Making Do With Less: Why Productivity Rises During Recessions

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During recent recessions, productivity has risen. In the recession of 2007 to 2009, aggregate output fell by 4.35 percent, but the aggregate number of hours worked decreased by 10.54 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 of the increase in productivity can be explained by compositional effects, i.e., having better workers on average during the recession, and how much is explained by increased effort.[2]

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

[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.

[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).

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 for over 20,000 moderately skilled workers. 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.

Empirically, 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 the average worker works harder. Evidently, effort increases to produce more output per unit of time.

The paper is organized as follows. Section I contain the theoretical framework. The data description and empirical results are in Sections II and III. Section IV decomposes economy wide changes in productivity into that which can be explained by changes in employment by education group and a residual. 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.

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 $c(e) / k$.

A worker chooses effort knowing that the firm at which he works pays a wage W and has some minimum effort requirement, x, which has distribution function G(x) and density g(x).[3] The worker does not know x precisely, but knows the distribution of requirements in the population of firms. 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 he does not locate a new job, he becomes unemployed, which has value normalized to be 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.

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

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) Surplus = G(e) (W - c(e)/k) + [1- G(e)] (1-u) R

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.

The first-order condition for (1) is

(2) $\partial/\partial e =$ 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

$$\frac{\partial e}{\partial k}\Big|_{F.O.C.} = -\frac{\partial / \partial k}{\partial^2 / \partial e^2}$$

$$= -\frac{g(e)c(e)/k^2 + G(e)c'(e)/k^2}{\partial^2 / \partial e^2}$$

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 more effort. This is a result that is standard in the efficiency-wage literature and follows directly from the model.[4] Using the first-order condition, once again,

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

or

$$\frac{\partial e}{\partial u}\Big|_{F.O.C.} = -\frac{\partial / \partial u}{\partial^2 / \partial e^2}$$

$$= -\frac{g(e)R}{\partial^2 / \partial e^2}$$

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). The choice of W is not of particular interest, but the firm chooses W to maximize profit knowing workers of different abilities respond differently to W and that higher W means more effort. If worker ability were unobservable but were distributed according to k~f(k) with distribution function F(k), the firm would choose W to maximize

[4] 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.

(3) $$PROFIT = \int [W - e(k,W)] f(k) dk$$

where e(k, W) is derived from solving for e from (2) in terms of k and W. It also depends on workers' assessment of g(x), namely their belief about the minimum cutoff for employment.*

Which workers increase their effort the most? The first-order effect comes through differential changes 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 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 are clear implications with respect to unemployment.

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

$$\Delta \equiv du_L - du_H$$

$$\lim_{\Delta \to 0} de_H - de_L > 0$$

For any given increase in unemployment,

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

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 Δ, the expectation is that low ability workers should increase their effort more than high ability types.

B. Employment, Productivity and Profit

What happens to employment, output, and profits? Because a recession is defined as a decline in output, employment unambiguously falls. Since effort-per-worker rises and output falls, employment must decline.

Productivity rises and cost-per-unit of output falls and during recessions. Productivity rises as long as the composition of the workforce during recessions does not shift dramatically in favor of low skilled workers. Any given worker experiences a rise in effort and productivity during recessions, which follows from the fact that $\partial e/\partial u > 0 \ \forall \ k$. If composition of the workforce remains the same or shifts toward skilled workers during recessions, then productivity is guaranteed to rise. As an empirical matter (well-known and shown below) recessions are characterized by greater layoffs among the low skilled, which raises rather than lowers productivity.

Unless wages rise by more than productivity during the recession, cost-per-unit of output also falls. Again, as an empirical matter, wages move with productivity over the long run, but do not generally outstrip productivity gains during recessions.

Profits may rise or fall, depending on movements in product price. If recessions have larger effects on product prices than they do on costs, profits fall. During the most recent recession, profits rose because cost cutting associated with the productivity increases described above was more pronounced than were price declines.

The skill mix is exogenous in this model. It depends on what happens to unemployment rates at the aggregate level. Again, as is well-known, at least at the typical firm, the proportion of skilled to unskilled workers rises during recessions. Whether this effect is large enough to account for changes in productivity at the aggregate level is discussed below in the empirical section. This is done both in the context of the firm in question and at the level of the aggregate economy.

C. **Differences Over Time and Across Countries**

Our goal is to discuss changes in productivity at the firm level. There is no attempt here to explain unemployment at the aggregate level or to reconcile the causes of recession with the behavior studied here. Still, it is useful to attempt to reconcile the results with patterns that have been observed, both over time and across countries.

