the workforce was not random, and that the average worker was of higher quality during the recession than in the preceding period. The second is that each worker produced more while holding worker quality constant. We call the second effect, “making do with less,” that is, getting more effort from fewer workers. Using data spanning June 2006 to May 2010 on individual worker productivity from a large firm, it is possible to measure the increase in productivity due to effort and sorting. For this firm, the second effect—that workers’ effort increases—dominates the first effect—that the composition of the workforce differs over the business cycle.

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During recent recessions, productivity has risen. In the recession of 2007 to 2009, aggregate output fell by 7.16 percent, but the aggregate number of hours worked decreased by 10.01 percent in nonfarm business.¹ Over the recession, labor productivity rose. From 2007 quarter 4, the start of the recession, to 2009 quarter 3, the quarter following the recession, labor productivity rose by 3.16% in nonfarm businesses. There are two obvious possibilities that can account for the rise in productivity. The first is that the decline in the workforce was not random, and that the average worker was of higher quality during the recession than in the preceding period. The second is that each worker produced more while holding worker quality constant. We call the second effect, “making do with less,” that is, getting the same output from fewer workers.

There are both theoretical and empirical questions that need to be answered. The most important empirical issue is determining how much is explained by increased effort, and how much of the increase in productivity can be explained by compositional effects, i.e., having better workers on average during the recession.²

¹ The recession was from December 2007 through June 2009. The drop in output and aggregate number of hours worked are measured from the fourth quarter 2007, the start of the recession, through the third quarter 2009, the quarter following the recession. Data come from the BLS and exclude farm workers.

² Other research makes reallocation – either of workers or of firms – the source of rising productivity over the cycle. Berger (2012) argues that labor productivity rises in recessions because firms restructure during recessions by laying off their least productive workers. His aim is to explain the jobless recoveries in the last three recessions, pointing out that output grows but employment lags because the workers are more productive. His evidence is a calibration model in which he compares his models to several alternative models of the business cycle, finding that the labor restructuring model has the greatest explanatory power. Thus, labor restructuring is an explanation for productivity growth (see also Koenders and Rogerson, 2005, Gali and van Rens, 2010, and van Rens, 2004, for models of the rising pro-cyclicality of productivity). Reallocation of workers across businesses can also explain why some businesses are more productive than others in the cross-section (Syverson, 2011).

The most important theoretical issue involves modeling the change in effort that a firm may require as the economy moves from normal times into recession. Intuitively, it seems that employers push their employees harder during recessions as they cut back the work force and ask each of the remaining workers to cover the tasks previously performed by the now-laid-off workers. But if it is possible to get more from employees during recessions, why don't employers demand the higher level of output during normal times?

There are two conceptual reasons for the rise in productivity. First, during recessions, demand for labor falls, which reduces the wage and other alternatives available to each worker. As a consequence, workers, especially those whose next best alternative is now leisure, may be willing to work harder for a given wage. The supply of effort to a given firm depends on a worker's alternatives and, as they become poorer, the supply to a given firm may improve. Even for the market as a whole, the reservation value of effort may decline when the number of jobs declines as workers are forced into poorer alternatives.

Second, the labor force may change average quality for the same reason. There is no reason to assume that workers of all ability levels are affected by the recession equally. To the extent that some are hurt more than others, the willingness to supply effort to a given firm (or the labor market in general) may be altered differentially across groups. Consequently, firms move in the direction of the labor type that is more cost effective and, during recessions, it is possible that this favors higher quality workers.

Is it possible in a standard model for work effort to increase, average ability to increase, output to fall and employment to fall when product demand falls? Normally, one would think that a downward shift in demand that brings with it a lower return to work would imply fewer

hours and less effort per hour rather than more as the economy moves down a positive supply curve. However, an exogenous downward shift in the demand for output at the economy level is sufficient to generate an increase in effort because it reduces the value of output and therefore of labor market work. In equilibrium, this lowers the cost at which workers will supply labor to any given firm, resulting in an increase in effort for each worker.

This theory is taken to the data for one large firm that measures output per worker. There is panel data on individual productivity for over 20,000 moderately skilled workers who perform the exact same task at different establishments throughout the United States. It is therefore possible to measure performance outcomes due to effort versus sorting using about 5.1 million data points on daily performance from June 2006 to May 2010.

For this firm, the first effect—that workers' effort increases—dominates the second effect—that the workplace composition differs over the business cycle. The most important result is that nearly all of the increase in productivity is a consequence of making do with less. The quality of the work force changes minimally. Instead, the increase in productivity comes about because workers work harder. Evidently, effort increases to produce more output per unit of time.

Several empirical results reinforce this conclusion. First, productivity increased by 5.3 percent during the recession at this firm. Workers in a balanced panel with no compositional changes increased their individual effort by between 4.5 – 5 percent over the recession period. Second, productivity is affected by the local unemployment rate even after accounting for possible changes in trends in productivity and the national unemployment rate with time fixed effects. Workers doing the exact same geographically portable task who faced relatively severe

local labor market conditions increased their effort most. Third, in a sample of workers who enter the firm after June of 2006 but prior to the beginning of the recession, the least productive workers in the pre-recession period increased their effort most in response to the local unemployment rate. Fourth, a variety of tests show that changes in the composition of the labor force were small, accounting for a small portion of the increase in productivity.

The paper is organized as follows. Section I contain the theoretical framework. The data description and empirical results are in Sections II and III. The conclusion follows.

I. Theory

A. A Rational Model of Changes in Effort and Ability During Recessions

Recall that the goal is to understand within the framework of rational firms how effort might rise during recessions and how the optimal quality of workers employed might also vary with business cycle conditions. During recessions output falls (or at a specific growing firm, output growth slows), employment falls (or in a specific growing firm, employment growth slows), output-per-worker rises and average ability of the work force may change. The firm makes do with less. An additional feature (observed empirically during the last recession) is that costs fell and profits rose, because cost saving was sufficiently great to offset the reductions in demand.

