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**Manufacturing Plants' Use of
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Manufacturing Plants' Use of Temporary Workers: An Analysis Using Census Micro Data

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Abstract

How is the nature of firms' output fluctuations associated with the firms' preferences between permanent (indefinite term) and temporary (definite term) labor contract? Using plant-level data from the Plant Capacity Utilization (PCU) survey, we explore how manufacturing plants' use of temporary workers is associated with the nature of their output fluctuations and other plant characteristics. We find that plants tend to use temporary workers when their output is expected to fall; this may indicate that firms use temporary workers to reduce costs associated with dismissing permanent employees. In addition, we find that plants whose future output levels are subject to greater uncertainty tend to use more temporary workers. We also examine the effects of wage and benefit levels for permanent workers, unionization rates, turnover rates, seasonal factors, and plant size and age on the use of temporary workers; based on our results, we discuss various views of why firms use temporary workers.

Key words: temporary workers, output fluctuations

JEL codes: J2, J3

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1. Introduction

The temporary help industry (THS) has grown rapidly over the last quarter century. The industry's rapid growth has attracted substantial attention from researchers (ex. Autor (2003), Erickcek, Houseman, and Kelleberg (2002), Golden (1996), Houseman (2001), Polivka (1996), and Segal and Sullivan (1995, 1997)) who, along with industry analysts, have identified a number of reasons why temporary workers may be attractive to client firms beyond their traditional role of filling in when permanent employees are absent for short periods.

In this paper, we investigate to what extent temporary workers are used by firms to accommodate fluctuations in production level. While various papers (Houseman (2001), Segal and Sullivan (1995, 1997), Golden (1996), Autor (2003)) seem to view this role as one of primary reasons why firms use temporary workers, few papers examine how a firm's use of these workers is associated with the nature of its output fluctuation.²

As many papers (ex. Hamermesh (1989), Bentolila and Bertola (1990), Aguirregabiria and Alonso-Borrego (1999), and Campbell and Fisher (2004)) have considered, adjusting the level of permanent employees can involve hiring and firing costs. This contrasts with adjusting the level of temporary workers; a firm can reduce the number of temporary workers when the short-term contract ends without additional costs, and less training is typically required for the type of jobs filled by temporary workers. The use of temporary workers may, however, incur higher unit costs of labor; because the short-term contracts impose more job insecurities (Houseman and Polivka, 2000), and, given the skill of

² Houseman (2001) surveyed firms about their use of temporary workers and found that a substantial fraction of firms reported meeting fluctuations in demand as a reason. Campbell and Fisher (2004) developed a theoretical model describing a firm's decision to adjust employment of two groups of workers with some of the characteristics of temporary and permanent workers and compare their calibration with aggregate level data. However, there are no empirical studies that examine the relationship between a firm's use of temporary workers and its own output fluctuations.

a worker, the worker may demand higher wages for a temporary job than a permanent job. The temporary help agencies also charge a margin. Productivity may also be lower for those under the temporal employment contract, which increase the costs for an efficient unit of labor.

Focusing on such differences in the nature of costs associated with using permanent and temporary workers, our stylized model suggests that the firm that experiences higher output volatility maintains a higher temporary worker share when firing costs are high. Our stylized model also suggests that the firm that expects its output to fall maintains higher temporary worker share. When the firm expects its output to fall, it can justify the use of temporary workers in the current period, even when the unit labor costs are higher than those of permanent employees. This is because the firm can avoid the potential costs associated with dismissing permanent employees. In the empirical section of this paper, we test the above implications by examining a manufacturing plant's use of temporary workers.

Few empirical papers document the characteristics of firms that use temporary workers, while the literature has focused on documenting the difference in demographic characteristics between temporary and permanent workers (Polivka (1996), Cohany (1998)). One reason might have been limited data that provide the detailed characteristics of firms using temporary workers. The data is limited because the temporary workers are not on the payroll of firms that they engage in production activities. Thus, they are not in the employment data collected in the major economic surveys or census, such as the ASM and the CM.³ Abowd, Corbel, and Kramarz (1999) use the French data⁴ that allows them to distinguish contract type (short-term or permanent) of employment and report that short-term

³ This has also caused issues in labor productivity measure based on payroll data as Houseman (2007) points out. Understanding what kind of firms use temporary workers helps us to infer whose labor productivity measure might have been influenced.

contracts represents high share in hiring and separations.⁵ However, the number of firm characteristics that are incorporated in their study is limited.

We use the plant-level data from the Plant Capacity Utilization (PCU) survey conducted by the U.S. Census Bureau.⁶ The PCU survey began collecting information on the number of temporary workers used at manufacturing plants in 1998. The data for 1998, 1999, 2000, and 2001 are available for our study. We also link the plant-level PCU data to the plant-level Annual Survey of Manufactures (ASM) and the Census of Manufactures (CM), which provides us with a unique opportunity to observe a plant's output fluctuations over time. We fit an autoregressive form to a plant's output trajectories to create a measure of output fluctuations and expected output growth.

While our focus is on testing to what extent firms use temporary workers to accommodate output fluctuation, we also discuss other motives. In particular, the use of temporary workers has been considered attractive to firms as a means to screen potential permanent employees. Autor (2003) points out that THS agency plays a role of facilitating worker screening. Given the sometimes significant costs of dismissing poorly performing employees, a client firm may want to first observe their performance as temporary workers. If that performance is judged inadequate, they can simply request a new worker from the THS agency. Such a trial period as a temporary worker may be preferable to a formal probationary period as a permanent employee.

Depending on the primary motive to use temporary workers, higher expected output growth could be associated with greater or lesser use of temporary workers. If the primary

⁴ Their data come from four surveys conducted by the Institut National de la Statistique et des Etudes Economiques.

⁵ They found that two-thirds of all hiring and more than half of all separations are involved with short-term contracts.

⁶ These data are used by the Federal Reserve Board to estimate capacity utilization rates for the manufacturing and publishing industries.

motive to use temporary workers is to reduce the potential costs of dismissing permanent workers due to the lower expected output, the expectations of higher output growth would be associated with lesser use of temporary workers. In addition, as our stylized model shows, if firing costs are sufficiently high, greater uncertainty about future output leads the firm to cap the number of permanent workers at a lower level, and thus hire more temporary workers. In contrast, if the primary motive to use temporary workers is to screen future permanent workers, then higher expected output growth is likely to be associated with greater use of temporary workers, because, by doing so, the firm can secure enough qualified workers for next period. In the empirical section, we also discuss which stories seem to dominate in our findings.