First, it is known that before the 1990s, recessions meant reduced productivity. The usual explanation was labor hoarding, although that is more of a name for the phenomenon than an explanation. If productivity goes down, then, by definition, labor is reduced by less than output. In Europe, productivity continues to fall during recessions. Figure 4 shows this. Note the decline in productivity in Germany, France, Italy and the United Kingdom during the recent recession, but not in the United States.

One possibility is that institutional factors prevent layoffs in earlier times and in Europe. Berger (2012) has made this argument in the context of the United States, arguing that the weakening of unions has allowed layoffs to occur more readily in recent times. Analogously, Europe has firing restrictions and intentional employment retention policies (e.g., Germany during the recent recession) that may artificially boost employment.

A problem with these explanations is that changing hiring rates allow a great deal of employment discretion, even absent changes in layoff policies. Even during the worst month of job loss, over 3.5 million workers were hired in the US. As documented in Lazear and Spletzer (2012) and elsewhere[1], most firms are hiring during the recession period. It is still possible that shutting down layoffs contributes to the differences, but this is not explored further here. The JOLTS (BLS Job Openings and Labor Turnover Survey) shows that separations and hires are positive, not negatively, correlated over time. Further, the reduction in employment that occurred during the recent recession was more due to hiring falling than separations rising. In fact, consistent with the logic of the model, separations fell during the recession because workers reduced their tendency to quit because of the inability to locate new jobs. These trends suggest that increased layoffs may not be able to account for the reason that employment shrinks now relative to the past or relative to Europe.

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[1] See Davis, Faberman and Haltiwanger (2010), Hall...

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 that 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, 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, 1999; 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.[5]

In this company, the productivity of the worker is controlled by the worker's effort. Productivity is measured as the time it takes to process a customer transaction from beginning to end. If there is no customer to be served, this downtime does not enter the productivity calculation. To get a better sense of the measure, we calculate the average number of transactions a worker can handle in an hour given the transaction processing time. The worker can speed up his transaction time by processing customers more quickly.

III. Empirical Results

A. Summary Statistics

There is an increase in productivity during the recession. 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) (Table 1). During the recession, productivity rises, then it drops down again after the recession. These results only examine aggregate time 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

[5] We also drop the data from the first month of operations for new locations.

period of reduced hiring. Despite growth, mean tenure rises during the recession to 699 days, from 680 days in the non-recessionary 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).[6] This is based on regressing log productivity on a cubic polynomial in workers' tenure, a cubic polynomial in time, month dummies to control for seasonality, and establishment dummies. 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 the productivity regression with a

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

person fixed effect sheds some light on this question:[7]

$$q_{ijt} = \gamma_1 R_t + X_{it}\beta + \alpha_i + \varepsilon_{ijt}. \quad (4)$$

where the treatment dummy variable is recession, R_t, the period December 2007 through May 2009. The matrix X_{it} again contains the exact same controls as column 1, and α_i is the worker fixed effect. 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 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 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.

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. Regressions in columns 3 and 4 of Table 2 follow the 2,240 workers (with 1.4 million daily productivity measures) for those who are continuously employed from June 2006 through May 2010. The productivity gain during the recession is estimated as 4.8 percent via OLS and 5.0 percent via fixed effects, little changed from the OLS recession effect of 5.3 percent for the full data set of 20 thousand workers.[8]

Another test of sorting is to test whether the exit and entry of workers exhibits changes in

[7] The methods follow those of Lazear (2000).

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

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 results are: log(productivity per hour) = .053(.001) Recession - .0002(.0024) Leaver during recession + .015(.003)New-hire during recession.[9] The set of Leavers should of indeterminate quality because some leavers are layoffs who are likely low quality and some leavers are quitters who are likely high quality.[10] 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,[11] so the total impact of New-hires is .005.

These conclusions, that sorting effects are very small, hold up after additional tests for worker sorting. If there are heterogeneous effects of the recession 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. The increase in productivity cannot be explained by raw comparisons of worker attrition, as workers who left the firm during these two months were only slightly less productive than workers who stayed. As measured by mean monthly productivity, workers who left in the first month of the recession were 0.75% less productive than stayers. Because only 6% of the total workforce left the firm in this month, the total increase in productivity during the first month of the recession due to worker attrition is about 0.04%. Using a similar calculation the

[9] Regression contains the same OLS estimation methods and control variables as in column 1 of Table 2.
[10] The market may infer that those who are laid off are of lower quality (Gibbons and Katz, 1992).
[11] The ratio of observations of New-hires to all those working during recession is 617,738/2,053,372.

total increase in productivity due to attrition is about 0.11% during the first two months of the recession.[12] 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, $\Delta y(t-1)^{Leaver}$, on mean changes in productivity for stayers, $\Delta y(t-1)^{Stayers}$, 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.[13] Counterfactual productivity for leavers is then computed as $y(t+1)^{Leavers} = y(t)^{Leavers} + \Delta y(t+1)^{Stayers}$.