The goal is to provide a theoretical structure that allows all the empirical phenomena to be captured. The following model accomplishes that.³

The Choice of Effort Level

³ See also Lazear (2000a).

Worker quality is indexed by k , where higher levels of k are associated with more able workers. The cost of effort for any type k is given by $c(e) / k$.

The timing is as follows. The firm calls out the terms of employment, which consist of a wage W , and minimum level of effort (or output) requirement, x , which has distribution function $G(x)$ and density $g(x)$.⁴ The worker does not know x precisely, but knows the distribution of requirements in the population of firms. At the time of hiring, market conditions, specifically, the level of the unemployment rate, are unknown, but after the worker begins the job, the state of the economy becomes known. If effort falls below the required level, the worker is fired. A terminated worker may find another job, which yields rent net of effort, equal to R . Rent R is positive and dominates unemployment, but is lower than the surplus (derived below) that is obtainable at the optimal level of e on the primary job. If the worker does not locate a new job, he becomes unemployed, which has value normalized to zero. Thus, the expected rent of a terminated worker is given by $(1-u) R$ where u is the probability that a terminated worker remains unemployed. No theory of unemployment is presented here; u is taken as given and exogenous, which it is for any particular worker.

The tradeoff for the worker is that effort is painful, but the higher the level of effort, the less likely is the worker to be terminated for poor performance. The probability of being terminated given any effort level e is merely the probability that $e < x$ or $1-G(e)$. Thus, the worker's problem is to choose e to maximize expected surplus, which is given by

$$(1) \quad \text{Surplus} = G(e) (W - c(e)/k) + [1- G(e)] (1-u) R$$

⁴ The setting of the minimum requirement, x , is taken to be exogenous. This is analyzed in Lazear (2000b).

The first term is the probability of surviving in the firm times expected rent at that firm. The second term is the expected rent associated with termination.⁵

The first-order condition for (1) is

$$(2) \quad \partial/\partial e = g(e) [W - c(e)/k - (1-u) R] - G(e) c'(e)/k = 0$$

with second-order condition $\partial^2/\partial e^2 < 0$ for an interior maximum.

The first result is that effort increases in k . The more able individuals put forth higher levels of effort because the cost of reducing the probability of termination is decreasing in ability. That follows directly from (2) using the implicit function theorem.

$$\frac{\partial e}{\partial k} \Big|_{F.O.C.} = - \frac{\partial / \partial k}{\partial / \partial e}$$

or

$$\begin{aligned} \frac{\partial e}{\partial k} \Big|_{F.O.C.} &= - \frac{\partial / \partial k}{\partial^2 / \partial e^2} \\ &= - \frac{g(e)c(e) / k^2 + G(e)c'(e) / k^2}{\partial^2 / \partial e^2} \end{aligned}$$

which is positive because the numerator is positive and the denominator is the second-order condition, which must be negative for the solution to the problem to be a maximum.

The next result is the key one for the analysis here, namely that a recession creates increased effort. When the probability of unemployment rises, workers of all ability put forth

⁵ Note that the contract here is one of a fixed wage, rather than a piece rate. One could envision that the firm would condition payment on the ex post observed level of output, e , especially since that is assumed to be known after work occurs. Indeed, in the jobs that we have in mind, e is easily measured and tracked by a computer. The analysis of whether to use a fixed wage or a piece rate is first laid out in Lazear (1986). There, issues of measurement costs and multi-tasking (defined as the tradeoff between quality and quantity) are discussed. For the purposes here, it is taken as given (and is true) that the firm does not use variable pay to any significant extent.

more effort. This is a result that is standard in the efficiency-wage literature and follows directly from the model.⁶ Using the first-order condition, once again,

$$\frac{\partial e}{\partial u}|_{F.O.C.} = -\frac{\partial / \partial u}{\partial / \partial e}$$

or

$$\begin{aligned} \frac{\partial e}{\partial u}|_{F.O.C.} &= -\frac{\partial / \partial u}{\partial^2 / \partial e^2} \\ &= -\frac{g(e)R}{\partial^2 / \partial e^2} \end{aligned}$$

which is positive because the numerator is positive and the denominator is again the second-order condition which is negative. Effort increases when the unemployment rate rises.

The same analysis also implies that higher wages induce more effort because u and W enter in the same way in (2).

Which workers increase their effort the most? The first-order effect comes through differential changes in unemployment rates. As an empirical matter, the increase in unemployment during recessions tends to be concentrated among the less skilled. That is not quite the same as ability as it is measured here, but if the least talented are more likely to see a rise in unemployment than the most talented, the increase in effort should be greater for the least

⁶ Rebitzer (1987) develops a model of individual worker productivity as a function of unemployment. Workers shirk less when the costs of dismissal fall during periods of slack labor markets. The key is that dismissal costs, which include the costs of replacing dismissed workers, fall during periods of high unemployment and the alternative wage falls for workers. Rebitzer shows that in two-digit industries the level of unemployment raises productivity growth from 1960 to 1980. In his model, workers are homogenous within firms – there is no reallocation of workers. The Shapiro and Stiglitz (1984) model also has reduced shirking and rising productivity during periods of unemployment.

talented. Another implication is that those regions or industries that experience the largest increase in unemployment during recessions should also witness the largest increase in effort.

That implication is not completely unambiguous because the result depends not only on which group experiences the greatest increase in unemployment, but also on which group responds the most to a given increase in unemployment. To get at this, it is necessary to sign $\partial(\partial e/\partial u)/\partial k$ and the response of effort to a change in unemployment may be increasing in k . This is shown in the appendix. The implication as to which group increases effort more in a recession is somewhat ambiguous. Still, there is one clear implication with respect to unemployment.