The different motives to use temporary workers are considered to have different labor market outcomes for temporary workers. As Houseman and Polivka (2000) and Houseman (2001) point out, while the growth of temporary work arrangements or other non-standard arrangements is considered to reduce job stability, if firms use these arrangements primarily to screen workers for regular jobs, then job stability for these workers may increase by facilitating better matches between workers and firms. Few empirical papers, however, compare the motivations for firms to use temporary workers.⁷

In addition to testing plant's use of temporary workers in relation to its output fluctuation, we also examine how a plant's temporary worker share depends on a number of other characteristics, such as its size, age, and the product that a plant produces. There are number of reasons why plant size may matter for a plant's use of temporary workers. One might imagine that the use of temporary workers to buffer fluctuations in the labor

⁷ In Houseman and Polivka (2000), only weak evidence is found for a firm's use of temporary workers for screening purpose, while there was clear evidence that temporary workers face much more job insecurities than regular full or part-time workers. Houseman (2001) also reports many employers report the use of temporary workers as accommodating fluctuations in their work load rather than screening.

requirement may require a level of sophistication likely to be found in a large plant. Its larger size may also increase a plant's ability to negotiate a lower margin from a THS firm. In addition, a larger plant, with its deeper pockets, may face higher costs in the event of an unjust dismissal lawsuit. On the other hand, the larger scale of such a plant may allow the plant to be flexible without relying on temporary workers, by redistributing its permanent workers across different production processes. Plant age and industry may also matter for the use of temporary workers because of their effect on the level of uncertainty and other factors.

Moreover, we investigate the relationship between the use of temporary workers and a plant's wage and benefit levels. It has been suggested that the use of temporary workers may allow client firms to circumvent nondiscrimination requirements in the provision of benefits (Houseman, 2001). Under normal circumstances, in order to secure the tax advantages associated with providing certain benefits, firms need to provide those benefits to all their employees. If the firm would not otherwise want to provide a certain benefit to a particular segment of its workforce, one strategy might be to staff that segment with employees of a THS agency. Having such a dual work force may allow it to provide benefits to the remainder of its workforce without jeopardizing their tax status.⁸ It is possible that a plant whose permanent workers earn high wage rates is more motivated to use temporary workers. However, what should matter for the choice of temporary worker share is the *ratio* of temporary worker to permanent worker wage rates. Industry observers indicate that THS agencies charge client firms a higher markup over wages in the case of higher skilled workers (Kilcoyne, 2004). Thus, it is possible that a firm with a high wage rate for permanent workers

⁸ The legal issues surrounding the employment status of temporary workers are complex. A temporary worker can under some circumstances be considered an employee of the client firm. In particular, in the Microsoft case, the U.S. Supreme Court ruled that temporary workers who provided services to Microsoft for a period of several years were entitled to benefits, including stock options, which Microsoft provided to all its permanent employees. The Microsoft decision has limited firms' ability to implement such a strategy of using the same temporary workers for long periods.

might use temporary workers less. A similar argument may apply to a firm that provides generous benefit packages, although it is also possible that a firm that provides expensive benefits packages may have greater incentive to employ temporary workers to keep benefit costs low.

Finally, we analyze how the temporary worker share at the three-digit NAICS industry level is dependent upon several additional variables. These variables include unionization, labor turnover rates, and seasonality. We expect unions to resist the use of temporary workers and thus would expect a lesser use of temporary help in an industry with a higher unionization rate. When voluntary turnover is high, the likelihood of a firm needing to fire workers due to insufficient demand would be lower. So, greater turnover could be associated with less use of temporary workers. At the same time, higher voluntary turnover rates would likely increase the value of screening potential employees and thus could lead to greater use of temporary workers. A stronger seasonal component would also be positively correlated with the higher use of temporary workers, *ceteris paribus*.

One can view our study as similar in intent to a number of micro-level studies of other forms of firm adjustment to demand shocks. For example, using plant-level data, Copeland and Hall (2005) examine how automakers accommodate shocks to demand by adjusting price, inventories, and labor inputs through temporary layoffs and overtime work. Such considerations are closely linked to a firm's decision to adjust temporary worker share. We intend to examine such interactions in future work.

In Section 2, we provide a stylized model that motivates our empirical specification. In Section 3, we describe our data in more detail and discuss empirical implementation. In Section 4, we present our empirical results. Section 5 concludes.

2. Motivational Model

In this section, we present a stylized model of a plant's choice on the number of permanent and temporary workers. The model is intended to help motivate and guide our empirical work, emphasizing the role of temporary workers in accommodating output fluctuations.

We assume that labor is the only factor of production and that, in each period, the plant manager must hire an appropriate quantity of labor, e_t , to meet an exogenously determined level of output, $y_t = f(e_t)$, where f is a standard, strictly increasing production function. The required labor input come from a combination of “permanent employees,” p_t , and “agency temporary workers,” a_t , with the total quantity of labor given by $e_t = p_t + \theta a_t$, where θ is a positive constant representing the productivity of a temporary worker relative to that of a permanent worker. The wage rates for permanent and temporary workers are w_p and w_a , respectively. The plant incurs costs, δ , to fire each permanent worker. Thus, the plant's total costs in a period are $w_p p_t + w_a a_t + \delta \max(p_{t-1} - p_t, 0)$. We assume that future levels of output are uncertain and that the firm minimizes the expected present value of total costs given a discount factor, $\beta = 1/(1+r)$, where r is a real interest rate.

Let the unit labor costs for permanent workers be $u_p \equiv w_p$ and that for temporary workers $u_a \equiv w_a / \theta$. We assume that $\Delta u = u_a - u_p > 0$; absent firing costs, temporary workers are more expensive, either because their wage rate is higher ($w_a > w_p$), they are less productive ($\theta < 1$), or both.⁹ We further assume that the cost of firing a permanent worker is

⁹ Kilcoyne shows that, for a given low-skilled occupation, temporary workers are paid lower hourly wages. This may reflect their lower productivity; for low-skilled jobs where experience or reputation is not important for future employment, it may be difficult to motivate temporary workers to achieve a high level of performance because their efforts would not, typically, be rewarded by promotion or future wage increases. The legal limit of a temporary employment contract duration would also imply that temporary employment would not increase a worker's firm-specific skills and knowledge. In high-skilled occupations,

greater than the (discounted) difference in unit labor costs, but less than a full period's wage; i.e., $\Delta u / \beta < \delta < w_p$. If $\Delta u > \beta \delta$, the plant never hires any temporary workers; it is cheaper to use permanent workers even if it is certain that they will be fired in the next period. The condition that $\delta < w_p$ is a convenient simplification implying that the firm does not keep any idle workers on the payroll; keeping an idle worker on the payroll costs more than firing the worker in the current period and may also increase firing costs in the future. With this configuration of costs, the plant faces a tradeoff between using more permanent workers, which lowers current wage costs, versus using more temporary workers, which may lower future firing costs.