For any given month, the change in productivity due to compositional differences is $y(t+1)^{Stayers} - y(t+1)^{Stayers}s^{Stayers} - y(t+1)^{Leavers}s^{Leavers}$ 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%.

In sum, there is an increase in productivity during the recession, almost all of which can be attributed to increased effort rather than to workforce composition effects. Is there any other

[12] This calculation does not include workers who enter the firm. The average new worker entering the firm in any recession month has lower productivity in the first month on the job than the average worker who leaves, so this number represents an upper bound on compositional increases.
[13] This relationship does not change with the recession; a recession main effect and a recession interaction term are not statistically different from zero.

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.

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

The impetus described in the theory section for affecting productivity through higher effort comes from the 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. Different geographic areas experienced varying rates of unemployment during the 2007-9 recession (as in all recessions) and it is possible to exploit this variation to test further the implications of the theory.

Establishments reside in states with different levels of unemployment. In Florida, the unemployment rate rose from 4.0 to 10.2 from 2007 to 2009. In Kansas, the unemployment rate rose from 3.0 to 7.1 over this period.

A plot of the data suggests that there will be higher productivity levels in areas of higher unemployment. Figure 3 divides the establishments into those located in areas of above average unemployment during the recession and those located in below average unemployment areas during the recession and then plots productivity over time. As displayed in Figure 3, productivity is higher for the high unemployment areas.[14] A series of regression results, described next, are consistent with these basic differences by area. The key takeaway from Figure 3 is that in the pre-recession period, establishments where the recession induced high unemployment looked very similar to establishments that had a smaller external labor market shock to unemployment during the recession.

Productivity regression (4) can be augmented to make use of the cross-sectional differences in labor market conditions. Cross-sectional differences in unemployment may enter the productivity regression. To test this, the augmented regression is

(5) $$q_{ijt} = \gamma_{11} R_t + \gamma_{12}\, Unemp_{it} + \gamma_{13}\, R_t * Unemp_{it} + X_{it}\beta + \alpha_i + \varepsilon_{ijt.}$$

where $Unemp_{it}$ is the unemployment rate during the year by state that is matched to the locations of the establishments. Unemployment enters in two ways. First, at all points in time, establishments located in high unemployment areas may have higher levels of productivity, or $\gamma_{12}>0$. Second, during the recession, the establishments located in high unemployment areas may be more sensitive to recession conditions, for unexplained reasons (as when durations of unemployment spells rise as they did during this recession). This implies $\gamma_{13}>0$.

Regression results reveal fundamental differences in productivity by the location of the establishment. The results of estimating (5) show that there is a greater increase in productivity in those locations where the unemployment rate is high. The cross-location unemployment rate enters directly and as an interaction between the unemployment rate and the recession (columns

[14] The productivity data used in the figure is the residual productivity from a regression of productivity on a cubic in tenure and establishment dummies, estimated over the pre-recession period. The establishment dummy variables control for the baseline unemployment rate in each area.

1 and 2, Table 3).[15] In terms of magnitude, as the unemployment rate rises from 4 percent to 10 percent in one area relative to another during the recession, productivity rises by 4.9 percent (column 2, Table 3). Columns (3) through (4) alter the underlying sample to exclude the period in Figure 1 and Figure 2 in which there is a large post-recession dip in productivity when the firm begins rapidly increasing daily headcount. The overall results are very similar, but the loading differs across measures. The cross-sectional unemployment effects become larger, and the recession-unemployment interaction effect declines in magnitude.

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 is rising when 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 average, and thus those who will face higher unemployment rates and lower quality future jobs. Define stars as those who are more able than average, and thus those who will face lower unemployment rates and higher quality alternative job offers. As described in the theory section, these laggards should work harder than stars.

The data are divided into two subsamples: those who are stars prior to the recession and those who are laggards. The stars are those whose person specific fixed effect, α_i, is above the median when regression (1) is estimated using data on workers first 60 days of tenure. The

[15] The regression controls for establishment fixed effects that would serve as proxies for cross-area differences in structural unemployment rates.