Consider two types of workers high, denoted H, and low, denoted L. If changes in the unemployment rate for the two groups are du_H and du_L , respectively, then

$$\lim_{du_H \rightarrow 0} de_H - de_L < 0$$

As the change in unemployment for the skilled gets small relative to that for the unskilled, the change in effort for the unskilled exceeds that for the skilled. Thus, as long as u_L rises enough relative to u_H , the unskilled will increase their effort by more than the skilled.

Although the relative increase in effort across skill groups during recessions remains an empirical question, the implication from the logic above is that at least for large differences between the increase in unemployment among the low ability and high ability types, the expectation is that low ability workers should increase their effort more than high ability workers.

Composition Effects

How does employment vary with market conditions? In order to ascertain this, it is necessary to present a model of hiring and determine which workers are retained when market conditions are worse than expected.¹

The firm knows the worker's behavior as determined by (1) and (2). Recall that R is the rent that a worker receives on the alternative job. Using (1), a worker accepts the job if

$$(3) \quad G(e) (W - c(e)/k) + [1 - G(e)] (1-u) R > 0$$

Recall that u is unknown at the time of hire so the worker bases his decision on whether to accept the job on the expectation of u .

Condition (3) implies that there is some k^* below which the worker will not accept the job so the workers who are successfully hired by the firm are those for whom $k > k^*$.² Suppose that the firm gets N applicants (exogenous) in any given period. If $k \sim f(k)$ in the population, then the firm's expected profit is given by

$$(4) \quad \text{Expected profit} = N \int_{k^*}^{\infty} [e(k) - W] f(k) dk$$

where $e(k)$ is the solution to (2) for worker of ability k .

⁷This analysis is based on the model presented in Lazear (2000a).

⁸There could also be an upper cutoff. This arises when R depends on k and R rises sufficient with k so that high ability workers find that the rent that they receive on the alternative job exceeds that on the one being offered.

The choice of x , which is the minimum standard against which workers are judged, and of W , is the result of maximizing (4) along these two dimensions. Both W and x enter in (1) and (2). Even though workers do not know x with certainty, the minimum standard x that is actually chosen may affect workers' assumptions about x as they are incorporated into $g(x)$. For example, the density of x may be unbiased, but still may have variation. Workers' estimate of x could be the true x , plus some random noise that reflects the imprecision of worker estimates. When the firm chooses a higher x , the distribution of values shift in an unbiased way, but workers continue to estimate the minimum effort cutoff imperfectly.

For the purposes here, finding an analytic solution to (4) is unimportant. What is essential, though, is that there is a distribution of worker abilities in the firm that is the truncated distribution derived from $f(k)$ and k^* . Once W and x are determined, k^* follows from (3). The density of workers who are actually employed at the firm is given by

$$\frac{f(k)}{1 - F(k^*)} \text{ for } k \geq k^*$$

and

$$0 \text{ for } k < k^*.$$

Intuitively, the structure is as follows. The firm calls out a wage W and sets a minimum standard x . That induces some workers to accept the job according to (3). Knowing this, the firm chooses W and x so as to maximize expected profits in (4).

Why does the firm tolerate different levels of ability within the firm? As shown in Lazear (2000a), the firm would be better off setting an x and W that caters to one particular type of worker. Implicit in the structure is that search is costly. Because the firm only gets N applicants with abilities drawn from $f(k)$, it does not have the luxury of hiring all of one ability type. Attempting to do so would mean that the firm would hire very few people and would sacrifice profit. Underlying this is that the firm does not operate in a market where there is a perfectly elastic supply of workers at all ability levels. Search costs create a situation where the firm is willing to accept workers who do not fit its requirements perfectly.

Now consider what happens during a downturn. Recall that W and x were set based on the expectation of u , but, as shown, effort rises when u rises and the definition of a recession is that the demand for output falls. This suggests that employment needs to be adjusted downward. Which workers should be laid off? Because this is a fixed wage contract, (4) implies that the firm should lay off those workers whose expected output during the recession is the lowest.

Note that this is not necessarily the low ability workers as denoted by having the lowest k . Recall that low ability workers, whose output is lowest during normal times, might increase their effort the most during a recession because the probability of obtaining another job may be related to k . As a result, although the composition of the workforce should change in the direction of higher effort workers, this does not necessarily imply that one can predict which workers are to be laid off based on their pre-recession levels of output. It is the ex post effort that matters so there is not an unambiguous prediction of how layoffs or composition of the workforce should relate to the fixed effects that are estimated before the recession.

The implication of this section is that effort rises unambiguously for each worker who is retained and the composition of the workforce should shift toward those who will be most productive during the recession, but this is not necessarily those who were most productive before the recession.

II. Data

The data is daily productivity data from an extremely large services company. The jobs in the company are what we label “technology based service” jobs or “TBS jobs.” Confidentiality restrictions limit our ability to reveal the exact nature of the work. Examples of TBS jobs include insurance-claims processing, computer-based test grading, technical call centers, retailing jobs such as cashiers, movie theater concession stand employees, in-house IT specialists, airline gate agents, technical repair workers, and a large number of other jobs.

What these jobs share in common is that a computer keeps track of the productivity of the workers. Many production processes in services now fit this description. The technology that is used to measure performance may be a new computer-based monitoring system such as an ERP (Enterprise Resource Planning) system that records a worker’s productivity each day (such as the number of windshield repair visits done by each Safelite[®] worker (Lazear, 2000b; Shaw and Lazear, 2008)), cash registers that record each transaction under an employee ID number, call centers, or computer-monitored data entry. These TBS jobs are widespread.

The data contain four years of daily productivity transaction records between June 2006 and May 2010. There are 20,386 unique workers for a total worker-day sample size of about 5.1 million observations. This company has multiple different service functions, but the data used come from one task classification where workers are involved in general transactions. This

ensures that all workers in the sample perform approximately the same tasks. The data come from many establishments, but the number of establishments is suppressed for confidentiality reasons. To study the effects of the recession, we restrict the data to locations with sufficient operating history prior to the recession.⁷ Finally, the data contain information on each worker's boss, or supervisor. The quality of the supervisor also influences the productivity of the worker, as is emphasized in Lazear, Shaw, and Stanton (2013). There are 1,630 bosses.