The Two-Period Case

It is easiest to see the logic of the model when there are only two periods. In this case, the plant is unconcerned about firing costs in the second period. Let y_2 represent a required output level in the second period. The plant meets its entire labor need with permanent workers, $p_2 = f^{-1}(y_2)$, incurring costs $C_2 = w_p f^{-1}(y_2) + \delta \max(0, p_1 - f^{-1}(y_2))$.

In the first period, given y_1 and knowledge of the distribution of y_2 , the firm chooses p_1 and a_1 to minimize total expected discounted costs, TC , which is written as $TC = w_p p_1 + w_a a_1 + \beta E[w_p f^{-1}(y_2) + \delta \max(0, p_1 - f^{-1}(y_2))]$. The quantity of labor that meets the required level of production is $f^{-1}(y_1) = p_1 + \theta a_1$. Thus, we can rewrite TC as a

temporary workers are often paid higher hourly wages than permanent workers (Kilcoyne,2005). For example, on average, registered nurses sent by THS agencies earn an hourly wage that is \$4.93 more than the national average for this occupation in 2004. Computer programmers sent by THS agencies earn \$7.85 more per hour than those hired as permanent employees. For occupations in which past experience or licenses help firms identify workers' skills, firms would be able to select temporary workers who are qualified to meet a given performance level. Among workers with the same qualifications, however, they

function of p_1 alone:

$$TC = u_p p_1 + u_a (f^{-1}(y_1) - p_1) + \beta E[w_p f^{-1}(y_2) + \delta \max(0, p_1 - f^{-1}(y_2))].$$

Thus, the derivative of costs with respect to (w.r.t.) permanent labor in the first period is

$$\frac{dTC}{dp_1}(p_1) = -\Delta u + \beta \delta \frac{d}{dp_1} E[\max(0, p_1 - f^{-1}(y_2))]. \quad (1)$$

Assume that y_2 follows a continuous distribution with density $g(y_2)$ that is strictly positive over the relevant interval; distribution function is $G(y_2)$. Then, the expected number of permanent workers fired in the second period given p_1 is

$$L(p_1) = E[\max(0, p_1 - f^{-1}(y_2))] = \int_0^{f(p_1)} (p_1 - f^{-1}(y_2)) g(y_2) dy_2. \text{ Thus the derivative of the}$$

number of permanent workers fired w.r.t. permanent labor in period 1 is

$$L'(p_1) = (p_1 - f^{-1}(f(p_1))) g(f(p_1)) + \int_0^{f(p_1)} g(y_2) dy_2 = G(f(p_1)). \quad (2)$$

From (2), we can rewrite (1) as

$$\frac{dTC}{dp_1}(p_1) = -\Delta u + \beta \delta G(f(p_1)). \quad (3)$$

Increasing permanent workers by one (and thus lowering the number of temporary workers by $1/\theta$) in period 1 reduces current costs by the difference in unit costs between temporary and permanent workers (Δu), but raises expected firing costs in the second period by the product of the cost of firing a worker (δ) and the probability that the marginal worker is fired ($G(f(p))$).

would not take temporary positions unless compensation for job insecurity is provided. Employers may also be willing to pay a premium to quickly meet, say, a sudden increase in demand.

Because $G(y)$ and $f(p)$ are increasing functions, $\frac{dTC}{dp_1}(p_1)$ is increasing in p_1 .

Moreover, $\frac{dTC}{dp_1}(0) = -\Delta u < 0$ and $\lim_{p_1 \rightarrow \infty} \frac{dTC}{dp_1}(p_1) = -\Delta u + \beta\delta > 0$. Thus, there exists a

unique level of permanent employment, \bar{p} , such that

$$\frac{dTC}{dp_1}(\bar{p}) = -\Delta u + \beta\delta G(f(\bar{p})) = 0. \quad (4)$$

See Figure 1 for an illustration of the case in which y_2 is uniformly distributed in the interval from y_{low} to y_{high} and $f(e)$ is linear. If $f^{-1}(y_1) < \bar{p}$, as permanent employment increases, TC decreases until permanent employment reaches the level that satisfies the plant's labor requirements given y_1 . Thus, the optimal number of permanent workers is $f^{-1}(y_1)$, and that of temporary workers is zero. On the other hand, if $f^{-1}(y_1) > \bar{p}$, TC falls with p_1 until $p_1 = \bar{p}$, and then begins to rise. Thus the optimal number of permanent workers is \bar{p} , and that of temporary workers is $(f^{-1}(y_1) - \bar{p})/\theta$, the level necessary to meet the rest of the labor requirement. We can summarize the solution by writing the optimal numbers of the first period permanent workers, p_1^* , and temporary workers, a_1^* , as

$$p_1^* = \min(f^{-1}(y_1), \bar{p}) \quad (5)$$

$$a_1^* = (f^{-1}(y_1) - p_1^*)/\theta, \quad (6)$$

where \bar{p} satisfies $\beta\delta G(f(\bar{p})) = \Delta u$. The plant hires permanent workers up to a maximum level at which the expected discounted costs of firing an additional permanent worker are equal to the extra current unit labor costs of substituting temporary workers. In Appendix A, we show that in the case of an infinite horizon with independently and identically distributed

(i.i.d.) random output levels; the plant's optimal policy is essentially identical to the solution of the first period of the two-period model.