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. 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).

There is a significant difference in the treatment effects for stars and laggards: laggards increase their productivity in the recession more than do stars. During the recession, productivity rises by 5.1 percent for laggards, and by 3.4 percent for stars (Table 4, column 1). Column 2, containing worker fixed 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.

IV. Sorting in the Labor Market

Recall that productivity rose by 3.16 percent from the start of the recession to the quarter following the recession. It is well known that less educated workers suffer from higher unemployment rates during recessions than well educated. Could this shift in employment explain a significant portion of the productivity gain experienced during the recession?

The gain in productivity can be decomposed into that due to a shift in the composition of the workforce to the better educated versus an increase in the within education group productivity? Given $P = \sum_i s_i p_i$ then the decomposition is

$$\Delta P = \sum_i \Delta s_i \overline{p_i} + \Delta p_i \overline{s_i}$$

Where ΔP, the change in productivity, is due to the change in the composition of the workforce, which is Δs_i, weighted by the average productivity for that group, $\bar{p}_i$, and changes in productivity, Δp_i , weighted by average shares, $\bar{s}_i$.

The second term cannot be measured, and there is nothing to restrict the second term to be constant over the business cycle. An approximation to the first term is possible. This is

$$\sum \Delta s_i \bar{p}_i \equiv \sum \Delta s_i \bar{w}_i \left({}^{\bar{p}_T}/_{\overline{w}_{iT}} \right)$$

Where Δs_i is the change in *group i* share of employment over the relevant t_0 to t time interval, $\overline{p_i}$ is the average productivity for group *i*. Because productivity is unobserved for each sub-group, we approximate it using wage rates. This approximation is the product of $\overline{w_i}$, the average wage for group *i* over the t_0 to t time interval ; and the quantity $\overline{p_T}$, the average of aggregate production over a 10-year interval divided by $\overline{w_{iT}}$, the average wage for group *i* over a 10-year interval where T is 10 years. The ratio $\overline{p_T}$ / $\overline{w_{iT}}$, is assumed to be fixed over all periods, representing the degree to which aggregate productivity is allocated to the wages of education group i in the long run.

Table 5 contains the estimates of the decomposition over the last two recessions and intervening years. The gain in the index of aggregate productivity is in the top row. The lower panel in Table 5 provides estimates of the contribution of each educational group to productivity gains due to shifts in employment shares. [16] The question that is being asked here is how much of the change in productivity can be accounted for by changes in the educational composition of the workforce. We see these movements of workers out of the labor force have very little effect on productivity gains. For example, during the recession of 2007:Q4 to 2009:Q2, the exit of those with less than a high school education accounts for a -.07 percent decline in productivity, and the exit of those with a high school education accounts for a -.39 percent decline in productivity. For those with some college or a BA and beyond, the productivity gains are .12 percent and .67 percent, due to the greater shares of the workforce with degrees. Overall, these sum to .33 percent, indicating that a tiny percent of the productivity gain during the recession can be explained by the movement of lower quality out of the workforce and increasing weight on higher quality labor.

Therefore, at the economy wide level, this is some evidence that changing shares of worker quality groups based on education do not explain the gains in productivity during the recession. Some other factors, like increased effort, must account for the productivity gains.

V. **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

[16] All the data for the shares of the workforce are from the Current Population Survey (CPS) and have been downloaded from www.bls.gov/cps . The productivity data are from the BLS website www.bls.gov/lpc.

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 also 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.

References

Berger, David (2011) “Countercyclical Restructuring and Jobless Recoveries.” W*orking paper.*

Davis, Steven, R. Jason Faberman and John Haltiwanger (2010) “The Establishment-Level of Vacancies and Hiring,” NBER Working Paper No. 16265.

Davis, S. and Haltiwanger, J. (1990) “Gross Job Creation and Destruction: Microeconomic Evidence and Macroeconomic Implications,” *NBER Macroeconomics Annual*.

Gali, J. and van Rens, T. (2010) “The Vanishing Procyclicality of Labor Productivity.” *Working paper.*

Garin, J., Pries, M. and Sims, E. (2011) “Reallocation and the Changing Nature of Business cycle Fluctuations.” W*orking paper.*

Koenders, K. and Rogerson, R. (2005) “Organizational Dynamics Over the Business Cycle: A View on Jobless Recoveries,” *Federal Reserve Bank of St. Louis Review.*

Lazear, Edward (2000a) “The Power of Incentives,” *American Economic Review P&P* 90:2 (May): 410-414.