In this company, the productivity of the worker is controlled by the worker's effort. The information technology system measures the time it takes to process a customer transaction from beginning to end. If there is slack time because there are no customers, this downtime is not measured. Productivity is, therefore, the average number of transactions a worker handles in an hour, when the hour working is measured from total processing time.⁸ The worker can increase his transactions by processing customers more quickly.

Workers in this firm are paid an hourly wage rate. While the firm could pay for performance, they do not do so.

III. Empirical Results

A. Summary Statistics

There is an increase in productivity during the recession. As shown in Table 1, productivity rises from an average of 9.87 units per hour during the non-recession period (June 2006 through November 2007, July 2009 through May 2010) to an average of 10.76 units during the recession period (December 2007 through June 2009). During the recession, productivity rises, then it drops down again after the recession. These results only examine aggregate time

⁷ We also drop the data from the first month of operations for new establishments.

⁸ There is no data on the number of hours the worker is scheduled to work per day.

series changes in productivity. Regression results will control for worker quality and add cross-area variation in unemployment rates to fully identify the effects of market conditions on the effort and sorting of workers.

How is the firm adjusting employment during this period? Figure 1 shows the time path of employment. This firm is growing. Therefore, employment does not fall during this time period, but the growth rate of employment falls. As is evident in the graph, the recession is a period of reduced hiring. Despite growth, mean tenure rises during the recession to 699 days, from 680 days in the non-recession period.

Given the reduction in employment growth during the recession, we would expect to see a steady rise in productivity as the recession worsens. This is shown in Figure 2. What is also shown is that the unemployment rate plateaus in the months post-recession, but the productivity in the firm declines during these months. The reason is that this firm resumes hiring (shown in Figure 1) post-recession, so output per person falls.

B. Productivity Effects of the Recession

Turning to regression results, there is a 5.3 percent increase in productivity during the recession (column 1, Table 2).⁹ This is based on estimating

$$(5) \quad \log(q_{ijt}) = \gamma_1 R_t + X_{it}\beta + \zeta_j + \varepsilon_{ijt}.$$

where q_{ijt} is the output per hour of worker i at establishment j at time t . The dummy variable R_t captures the recession period from December 2007 through May 2009. The matrix X_{it} contains a cubic polynomial in workers' tenure, a cubic polynomial in time, and 11 month dummies to

⁹ Because we model the productivity of workers within establishments, we need not control for the restructuring of firms that involves the closing of the least productive establishments during recessions (Davis and Haltiwanger, 1990; Garin, Pries and Sims, 2011; Rebitzer, 1987).

control for seasonality; ζ_j is an establishment fixed effect. Thus, holding constant the factors that are seasonal or location specific, there is a sizable jump in productivity.

As mapped out in the theory, there are two channels through which productivity can increase during recessions. First, a given worker may put forth more effort during recessions. Second, the composition of the workforce may change in the direction of higher quality workers being employed during recessions. This is an empirical question. Does the increase in productivity during the recession come from people on the job working harder, or from the attraction and retention of higher caliber people? Estimating productivity equation (5) with a person fixed effect sheds some light on this question.¹⁰

A person fixed effect, α_i , is added to the productivity regression in column 2 of Table 2. If more productive people are employed during the recession due to compositional shifts in the workforce, there will be a positive correlation between R_t and α_i and the estimate of γ_1 will decline when worker fixed effects are added to the regression. The productivity gains appear to be from increased effort, not sorting. During the recession, productivity rises by 5.4 percent in the worker fixed effects model (column 2), which is nearly identical to the 5.3 percent increase in the OLS estimation. There is no evidence that the increased effect $\gamma_1 R_t$ is correlated with the unobserved α_i in the productivity regression. Finally, column 3 adds boss fixed effects. The results are unchanged.

In a related test, if sorting of workers to the firm does not change over time, regressions using a balanced sample of continuously employed workers should produce the same estimates as the sample with the entry and exit of workers to the firm. The estimates are very similar.

¹⁰ The methods follow those of Lazear (2000b).

Regressions in columns 4 through 6 of Table 2 follow the 1,623 workers (with 1.1 million daily productivity measures) for those who are continuously employed before October 2006 through May 2010. The productivity gain during the recession is estimated as 4.6 percent via OLS and 4.9 percent via fixed effects, little changed from the OLS recession effect of 5.3 percent for the full data set of 20 thousand workers.¹¹

Another test of sorting is to assess whether the exit and entry of workers exhibits changes in the quality of the workforce. We run a regression of productivity on two measures: whether the worker separated during the recession, and whether the worker was hired during the recession. The parameter estimates (standard errors) are: $\log(\text{productivity per hour}) = .053(.001) \text{ Recession} - .0002(.0024) \text{ Leaver during recession} + .015(.003) \text{ New-hire during recession}$.¹² The set of leavers should be of indeterminate quality because some leavers are layoffs who are likely low quality and some leavers are quitters who are likely high quality.¹³ The estimates show no quality differential for leavers. The set of new-hires should be of higher quality during the recession because better workers would be hired, and the regression shows their mean value is .015, or 1.5 percent more productive than all others. However, the new-hires impact on productivity is small because they are only 30 percent of all those working during the recession,¹⁴ so the total impact of new-hires on aggregate productivity is .005.

The conclusion that sorting effects are very small holds up after additional tests for worker sorting. One potential concern is that if there are heterogeneous effects of the recession

¹¹ The parameter estimates between OLS and fixed effects for the balanced sample may differ because tenure is included in both models, but the start dates for workers are not equal, meaning that worker's tenure and fixed effects are likely correlated.