Lognormal Output Levels and Power Production Function

Suppose that the distribution of y_2 is lognormal, $\log y_2 \sim N(\mu_2, \sigma^2)$ and that the production function takes the power form,

$$f(e) = Ae^\alpha. \quad (7)$$

Then, based on (4), \bar{p} is such that (s.t.) $\Delta u = \beta\delta\Phi\left(\frac{\log A + \alpha \log \bar{p} - \mu_2}{\sigma}\right)$, where $\Phi(x)$ is the standard normal distribution function. Alternatively, we can write

$$\log \bar{p} = \alpha^{-1}[\mu_2 - \log A + \sigma\Phi^{-1}\left(\frac{\Delta u}{\beta\delta}\right)]. \quad (8)$$

The impact of σ on \bar{p} depends on Δu and firing costs δ .¹⁰ If firing costs are sufficiently high so that $\Delta u < \frac{1}{2}\beta\delta$, then $\Phi^{-1}\left(\frac{\Delta u}{\beta\delta}\right) < 0$, and the probability of needing to fire the marginal worker is less than one half. In this case, greater uncertainty increases the probability, moving it toward one half. The increased probability of firing causes the plant to use fewer permanent workers and more temporary workers to produce the given output.¹¹

¹⁰ Because α and δ are positive constants and $\Phi^{-1}(\cdot)$ is an increasing function, a higher value of Δu is associated with a greater level for \bar{p} , leading to the use of fewer temporary workers. On the other hand, a higher value of the firing cost, δ , is associated with a lower level of \bar{p} , leading to the use of more temporary workers.

¹¹ Note that the opposite is true if firing costs are low so that $\Delta u > (1/2)\beta\delta$. It is somewhat counterintuitive that an increase in uncertainty could lead to the use of fewer temporary workers. When firing costs are low, the plant worries little about firing and thus hires so many permanent workers that the probability of firing a marginal permanent worker in the second period exceeds one half. In such a situation, an increase in the uncertainty in the second period labor requirements lowers the probability of firing to the level closer to

Implications for Empirical Analysis

The simple model sketched above suggests that expected output growth, $g^e \equiv \mu_2 - \log y_1$, is an important determinant of a plant's use of temporary workers. When g^e is lower, the model suggests that firms tend to use more temporary workers in order to avoid future firing costs. The model also says that if firing costs are high enough, higher uncertainty, σ , increases the use of temporary workers. These are two key hypotheses we test in the empirical section. As noted above, if screening is the primary reason why firms use temporary workers, then in contrast to the above model, higher expected output growth would be associated with greater use of temporary workers.

3. Empirical Implementation and Construction of Variables

Empirical Specification

Using (7) and (8) and assuming for simplicity that α and A are one, the condition that a plant hires temporary workers is

$$f^{-1}(y_1) > \bar{p} \Leftrightarrow Z = -g^e - \sigma\Phi^{-1}\left(\frac{\Delta u}{\beta\delta}\right) > 0. \quad (9)$$

Introducing heterogeneity across plants through a normally distributed random components in log output, v_i , and assuming (9) can be well approximated by a linear function, we can rewrite the condition that a plant uses temporary workers as $Z_i = [g_i^e, \sigma_i, \mathbf{X}_i]\boldsymbol{\beta} + v_i > 0$, where \mathbf{X}_i contains other control variables. The plant uses no temporary workers when Z_i is negative; once Z_i is positive, the plant begins using temporary workers, and its temporary

one half. This reduces the marginal expected firing costs and gives the plant the incentive to hire more permanent workers.

worker share increases as Z_i continues to increase. Both a plant's likelihood to use temporary workers and its temporary worker share increases with g_i^e and σ_i .

To examine a plant's discrete choice to use any temporary workers, we estimate the Probit model. We also estimate Tobit models to examine how the temporary worker share is associated with our key variables. The Tobit model is consistent with our framework in that plants start using temporary workers once Z_i becomes positive and continue to increase their use of temporary workers as Z_i increases further. Using the observations on plants with positive numbers of temporary workers, we also fit linear regression models relating the continuous part of temporary worker share to our key variables, thus relaxing a restriction imposed by Tobit analysis. \mathbf{X}_i includes industry dummies as well as other plant characteristics such as plant size and age that may proxy for variation in the level of firing costs and wage differentials between temporary and permanent workers, which the model says should also influence the use of temporary workers.

Data

The main data set for this study is the Plant Capacity Utilization (PCU) survey from 1998, 1999, 2000, and 2001.¹² The surveys collect information only for the fourth quarter of each year. The key variable for our study is the number of temporary production workers. In the PCU questionnaires, temporary production workers are defined as “production workers not on the payroll (hired through temporary help agencies or as their own agent)”.¹³

¹² The PCU survey is used by the Federal Reserve Board to estimate capacity utilization rates of manufacturing and publishing plants <http://www.census.gov/econ/overview/ma0500.html> (August 2006)

¹³ In the PCU questionnaires, “production workers” are defined as workers (up through the line-supervisor level) engaged in fabricating, processing, assembling, inspecting, receiving, packing, warehousing, shipping (but not delivering), maintenance, repair, janitorial, guard services, product development, auxiliary production for plant's own use (e.g., power plant), record keeping, and other closely associated services. They also include truck drivers delivering ready-mixed concrete (U.S Census Bureau, 2000). Note

In our empirical work, we include manufacturing plants that are in operation and that provide valid answers to the key employment questions. We further select those for which we can calculate measures of the expected level and volatility of production; (we describe in detail below.) We also limited our sample to plants that appear in the ASM for enough consecutive years prior to being in the PCU to allow us to use lagged variables in the regressions. Appendix B provides more details about which plants are included in our sample. Combining both years of available PCUs leaves us with about 11,000 plants.

Measure for g_i^e

As our stylized model shows, expected output growth is a key variable in determining a plant's use of temporary workers. In order to create an empirical measure of this variable, we have to make three choices. We have to specify the current period, the future period, and how the expectation of the future period's output is estimated. Because information on temporary worker employment from the PCU is that of the fourth quarter, we take the current period to be the fourth quarter of the survey year. We use the annualized fourth quarter total value of shipments (TVS) reported in the PCU survey as the current output; the ASM and the CM, which we use to estimate time series process for TVS, report annual TVS. As a future period, one could view the length of the horizon considered by the plant for employment decisions as an empirical question to be investigated thoroughly. However, given that no monthly or quarterly output series at plant-level are available, we take the entire year following the survey to be the future period.

that while the PCU provides employment and hours data for each shift, examining the allocation of permanent and temporary workers between different shifts is beyond the scope of this paper. We focus on a plant's overall use of temporary workers for all shifts in total.

Let us define the annualized fourth quarter output for plant i in year t as $ltvs_{it}^{AQ4} \equiv \ln(4 \times tvs_{it}^{Q4})$, where tvs_{it}^{Q4} is the TVS of plant i 's fourth quarter in year t . We define $g_{it}^{e,Q4} \equiv E_t[ltvs_{it+1}] - ltvs_{it}^{AQ4}$, where $E_t[ltvs_{it+1}]$ is plant i 's expected TVS in year $t+1$. $g_{it}^{e,Q4}$ reflects the difference between the current quarter's output and the expected average quarterly output over the next year.