Lazear, Edward (2000b) “Performance pay and Productivity,” *American Economic Review* 90:5 (December 2000): 1346-1361.

Rebitzer, James B. (1987) “Unemployment, Long-Term Employment Relations, and Productivity Growth,” *Review of Economics and Statistics*, 69:4 (1987): 627-635.

Shaw, Kathryn and Edward Lazear (2008) “Tenure and Output,” *Labor Economics,* 15 (2008): 710-724.

van Rens, T. (2004) “Organizational Capital and Employment Fluctuations.” *Working paper.*

Figures and Tables

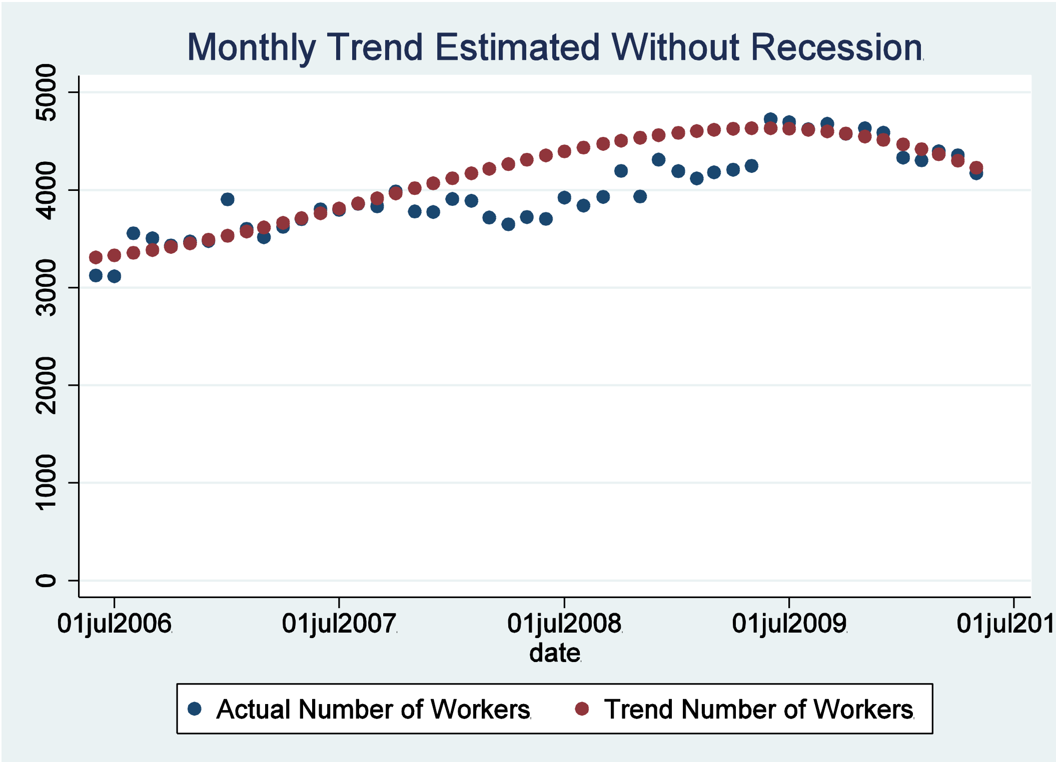

Figure 1: Average number of workers-per-day aggregated to the monthly level (in blue) is plotted against an estimated number of workers (in red) where the estimates come from a regression of average workers-per-day on a cubic polynomial in time, excluding the recession period.