¹² Regression contains the same OLS estimation methods and control variables as in column 1 of Table 2.

¹³ The market may infer that those who are laid off are of lower quality (Gibbons and Katz, 1992).

¹⁴ The ratio of observations of New-hires to all those working during recession is 617,738/2,053,372.

on different types of workers, the inference about workforce composition changes that comes from the formula for omitted variable bias when comparing OLS and fixed effects estimates in the unbalanced panel may not be correct.

Ignoring the small number of new workers who enter, a simple measure of the recession productivity increase due to compositional changes is calculated by taking the difference in actual productivity for workers who stay minus estimated productivity for the workforce as if no attrition occurred. However, there is an empirical difficulty because the productivity of leavers is unobserved. To estimate counterfactual productivity for workers who leave, workers' productivity is aggregated to the monthly level and changes in monthly productivity are calculated for each worker. By regressing changes in productivity for leavers, $\Delta y(t-1)^{\text{Leavers}}$, on mean changes in productivity for stayers, $\Delta y(t-1)^{\text{Stayers}}$, prior to a worker's attrition, it is possible to determine whether aggregate counterfactual productivity for leavers can be estimated using productivity changes for stayers. We cannot reject a coefficient of 1, indicating that this is a reasonable approach.¹⁵ Counterfactual productivity for leavers is then computed as $y(t+1)^{\text{Leavers}} = y(t)^{\text{Leavers}} + \Delta y(t+1)^{\text{Stayers}}$.

For any given month, because the share of new entrants is small, the change in productivity due to compositional differences is approximately $y(t+1)^{\text{Stayers}} - y(t+1)^{\text{Stayers}} s^{\text{Stayers}} - y(t+1)^{\text{Leavers}} s^{\text{Leavers}}$ where s^{Stayers} is the share of stayers and s^{Leavers} is the share of leavers. Adding across all recession months gives a total increase in productivity due to compositional factors of 0.68%, relative to a total change of 5.33%.

In sum, there is an increase in productivity during the recession, almost all of which can

¹⁵ This relationship does not change with the recession; a recession main effect and a recession interaction term are not statistically different from zero.

be attributed to increased effort rather than to workforce composition effects. Is there any other omitted variable bias that might explain the rising productivity? The regressions do not contain measures of the capital stock. There was no reason for this firm to invest in new capital during the recession, or, to the extent that they did invest, it should enter the time controls in the regression. Moreover, the regression contains establishment dummies. This is important because once an establishment is built, its capital stock is likely to remain fixed over time and be uncorrelated with the recession dummy variable.

As a further check on the robustness of the results and interpretation, we turn next to a test of whether higher productivity is also associated with cross sectional differences in unemployment rates. Potential sources of omitted variable bias are unlikely to explain the cross-sectional responses to the recession that are documented below.

C. Heterogeneity in the Treatment: Cross-Sectional Unemployment Differences

The impetus described in the theory section for recessions affecting productivity through higher effort comes from workers' alternative use of time being lower during recessions. If unemployment rises so that a worker's probability of finding a job declines and if wages do not grow in high unemployment periods or places, then the relative cost of effort falls during recessions and work effort increases. Workers in different establishments experienced differences in unemployment conditions over the five years of the data. In Florida, the unemployment rate rose from 3.3% to 11.2% from June 2006 to May 2010. In Kansas, the unemployment rate rose from 4.4% to 7.1% over this period. Differences in the cross-section as well as the time series should impact productivity.

Productivity regression (5) can be augmented to make use of differences in labor market

conditions. Across-establishment differences in unemployment may enter the productivity regression. To test this, the augmented regression is

$$(6) \quad \log(q_{ijt}) = \gamma_{11} \text{UnempR}_{ijt} + \mathbf{X}_{it}\beta + \zeta_j + \alpha_i + \tau_t + \varepsilon_{ijt}.$$

where UnempR_{ijt} is the monthly unemployment rate by state matched to each establishment j and τ_t is a year-by-month fixed effect. The year-by-month fixed effects remove time-series shocks to the unemployment rate and firm productivity, so the model is identified using across-establishment variation in the unemployment rate within a given month.

In the model with only establishment fixed effects, year-by-month fixed effects, and a cubic polynomial in tenure (column 1, Table 3) gives a point estimate of 0.0075, which corresponds to a 3.75% increase in productivity for a 5 percentage point increase in the local unemployment rate. The next two columns add worker and boss fixed effects, respectively. The results are little changed from column 1, indicating that individual workers increase their effort in response to worsening local labor market conditions. In labor intensive industries that are as competitive as the industry surrounding this firm, even a 3.75 percent increase in productivity is sizable.

Turning to results using the balanced sample, we see again that compositional changes in the labor force explain only a small portion of the increase in productivity at the firm level. Columns 4 through 6 repeat columns 1 through 3 for the sample of workers who are present in both the pre-recession and post-recession periods. Point estimates for the balanced sample of workers are similar to those in Columns 1-3.

In this firm, the management did not change the nature or difficulty of tasks for workers in establishments that were relatively highly affected by the recession. The nature of the task,

and demand conditions for workers' services, were uniform for all establishments. This alleviates many potential concerns about omitted variable bias that is correlated with the local unemployment rate. Regressions similar to those in Table 3 using a second productivity measure, uptime, confirm the results. Uptime is defined as the percentage of time a worker is physically available to receive transactions during his or her shift. This is a measure of effort that is controlled by the worker directly.

The mean uptime in the sample is 0.963, meaning that workers are available to process transactions for over 96% of their working hours. Table 4 estimates regressions with uptime as the dependent variable. The point estimates on the local unemployment rate are positive and statistically significant in columns with establishment effects. The results are similar when adding worker and worker and boss fixed effects. The most natural way to interpret the parameter estimates is in relation to the percentage of a worker's shift spent as downtime, or 1 - uptime. The corresponding estimates imply that a 5 percentage point increase in the local unemployment rate would cause workers to reduce downtime on the job by between 3.5 and 4.6 percent.