Specification for the Expected Output Level and the Uncertainty Level

To measure expected future output, $E_t[ltvs_{it+1}]$, as well as the uncertainty, σ , for each plant, we use the time series data of the plant's TVS from the ASM and the CM. The combination of ASM and CM, often called the Longitudinal Research Database (LRD), provides us annual time series data for the U.S. manufacturing plants. While the CM is a population survey and is conducted every five years, the ASM is a sample survey in off-census years. Thus, we observe the TVS of all manufacturing plants in a census year as long as they exist, but in off-census years, we observe only for plants sampled in the ASM. Using a plant identification number, which is given based on the physical location of the plant, we match these data to PCU by plant identification number to learn the nature of each plant's output fluctuation. To use a consistent plant identifier, we limit ourselves to the ASM and CM observations from 1976 and after;¹⁴ the final year we use is 2001. We focus on real TVS by employing the TVS deflator for each of 4-digit SIC calculated by Bartelsman, Becker, and

¹⁴ As a plant identifier, we use the Longitudinal Business Database (LBD) number, which is a revised version of the Permanent Plant Number (PPN) used for manufacturing plants in the Longitudinal Research Data. Similar to the PPN, the LBD number does not change in the event of merger and acquisition and is specific to a plant's physical location. The LBD number is created as a part of the effort by Census to create the LBD data set, which reviews and updates the longitudinal linkage as well as the operation status of the establishments/plants in the Standard Statistical Establishment List. While the Census of Manufactures goes back to 1963, the LBD begins in 1976.

Gray.¹⁵ As we previously noted, monthly and quarterly series on plant level TVS are not available in the ASM, CM, or any other sources that can be matched to PCU. Thus we analyze output fluctuations at the annual frequency.

Note that, to measure the fluctuation that the plant faces in its demand or output, one might also consider using a plant's employment given by the Longitudinal Business Database (LBD), which provide annual employment data for virtually all U.S. business establishments (that have employees). However, like most other data sources, the employment reported in the LBD includes only workers on a plant's payroll and thus excludes temporary workers. To the extent that a plant uses temporary workers to accommodate output fluctuations, permanent employment fluctuations should be smoother than the fluctuation of all workers including temporary workers. Thus, any unobserved or uncontrolled factors that increase a plant's use of temporary workers may be translated into a smaller fluctuation in permanent employment, which biases our estimation. Thus, in this paper, we use TVS from the ASM-CM data to capture output fluctuations.¹⁶

We assume that output growth follows a first order autoregressive process. In particular, denoting the growth rate of TVS by $gtvs$, we estimate:

$$gtvs_{it} = \tilde{\beta}_i + \rho_i gtv_{s_{it-1}} + \gamma_i dn_{t-1} + v_{it}, \quad (12)$$

where $dn_t \equiv n_t - n_{t-1}$; n_t is a macroeconomic variable that captures the business cycle. Any linear plant-specific time trend is captured by $\tilde{\beta}_i$. The uncertainty measure σ_i is the standard deviation of the residuals of the model, which is written as $gtvs_{it} - E_{t-1}[gtvs_{it}] = ltv_{s_{it}} - E_{t-1}[ltv_{s_{it}}] = v_{it}$ and represents unforeseeable events after a plant

¹⁵ <http://www.nber.org/nberces/> We thank Randy Becker for letting us use the preliminary version of the TVS deflators for the later period.

¹⁶ Note that labor hours reported in ASM and CM suffer the same problem, as they include only the hours worked by permanent employees. The LBD does not provide any data on labor hours.

observes the output or growth rate from the previous year. For n_t , we use the deviation of log real gross domestic products (GDP) from log potential GDP provided by the Congressional Budget Office.

Summary Statistics of Key Variables

Table 1 shows the summary statistics of the variables we use in the analyses. On average, $g_{it}^{e,Q4}$ varies widely across plants. σ_i is on average 0.19. Large heterogeneity in σ_i across plants is also observed. A plant with σ_i that is one standard deviation (s.d.) larger than the mean experiences annual output levels that typically deviate from the expected output by over 30%.

In our sample, the fraction of plants employing a positive number of temporary workers in a particular year is 41%. The remaining 59% of plants operate without using any temporary workers. Of plants with temporary workers, on average, the temporary worker share of total production workers is about 12%.

Other Control Variables in Analyses

We also include a number of additional control variables. The most important of these is a variable that controls for the previous level of permanent employees. As we mentioned above, our two-period model does not address how the previous level of permanent workers influences a plant's current use of temporary workers. However, in reality, if a plant's permanent employment in the previous period is greater than the level required to produce the current output, then to respond to any positive shock to the current output, a plant would be more likely to rely on already hired permanent workers and less likely to rely on temporary workers. Indeed, in a version of our model with more realistic time series

processes for output, the number of permanent workers from the previous period is a state variable. As a remedy, one might consider controlling for the level of permanent employment, p_{t-1} , in the previous period. However, in the cross-section, such a variable may capture other factors. While the model assumed a homogenous production function, plants are, in fact, heterogeneous. A high level of p_{t-1} may simply mean that the plant is unproductive, rather than that it has a binding level of permanent workers on its payroll.

As an alternative way to control for variation in the previous number of permanent workers relative to current output levels, we include plants' recent output growth rates.¹⁷ If a plant's output has been growing, it is unlikely that the number of permanent workers in the last period is binding. However, if output has been falling, the number of permanent workers inherited from the previous period may constrain the plant; in this case, even when a plant's current output is greater for a given future expected level, the plant would be unlikely to use temporary workers.

In addition to the control for the previous level of permanent employees, we control for several other variables that may influence a plant's use of temporary workers. Such variables include plant size age, and whether a plant is a part of a multi-plant firm or not. For plant size, we use lvs_{it}^{AQ4} . Age is measured based on the first year that a plant's identifier for its physical location appeared in the LBD.