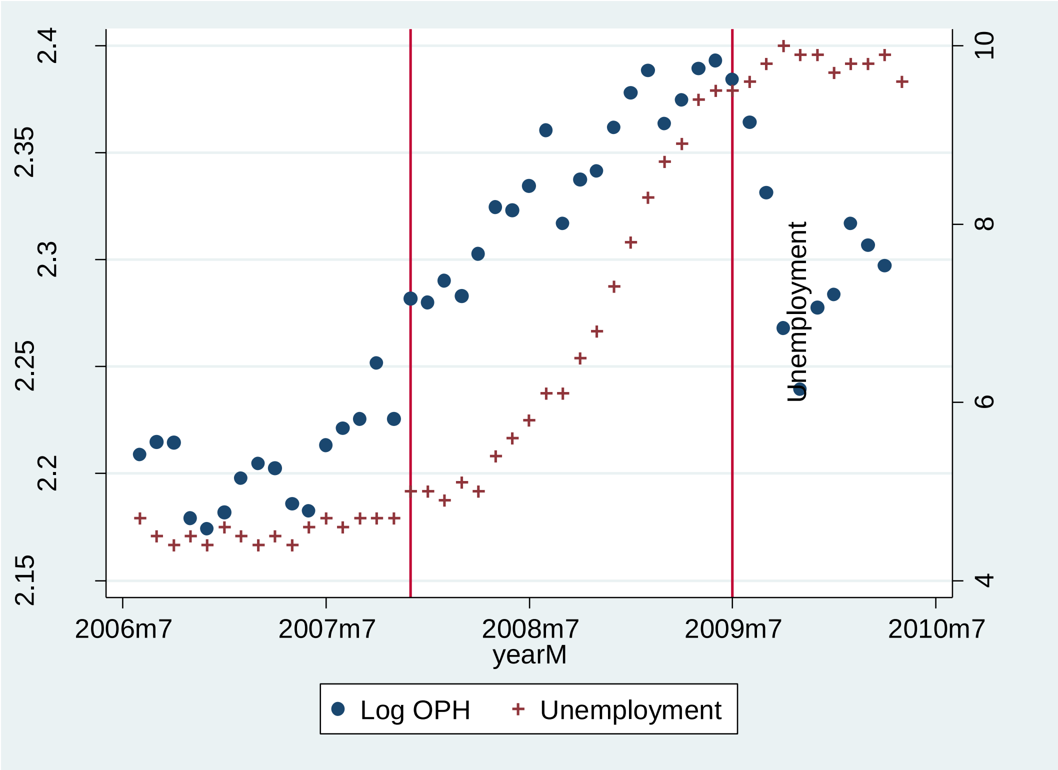

Figure 2: This figure plots actual monthly mean log productivity per worker against the monthly unemployment rate. Vertical red lines indicate recession beginning and end.

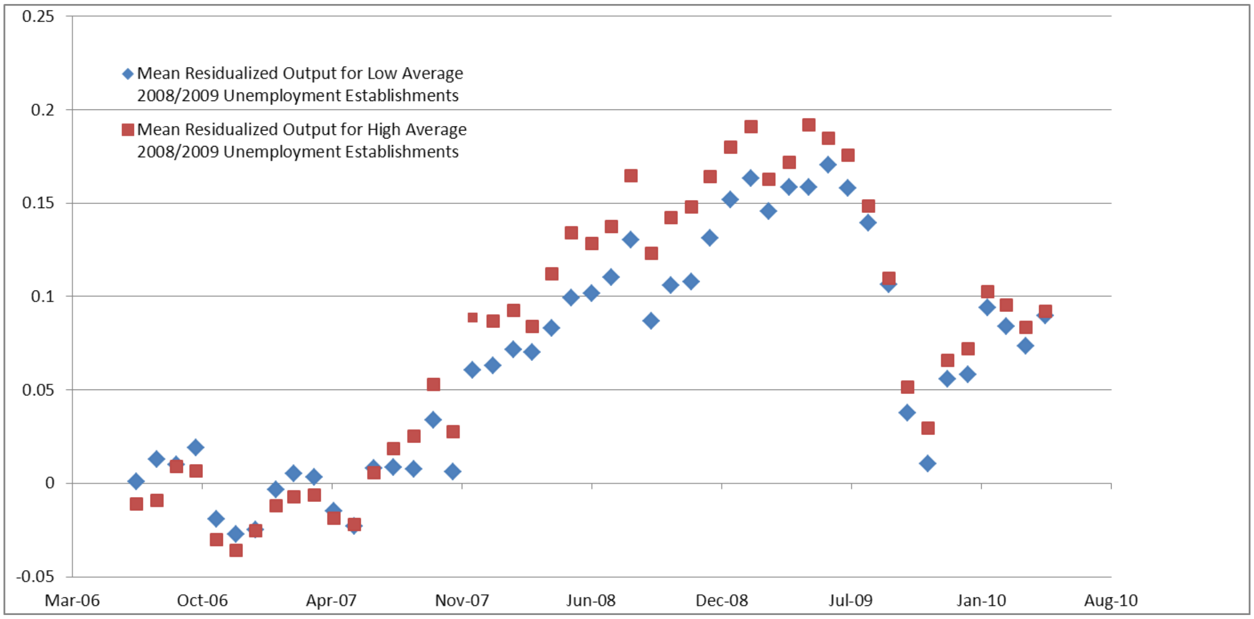

Figure 3: Residualized output is calculated by regression log productivity on a cubic polynomial in tenure and establishment fixed effects using data from the pre-recession period. Establishment fixed effects control for baseline unemployment in the pre-recession period. No time fixed effects or controls are included in the regression. Establishments are classified as high or low unemployment depending on whether they are above or below the sample average of 2008 and 2009 unemployment.