In summary, productivity rises when and where unemployment rates are high. The likely explanation for this rise in productivity with unemployment rates is that worker effort increases when the unemployment rates rise. Because the value of the workers' alternatives decline with the unemployment rate, the theory predicts and results confirm that effort should increase as unemployment rises.

D. Heterogeneity in the Treatment Effect: Stars and Laggards

Workers need not respond equally to the recession. Define laggards as those who are less

able than the median, and thus those who will face higher unemployment rates and lower quality future jobs. Define stars as those who are more able than the median, and thus those who will face lower unemployment rates and higher quality alternative job offers. As described in the theory section, laggards may or may not respond more to the recession than stars. Theory proposes that the less skilled group will increase their effort less for a given change in unemployment, but that unemployment is likely to rise more for the less skilled. The predicted effect of skill level on productivity is therefore ambiguous.

To assess whether stars or laggards are most responsive to the recession, we use data on those workers who enter the firm in the pre-recession period covered by our data. These data are used to classify workers based on their pre-recession productivity into those who are stars prior to the recession and those who are laggards. Define stars as those workers whose person specific fixed effect, α_i , is above the median using data on workers' first 60 days of tenure when regression (5) is estimated with a worker fixed effect.¹⁶ Laggards are those with below median fixed effect productivity prior to the recession in this sample. There are 2,701 laggards and there are 2,878 stars (the discrepancy is due to taking a median weighted by days of work, and laggards are slightly more likely to leave the firm in the pre-recession period).

There is a significant difference in the effect of the recession for stars and laggards: laggards increase their productivity in the recession more than stars. During the recession, productivity rises by an additional 3.7 percent for laggards against a baseline effect of the recession for stars of 4.5 percent (Table 5, column 1). Column 2, containing worker fixed

¹⁶ Workers with entry dates prior to the beginning of our sample are not included. The sample includes only workers whose first day of work is both present in the sample and occurs prior to 11/1/2007. The 11/1/2007 cutoff period is used to ensure that workers in the pre-recession estimation sample have at least some data from which to estimate their fixed effect that is not contaminated by the recession.

effects, confirms these results. If the threat of unemployment and the alternative job is poorer for laggards than for stars, one might expect that the effort of laggards would rise by more than that for stars. Column 3 of Table 5 includes boss effects.

The remaining columns of Table 5 repeat the specification in Table 3. In these models, stars' effort response to the local unemployment rate is minimal. Laggards, however, increase their effort substantially. In the specification with year x month and establishment fixed effects, laggards' productivity increases by 5.75 percent in response to a 5 percentage point increase in the local unemployment rate (Column 3). When adding worker fixed effects, a 5 percentage point increase in the local unemployment rate increases laggards' effort by 6.5 percent. These point estimates are approximately twice the size of the point estimates in Table 3 (although the sample is different), suggesting that most of the effect is coming from the lower-tail of the distribution of worker quality. Column 6 includes boss fixed effects. The similarity of results with and without boss effects suggests that the large point estimates for laggards is not due to omitted variable bias, as stars and laggards with the same boss are on the same team and experience the exact same employment conditions and demand for their services.

IV. Conclusion

Productivity has risen during recent recessions and there are two possible reasons for the increased productivity. It could be that firms are laying off workers and each employed worker is working harder – that is, firms are making due with less, as effort levels of workers rise. It could be that firms are sorting workers – retaining the highly productive and letting go the least productive. By using detailed data from one firm, data in which measures of individual worker output are available, it is possible to disentangle these alternative causes of the rise in

productivity that occurred during the 2007-9 recession. Because panel data are available for this firm, the two effects of higher effort versus sorting can be estimated separately.

The main finding is that productivity rose in this firm because the firm made do with less. Each worker produced more output than would have been the case during normal times: output-per-worker rose during the recession by 5.33 percent. Labor quality changes throughout the recession period were small despite a large amount of turnover.

Because the data are from many different establishments across the country, it is possible to examine the effects by local labor market conditions. In those areas where the recession was most pronounced, the productivity gains are the strongest and the increase in effort the most pronounced. This same conclusion holds for non-recession years, when cross-sectional increases in unemployment are associated with increased worker productivity.