As we discussed earlier, we also include various other variables. We control for the wage rate of permanent workers and the ratio of benefit payments to wages at plant-level. To calculate the permanent production worker wage rate, w_{it}^P , for each plant, we use the ASM; the PCU does not provide any wage information. Note that we cannot distinguish overtime hours from total production hours in the ASM. Thus the calculation for w_{it}^P is influenced by wage

premium for overtime; w_{it}^P would be greater for plants that use more overtime. If a plant's use of overtime is motivated by a reason similar to why they use temporary workers, it would induce the positive correlation between w_{it}^P and temporary worker share. Thus, we calculate the straight rate permanent worker wage, $w_{it}^{SP} \equiv w_{it}^P (1 + .5s_{it}^{over})$, using the overtime share, s_{it}^{over} ,¹⁸ from the PCU, and use this measure in our regressions. We also use the ASM to calculate supplemental labor costs for each dollar of wage payments.¹⁹

We further add the unionization rate, turnover rate, and the seasonal factor for the fourth quarter at 3-digit SIC industry level. The unionization rate, turnover rate, and seasonal component are all calculated at the three-digit SIC level, as plant-level information is not available. The data on the unionization rate among production workers are derived from the monthly outgoing rotation files of the Current Population Survey (CPS). We pooled data from 1996 through 2000 to estimate the rate of unionization for each three-digit SIC industry. As a proxy for voluntary turnover, we use job-to-job transition rates based on the non-outgoing rotation groups of CPS.²⁰ The job-to-job transition rate would be more associated with the tendency of voluntary quit than the overall turnover rate.²¹ Again, we pool all data

¹⁷ A dummy variable for a survey year is also included.

¹⁸ The PCU data provide information on hours for all production workers (including temporary workers), hours worked by temporary workers (including overtime if any), and total overtime. Assuming that overtime is performed only by permanent workers, we use the ratio of the overtime to the hours worked by permanent workers. We also used the ratio of overtime to hours worked by all workers, which did not qualitatively change our results.

¹⁹ Supplemental labor costs are not provided separately for production and non-production workers in the ASM/CM. We divide such a total number by wage payments to all employees. Note that some years in the micro data provide the decomposition of supplemental labor costs into voluntary and non-voluntary parts. Such data are not available for the years relevant to this study.

²⁰ The Bureau of Labor Statistics (BLS) produces a voluntary quit rate, but only at the level of broad industry category, which does not provide us enough detail for our study.

²¹ Specifically, we matched each observation in the non-outgoing rotations to the corresponding observation in the following month using the household ID and line numbers. In addition, we required that the sex of respondents match and that the reported ages be within one year of each other. We then determined which workers remained employed at the same firm as in the previous month using the employment status variable and the indicator for whether an employed worker remained at his previous employer. This latter variable is available starting in 1996 and makes possible the identification of job-to-job transitions. See Fallick and Flieshman (2004).

since 1996 for each detailed CPS industry. We also calculate seasonal components for each 3-digit SIC based on the industrial production (IP) quarterly series (not seasonally adjusted) for the period between 1987 and 2005 from the Federal Reserve Board of Governors. Denoting IP of industry j in q th quarter in year y by using IP_{jt}^q , we specify the seasonal component of q th quarter for industry j , f_j^q , as $f_j^q \equiv \sum_t \{\ln(4 \times IP_{jt}^q) - \ln(IP_{jt})\}$. When we include the above 3-digit SIC level variables in our models, we report standard errors that account for clustering at the 3-digit SIC level.

Table 1 includes the summary statistics of the above variables. Plants in our sample are much bigger and older than that of average manufacturing plants in the CM for 1997. Plant TVS is on average 54 million based on the 1987 dollar. Sixty-one percent of the plants in our sample exist in 1975 or before.

4. Results

In Table 2, we report results with our base specification with and without industry dummies. The net effects of $g_{it}^{e.Q4}$ is negative and significant, and σ_i is positive and significant. The data seem to support the view that higher expected growth decreases both a plant's likelihood of using temporary workers and, for a plant that uses temporary workers, decreases its temporary worker share. The model in section 2 illustrated that the expectation of growth reduces the probability for a marginal permanent worker to be fired, which in turn reduces the expected future firing costs and motivates a plant to use more permanent workers. Our results are consistent with such a view. Note that, as we discussed, it is still possible that a higher expectation of growth might necessitate more screening of future permanent workers and thus more current temporary workers, but in our analysis, such effects seem to be dominated by the former effect. It is also possible that screening matters for short-run growth

prospects, while our data do not allow us to capture plant-level growth rates at the monthly or quarterly levels.

We also perform the analysis, controlling for a variable representing a current year shock, $lvs_{it} - E_{t-1}[lvs_{it}]$, to see if our data identify any effect of current shock separate from that of $g_{it}^{e,Q4}$. The results are in Appendix C. We find that, even after controlling for a current year shock, the coefficient for the expected growth rate remains negative and significant. The measure of current shock obtains a positive and significant coefficient. The size of the effect of $g_{it}^{e,Q4}$ remains almost the same. Note that, in this regression, we exclude $gtvs_{it}$ as it is highly correlated with the current year shock measure.

Based on the Probit result with industry dummies, if $g_{it}^{e,Q4}$ increases by a one s.d. from its average, moving from 0.12 to 0.56, the probability to use temporary workers decreases from 0.42 to 0.39. Based on the Tobit results with industry dummies, for plants using temporary workers, a one s.d. increase in $g_{it}^{e,Q4}$ decreases the temporary worker share by 1.2 percentage points, which is 10% of the average temporary worker share.

Plants that face more uncertainty appear to use more temporary workers. As we also discussed, when firing costs are large enough, it is possible that greater uncertainty increases the probability of marginal permanent worker to be fired, discouraging plants to use permanent employees. For plants using temporary workers, the uncertainty level that is one s.d. greater than average is associated with temporary worker share that that is 0.6 percentage points lower than average, based on the Tobit and OLS results with industry dummies.²²

²² We also performed Probit and Tobit analyses replacing expected annual output level in $t + 1$ with its realized value. For this exercise, out of 4,909 plants used in Table 3, we used the data of 4,617 plants, which appear in ASM sample in the year following their PCU survey. The results remain qualitatively the same.

We also performed quantile regression analysis using the data of plants with temporary workers to see whether the magnitude of effects vary between plants in different quartiles of the distribution of the temporary worker share. The quantile regressions showed that, among plants with temporary workers, the magnitudes of the effects of our key variables are much greater for plants with higher temporary worker shares. Once we replace our dependent variable with log of the temporary worker share, however, the quantile regressions obtain almost the same coefficients across all quantiles. It seems that the effects of our key variables are constant in terms of the percentage by which they increase the share.