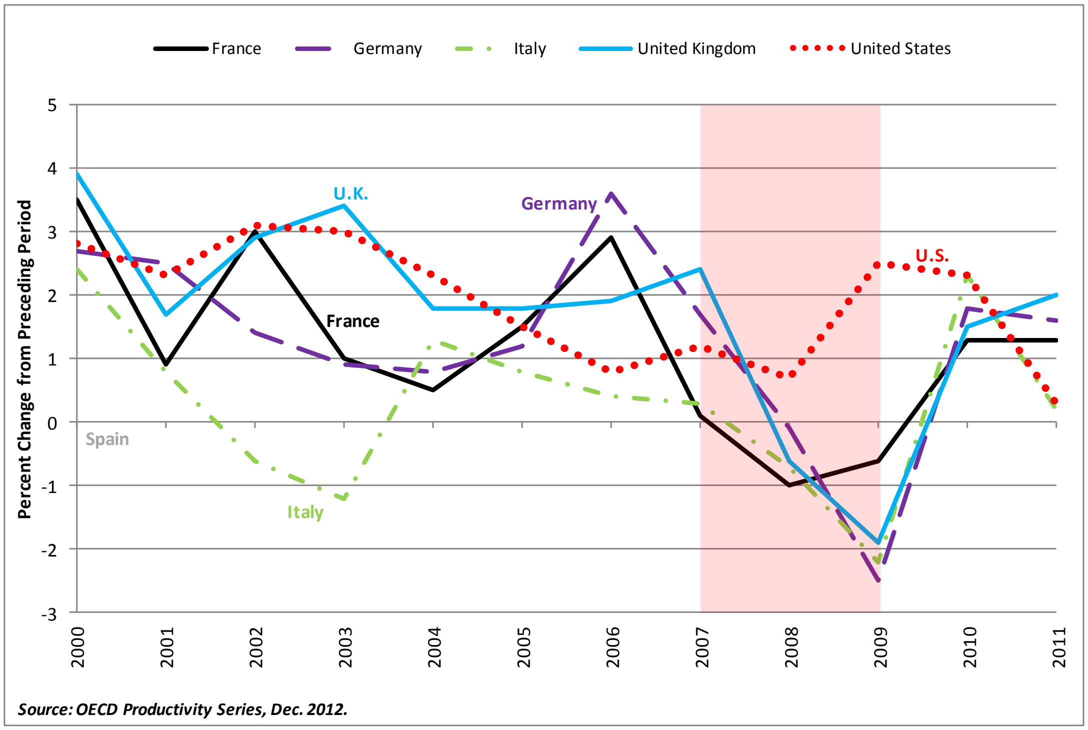

Figure 4: This figure charts the labor productivity in the total economy for five European Union nations, and the United States. The transparent red area indicates the recession beginning and end. Data retrieved from the most recent update of the OECD productivity series.

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: Productivity Regressions with Recession Effect
Dependent Variable: Log (Productivity per Hour)

	Entire Sample		Balanced Sample	
	OLS	Fixed Effects	OLS	Fixed Effects
Recession	.0533	.0540	.0484	.0500
	(.0013)	(.0011)	(.0019)	(.0018)
Tenure	.0002	.0004	.0002	.0003
	($7.87e^{-06}$)	(.00003)	(.00002)	(.00004)
Tenure-squared	$-1.73e^{-07}$	$-2.00e^{-07}$	$-1.21e^{-07}$	$-1.43e^{-07}$
	($0.08e^{-07}$)	($0.06e^{-07}$)	($0.11e^{-07}$)	($0.09e^{-07}$)
Tenure-cubed	$3.40e^{-11}$	$3.83e^{-11}$	$2.17e^{-11}$	$2.63e^{-11}$
	($0.22e^{-11}$)	($0.15e^{-11}$)	($0.24e^{-11}$)	($0.19e^{-11}$)
Time	-.0002	-.0003	-.0002	-.0003
	(.00001)	(.00003)	(.00002)	(.00004)
Time-squared	$6.50e^{-07}$	$5.98e^{-07}$	$5.82e^{-07}$	$6.20e^{-07}$
	($0.20e^{-07}$)	($0.16e^{-07}$)	($0.29e^{-07}$)	($0.30e^{-07}$)
Time-cubed	$-3.20e^{-10}$	$-2.93e^{-10}$	$-2.81e^{-10}$	$-2.96e^{-10}$
	($0.09e^{-10}$)	($0.07e^{-10}$)	($0.13e^{-10}$)	($0.12e^{-10}$)
N	5,076,387	5,076,387	1,419,120	1,419,120
R^2	.064	.244	.054	.184

The Entire Sample is daily data from June 2006 to May 2010, for 20,387 workers. The Balanced Sample contains only those 2,240 workers employed the entire period. The regressions contain month and establishment fixed effects, and robust standard errors clustered at the worker level.