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Figures and Tables

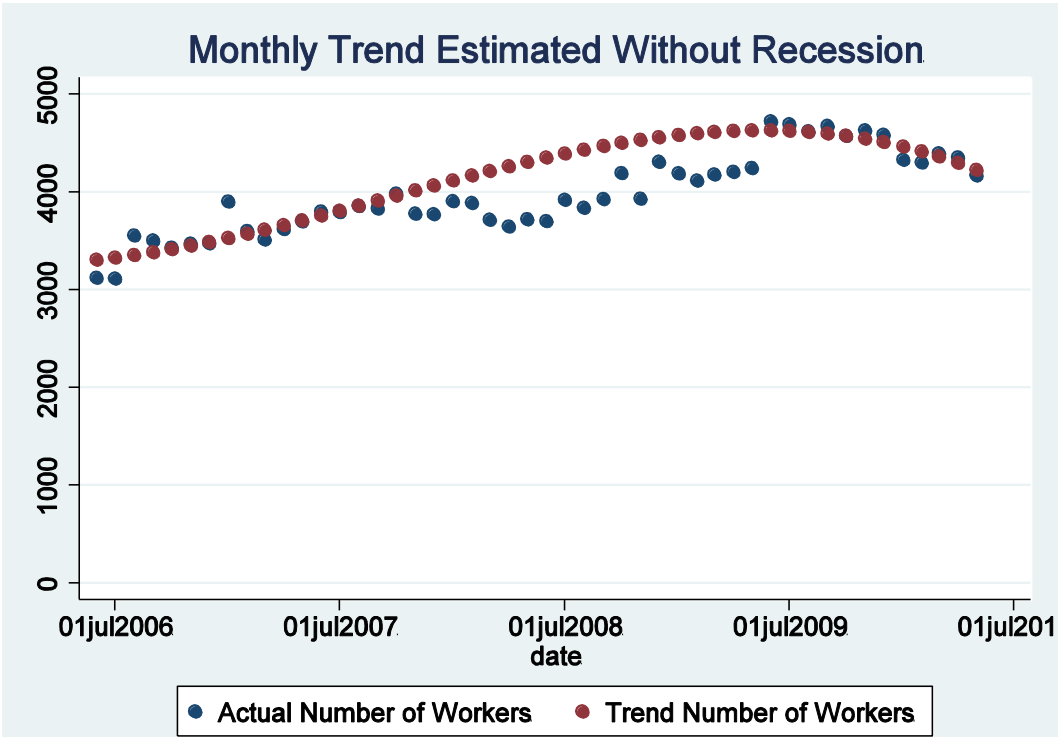


Figure 1: Average number of workers-per-day aggregated to the monthly level (in blue) is plotted against an estimated number of workers (in red) where the estimates come from a regression of average workers-per-day on a cubic polynomial in time, excluding the recession period.

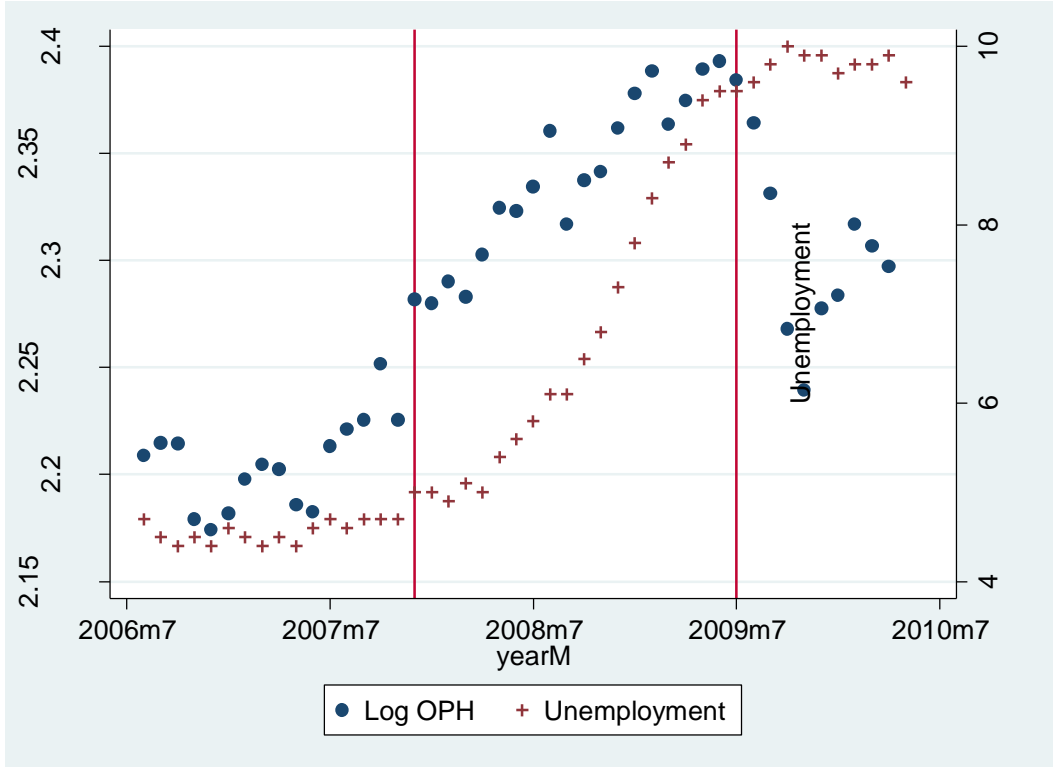


Figure 2: This figure plots actual monthly mean log productivity per worker, Log OPH, on the left axis and the the monthly unemployment rate on the right axis. Vertical red lines indicate recession beginning and end.

Table 1: Means (Standard Deviation)

	Non-Recession*	Recession**
Productivity per hour.	9.87 (3.18)	10.76 (3.05)
Tenure (days)	680.4 (612)	699.0 (636)
N	3,023,015	2,053,372

* June 2006 through November 2007, and July 2009 through May 2010.

** December 2007 through June 2009.

Table 2: The Effect of the Recession on Productivity
Dependent Variable: Log (Productivity per Hour)

	Entire Sample			Balanced Sample		
	Establishment Fixed Effects	Worker Fixed Effects	Worker and Boss Fixed Effects	Establishment Fixed Effects	Worker Fixed Effects	Worker and Boss Fixed Effects
	(1)	(2)	(3)	(4)	(5)	(6)
Recession	0.0533 (0.001)	0.054 (0.001)	0.052 (0.001)	0.046 (0.002)	0.049 (0.002)	0.048 (0.002)
N	5,076,387	5,076,387	5,076,387	1,102,389	1,102,389	1,102,389
R ²	0.064	0.244	0.253	0.049	0.177	0.186

Notes: The Entire Sample contains daily data from June 2006 to May 2010, for 20,387 workers. The Balanced Sample contains only those 1,623 workers who were employed before October 2006 and who remain in the sample as of May 2010. All specifications contain cubic polynomials in tenure, establishment fixed effects, and 11 month fixed effects. OLS regressions contain cubic polynomials in time. Regressions with worker fixed effects contain time squared and time cubed. Robust standard errors are clustered at the worker level in OLS and worker fixed effects models. Standard errors are calculated by block-bootstrap using the worker as the unit of analysis in models with worker and boss fixed effects.