Let us now look at the coefficients of other variables. The results generally suggest that bigger plants are more likely to use temporary workers, and if they do, the temporary worker share is greater than smaller plants. It is possible that fixed costs are involved in using temporary workers for, perhaps, negotiating with temporary help agencies. The results may also be reflecting that larger plants are more likely to face greater penalty in the event of an unjust dismissal lawsuit. Such effect seems to offset possible negative effect, if any, from the larger plants' ability to redistribute workers within itself. A one s.d. increase in lvs_{it}^{AQ4} raises a plant's likelihood to use temporary workers by 4.1 percentage points. Note that the ability to negotiate or allocate workers should be better captured at firm level rather than plant level. Our analysis also control for a dummy indicating whether the plant is affiliated with multi-plant firm.²³ The dummy obtains a positive coefficient for Probit and a negative coefficient for OLS. It is possible that the plants in a multi-plant firm can share the fixed costs, which justify each plant to use temporary worker even by a small amount.

We found that older plants tend to use temporary workers less. The likelihood for plants built pre-1975 to use temporary workers is 8.2 percentage points smaller than newer

²³ Firm output size is not available.

plants. For plants using temporary workers, the temporary worker share for older plants is 3.7 percentage points lower than the young plants. Plant age may reflect the degree of uncertainty that is not captured by σ . While σ is an average measure of uncertainty over the lifecycle of a plant, the degree of uncertainty may change over time.

While we treated firms' output level to be exogenous, in reality, a firm's use of flexible labor can influence a firm's output adjustment. To the degree that such adjustments are not predicted by equation (12), it may decrease or increase our measure of uncertainty level. For example, with the easy access to temporary workers, under negative labor productivity shocks, a firm may be able to keep the firm's output stable using temporary workers rather than decreasing the firm's output; this may lower our measure of uncertainty level. On the other hand, the firm may adjust outputs more flexibly having the access to temporary workers; this may increase our measure of uncertainty level. Such effects are screened out to some extent by industry dummies and other controls. As we show later, we also control for geographical area fixed effects and the key results remain the same.

However, as a robustness analysis, we also create a variable for a plant's output volatility using only the data before 1985. The THS industry grew rapidly starting late 1980s. Before 1985, the use of THS by manufacturing plants was not common.²⁴ The growth of THS industry might have reduced the costs to deal with temporary employment assignments, and enhanced the manufacturing plants' use of temporary workers in general. Thus by using the output data before 1985, we can capture a manufacturing plant's output volatility minimizing the influence by its use of temporary workers. We denote the new measure by $\tilde{\sigma}^{pre-1985}$. The results are presented in Table 3. As you can see, the coefficients for $\tilde{\sigma}^{pre-1985}$ are positive, and for the Probit analysis, the coefficient turns more significant than we saw in Table 2.

Next we explore the effect of other variables, including wage, unionization rate, job-to-job transition rates, and seasonality. The results are summarized in Table 4. First, let us look at the effect of two variables that summarize the compensation paid to permanent workers. As discussed earlier, one might expect that plants that pay high wages or high benefits would have an incentive to use temporary workers to reduce labor costs. In contrast, industry analysts report that the markup that staffing agencies charge over wages for temporary workers tends to be higher for high wage occupations. Thus, higher wage plants may use fewer temporary workers. In our analysis, the latter story seems dominate. The straight rate wage for permanent production workers and the supplemental labor costs per dollar of permanent worker wages are both negatively correlated with plants' use of temporary workers. Note that when we control for these two variables, the positive coefficient obtained for plant size becomes bigger. Since larger plants tend to pay higher wages, once we separate the negative effect of wage, the scale effect seems to be more pronounced.

Next we add the unionization rate, the turnover rate, and the fourth-quarter seasonal component, which we measure at the three-digit SIC level. Columns 4, 5, 6 in Table 4 show the results where we replace three-digit SIC dummies with these three continuous variables. The results seem to suggest that the unionization rate is negatively correlated with a plant's use of temporary workers. This is counter to the idea that unions might increase the use of temporary workers through their effect in increasing wages as well as firing costs relative to productivity. Similar results are found in the study by Houseman (2001). Analogous to what she argues, it is possible that our results reflect the fact that unions oppose the use of non-standard employment relationships to secure regular employment positions. Note that the

²⁴ Based on the BLS's Occupational Employment Statistics data, the workers defined as "production workers" in that survey represents only 4.4% of THS workers in 1990, where in 2007, it is 19.2%.

coefficient for unionization rate is not significant in the OLS result. The unionization rate may not influence the temporary worker share once plants decide to use temporary workers. Note that we also examined whether the unionization rate has any interaction effect with $g_{it}^{e,Q4}$, which seems to suggest that greater union pressures against the use of temporary work arrangements also enhance the negative effect of $g_{it}^{e,Q4}$ on a plants' likelihood to use temporary workers.

Coefficients for the job-to-job transition rate are not significant in any specification. This is different from our original conjecture that higher voluntary turnover reduces the probability of needing to fire permanent workers in the future and thus increases the permanent worker share. As we discussed, it is possible that greater voluntary turnover increases the on-going need to screen workers through temporary employment, and this might have offset the effect of the decreased probability of needing to fire permanent workers. The coefficients for the fourth-quarter seasonal component are positive and significant; the higher seasonal component for output increases the use of temporary workers.

Note that in the specifications with the above additional controls, the coefficients for our key variables, $g_{it}^{e,Q4}$ and σ , are still consistent with our conjectures. It would be, however, instructive to note that the variations of our control variables such as wage, benefit, and unionization rate seem to have relatively large contribution to the overall variation of the plants' use of temporary workers. Based on the Probit analysis in Column 4 in Table 4, one s.d. increase in wage, benefit, unionization rate, and fourth-quarter seasonal factor decrease the probability for a plant to use some temporary workers by 6.9, 2.8, 3.8, and 2.7 percentage points, respectively. In terms of the variation of temporary worker shares across plants, based on the Tobit analysis in Column 5 in Table 4, one s.d. increase in wage, benefit, unionization

rate, and fourth-quarter seasonal factor decrease the share by 2.6, 1.1, 1.2, and 1.1 percentage points, respectively.