Table 3: Productivity Regressions with Unemployment Effects
Dependent Variable: Log (Productivity per Hour)

	(1)	(2)	(3)	(4)
Sample	Full		Excluding 10/1/2009 to 1/30/2010	
Estimation Method	OLS	Worker Fixed Effects	OLS	Worker Fixed Effects
Recession Dummy	0.0245	0.0234	0.025	0.0245
	(0.0034)	(0.0026)	(0.0035)	(0.0027)
Unemployment Rate	0.0024	0.0015	0.0052	0.0051
	(0.0008)	(0.0006)	(0.0008)	(0.0006)
Unemployment Rate x Recession	0.0058	0.0059	0.0025	0.0023
	(0.0005)	(0.0004)	(0.0005)	(0.0004)
R^2	0.065	0.248	0.071	0.258

Notes: Robust standard errors clustered by worker are below each coefficient. The Unemployment Rate is the yearly average unemployment rate for the state matched to each establishment. The regressions also contain tenure, tenure-squared, tenure-cubed, time, time-squared, time-cubed, and establishment fixed effects. Month fixed effects are also included to remove potential seasonality. N = 5,076,387 for columns 1 - 2 and N = 4,654,172 for columns 3 and 4.

Table 4: Productivity Regressions with Stars and Laggards
Dependent Variable: Log (Productivity per Hour)

	(1)	(2)
Estimation Method	OLS	Worker Fixed Effects
Recession Dummy	0.0336	0.0333
	(0.0030)	(0.0024)
Laggard Dummy	-0.0877	
	(0.0076)	
Laggard x Recession	0.0174	0.0105
	(0.0039)	(0.0032)
R^2	0.124	0.31

Notes: Robust standard errors clustered by worker are below each coefficient. The sample consists of workers whose first day of work is both contained in the sample period and 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 from the regression of log(Productivity per Hour) on tenure, tenure-squared, tenure-cubed, time, time-squared, time-cubed, month, establishment, and worker fixed effects. Each of the regressions contains this same set of controls as well as a laggard dummy and a laggard x recession dummy. N= 1,615,412 with 5,579 workers.

Table 5: Productivity Level Decomposition by Education

$$= \sum_i \Delta s_i \bar{p}_i$$

	2000:Q1-2001:Q4	2002:Q1-2007:Q3	2007:Q4-2009:Q2	2009:Q3-2012:Q3
$p_t - p_{t_0}$	5.8	11.2	1.93	4.9
$\bar{p}$	87.13	98.10	103.64	109.79
$\sum \Delta s_i \bar{p}_i \equiv \sum \Delta s_i \bar{w}_i \left(\bar{p}_T / \bar{w}_T \right)$				
< HS	0.05%	-0.69%	-0.07%	-0.45%
HS Diploma	-0.75%	-1.15%	-0.39%	-.91%
Some Coll. or A.A.	0.17%	0.01%	0.12%	0.30%
B.A. and Beyond	0.95%	3.69%	0.67%	2.31%
Sum	0.42%	1.86%	0.33%	1.25%

Source: CPS data downloaded from www.bls.gov/cps
Source: Productivity data downloaded from www.bls.gov/lpc
Productivity and wage data for those employed full time.
Education results are for the population aged 25+.
Percent change in productivity levels are annualized.

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

From the text,

$$\frac{\partial e}{\partial u}|_{F.O.C.} = -\frac{\partial / \partial u}{\partial^2 / \partial e^2}$$

$$= -\frac{g(e)R}{\partial^2 / \partial e^2}$$

so

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

(A2) $$= \frac{g(e)R\left(\frac{\partial SOC}{\partial k}\right)}{SOC^2}$$

which has the sign of ∂SOC / ∂k .

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

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

(A4) g'(e)[W - R(1-u)] - k ∂SOC/∂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, ∂SOC/∂k must be positive for (A4), which is the second order condition, to be negative. But if (k ∂SOC/∂k) is positive, then ∂SOC/∂k is also positive, which implies that

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

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