Table 3: Productivity Regressions with the Local Unemployment Rate
Dependent Variable: Log (Productivity per Hour)

	Entire Sample			Balanced Sample		
	Establishment Fixed Effects	Worker Fixed Effects	Worker and Boss Fixed Effects	Establishment Fixed Effects	Worker Fixed Effects	Worker and Boss Fixed Effects
	(1)	(2)	(3)	(1)	(2)	(3)
Monthly unemployment rate in state	0.0075 (0.0012)	0.0072 (0.0012)	0.0067 (0.0008)	0.0084 (0.0012)	0.0088 (0.0013)	0.0081 (0.0016)
Impact of 5 % change in unemployment	0.0375	0.036	0.0335	0.042	0.044	0.0405
N	5,076,387	5,076,387	5,076,387	1,102,389	1,102,389	1,102,389
R ²	0.069	0.252	0.258	0.053	0.182	0.191

Notes: All models include a cubic polynomial for workers' tenure, year x month fixed effects, and establishment fixed effects. Robust standard errors are clustered at the state x month level in columns without boss fixed effects. Standard errors are calculated by block-bootstrap using the worker as the unit of analysis in columns with boss fixed effects.

Table 4: Productivity Regressions with the Local Unemployment Rate
Dependent Variable: Uptime

	Establishment Fixed Effects	Worker Fixed Effects	Worker and Boss Fixed Effects
	(1)	(2)	(3)
Monthly Unemployment Rate in State	0.00026 (0.0003)	0.00034 (0.00016)	0.00029 (0.00007)
Impact of 5 % change in unemployment relative to downtime.	0.035	0.046	0.039
Mean of Dependent Variable	0.963	0.963	0.963
N	4,323,136	4,323,136	4,323,136
R ²	0.013	0.093	0.098

Notes: All models include a cubic polynomial for workers' tenure and year x month fixed effects, and establishment fixed effects. Robust standard errors are clustered at the state x month level. The impact of a 5 percent change in unemployment is calculated relative to a "downtime" baseline, where mean downtime is 1 - mean uptime.

Table 5: Productivity Regressions for Stars and Laggards
Dependent Variable: Log (Productivity per Hour)

	(1)	(2)	(3)	(4)	(5)	(6)
Laggard	-0.1698 (0.0032)			-0.2275 (0.0050)		
Recession	0.0449 (0.0024)	0.0468 (0.0020)	0.0508 (0.0073)			
Recession x Laggard	0.0368 (0.0032)	0.0244 (0.0026)	0.0107 (0.0046)			
Monthly unemployment rate in state				-0.0001 (0.0016)	0.0012 (0.0015)	0.0002 (0.0012)
Monthly unemployment rate in state x Laggard				0.0115 (0.0006)	0.013 (0.0005)	0.013 (0.0008)
Establishment Fixed Effects	Y	Y	Y	Y	Y	Y
Year x Month Fixed Effects	N	N	N	Y	Y	Y
Worker Fixed Effects	N	Y	Y	N	Y	Y
Boss Fixed Effects	N	N	Y	N	N	Y
N	1,763,552	1,763,552	1,763,552	1,763,552	1,763,552	1,763,552
R ²	0.175	0.299	0.309	0.184	0.308	0.318

Notes: The sample consists of workers whose first day of work is prior to 11/1/2007. Stars and laggards are defined using a sample of worker productivity over each worker's first 60 days of tenure. Using this sample, the classification of stars and laggards is based on whether a worker's estimated fixed effect is above or below the median of the distribution of worker fixed effects after regressing $\log(\text{oph})$ on a cubic polynomial in tenure, year x month, establishment, and worker fixed effects. All models include a cubic polynomial for workers' tenure. Robust standard errors are clustered at the state x month level in columns 4 and 5. Clustering is at the worker level in columns 1 and 2. Standard errors are calculated by block-bootstrap using the worker as the unit of analysis in columns with boss fixed effects.

Appendix

Proof that effort may increase more with unemployment as skill rises:

The goal is to show that $\frac{\partial(\frac{\partial e}{\partial u})}{\partial k} > 0$.

The second order condition is given by

$$(A1) \quad SOC = g'(e)[W - c(e)/k - R(1-u)] - 2g(e)c'(e)/k - G(e)c''(e)/k < 0$$

From the text,

$$\begin{aligned} \frac{\partial e}{\partial u} \Big|_{F.O.C.} &= - \frac{\partial / \partial u}{\partial^2 / \partial e^2} \\ &= - \frac{g(e)R}{\partial^2 / \partial e^2} \end{aligned}$$

so

$$\begin{aligned} \frac{\partial \left(\frac{\partial e}{\partial u} \right)}{\partial k} &= \frac{\partial}{\partial k} \left(- \frac{g(e)R}{\partial^2 / \partial e^2} \right) \\ &= \frac{g(e)R \left(\frac{\partial SOC}{\partial k} \right)}{SOC^2} \end{aligned}$$

(A2)

which has the sign of $\partial SOC / \partial k$.

$$(A3) \quad \frac{\partial SOC}{\partial k} = \frac{c(e)g'(e)}{k^2} + \frac{2g(e)c'(e)}{k^2} + \frac{G(e)c''(e)}{k^2}$$

Note that the second-order condition in (A1) can be written as

$$(A4) \quad g'(e)[W - R(1-u)] - k \partial SOC / \partial k$$

But since $W - R(1-u)$ is positive (since the rent on the primary job is greater than that on the secondary job even taking into account the cost of effort), if $g' \geq 0$, $\partial SOC / \partial k$ must be positive for (A4), which is the second order condition, to be negative. But if $(k \partial SOC / \partial k)$ is positive, then $\partial SOC / \partial k$ is also positive, which implies that

$$\frac{\partial \left(\frac{\partial e}{\partial u} \right)}{\partial k} > 0$$

A simple example where $g' \geq 0$ is a uniform distribution, which has $g' = 0$.