Finally, we examine whether our key results hold when we control for the effects of geographical variables. In Columns 1, 2, 3 in Table 5, we show the results based on our base specification, adding a dummy indicating urban plants (plants in metropolitan areas). We then limit our sample to urban plants and control for Metropolitan statistical area fixed effects in addition to three-digit industry effects. We find that in both cases, the effect of our key variables stay qualitatively the same. We also found that plants in urban area are more likely to use temporary workers. To the extent that markets for temporary worker are local, there are many geographic variables such as the unemployment rate and the degree of local concentration of temporary agencies, which would be associated with a plant's use of temporary workers. Examining the effect of these variables requires a thorough consideration of local labor markets. We leave it to our future research to explore the influence of local demand and supply of the temporary workers on a plant's use of temporary workers.

5. Conclusion

We have provided some evidence in support of the proposition that temporary work arrangements facilitate flexibility in a firm's use of labor and allow it to accommodate output fluctuations at lower cost. Our stylized model identifies the expected output growth rate and the uncertainty in that expectation as two key variables in a firm's decision to use temporary workers. We approximated both of these variables using the ASM and the CM. We used Probit, Tobit, and OLS analyses to examine the relationship between these two variables and plants' use of temporary workers.

First, we find that plants make greater use of temporary workers when their expected output growth is lower. This suggests that a plant chooses temporary workers over permanent

workers when it expects its output to fall and thus wants to avoid costs associated with dismissing permanent employees. This effect remains identified after netting out the effect of a seasonal factor in a plant's output, which itself had a positive relationship with a plant's use of temporary workers, as well as other variables.

Second, we find that a plant with greater uncertainty over its future output level uses more temporary workers. Firing costs appear to be large enough to induce a more volatile plant to make greater attempts to minimize the costs of firing permanent workers; this might have made the plant rely more on temporary workers even though the current unit costs of using temporary workers is greater than those for permanent workers.

In addition to output fluctuations, we also examine the effect of several other motivations that are thought to play an important role in a plant's decision to use temps. First, we found evidence that a plant's that requires high-skill workers are less likely to use temporary workers, likely because the wage premium or the margin paid to agencies for high-skill temporary workers may be higher than that for low-skill temporary workers. Second, a plant in an industry that is highly unionized seems to use fewer temporary workers, possibly because unions are successful in resisting the use of nonmembers' labor.

Table 1. Summary Statistics

Plant characteristics (10,964 observations)		
	Mean	(S.d.)
$g_{it}^{e,Q4}$.120	.420
σ_i	.195	.121
lvs_{it}^{AQ4}	10.9	1.34
$givs_{it}$: growth rate of annual real output in survey years	-0.0164	0.247
$givs_{it-1}$: growth rate of annual real output in previous years	0.0179	0.245
Percentage of plants that existed from 1975 or before:		60.5%
Percentage of plants belonging to a multi-unit firms		91.3%
Percentage of plants in urban areas		71.4%
Three-digit SIC level variables included in the study (8,142 observations) [†]		
In. straight wage of perm production worker [†]	2.67	0.355
Benefit per \$1 perm wage [†]	0.274	0.105
Unionization rates	0.234	0.116
Job-to-job transition rates	0.0200	0.00568
Fourth quarter seasonal factor	0.00793	0.0415

[†]: The sample is restricted due to the missing observations of overtime used to calculate straight wage. It is used in Table 3.

Table 2. Base specification

	Without 3-digit SIC dummies			With 3-digit SIC dummies		
	Probit (dF/dX)	Tobit	OLS	Probit (dF/dX)	Tobit	OLS
	D=1 for plants w/ temps	Temp Share	Temp Share	D=1 for plants w/ temps	Temp Share	Temp Share
	(1)	(2)	(3)	(4)	(5)	(6)
Expected growth $g_{it}^{e,Q4}$ $= E_t[lvvs_{it+1}] - lvvs_{it}^{AQ4}$	-0.0556*** [4.62]	-0.0248*** [5.21]	-0.00872** [2.04]	-0.0665*** [5.29]	-0.0285*** [6.08]	-0.0116*** [2.79]
Volatility measure σ_i	0.0271 [0.68]	0.0424*** [2.72]	0.0602*** [4.50]	0.0667 [1.54]	0.0497*** [3.17]	0.0494*** [3.55]
Plant size $lvvs_{it}^{AQ4}$	0.0411*** [10.60]	0.0167*** [10.82]	0.00362** [2.55]	0.0304*** [6.35]	0.00900*** [5.02]	-0.0017 [1.04]
Growth rate $gtvs_{it}$ $= lvvs_{it} - lvvs_{it-1}$	0.162*** [7.79]	0.0721*** [8.83]	0.0261*** [3.29]	0.157*** [7.35]	0.0673*** [8.51]	0.0273*** [3.59]
Growth rate (t-1) $gtvs_{it-1}$ $= lvvs_{it-1} - lvvs_{it-2}$	0.0670*** [3.29]	0.0302*** [3.79]	0.0122* [1.74]	0.0622*** [2.95]	0.0293*** [3.79]	0.0155** [2.24]
D1: =1 for plants born pre 1975	-0.0902*** [9.21]	-0.0429*** [11.01]	-0.0199*** [6.21]	-0.0821*** [7.96]	-0.0374*** [9.74]	-0.0203*** [6.20]
D2: =1 for plants affiliated w/ multi-unit firms	0.0347* [1.94]	0.00421 [0.58]	-0.0188*** [2.91]	0.0314* [1.67]	0.00510 [0.71]	-0.0129** [2.05]
3-digit SIC dummies	No	No	No	Yes	Yes	Yes
Survey year dummies	Yes	Yes	Yes	Yes	Yes	Yes
N. of observations	10,964	10,964	4,513	10,964	10,964	4,513

Table 3. Robustness Check with a volatility measure calculated using pre-1985 data

	Probit (dF/dX)	Tobit	OLS
	D=1 for plants w/ temps	Temp Share	Temp Share
	(1)	(2)	(3)
Expected growth $g_{it}^{e,Q4}$ $= E_t[lvvs_{it+1}] - lvvs_{it}^{AQ4}$	-0.0415** [2.24]	-0.0187*** [2.85]	-0.0130** [2.02]
Volatility measure based on pre-1985 data $\sigma_i^{pre-1985}$	0.140** [2.18]	0.0514** [2.29]	0.0206 [1.12]
Plant size $lvvs_{it}^{AQ4}$	0.0335*** [4.59]	0.0106*** [4.13]	-0.000240 [0.09]
Growth rate $gtvs_{it}$ $= lvvs_{it} - lvvs_{it-1}$	0.139*** [4.52]	0.0562*** [5.16]	0.0251** [2.21]
Growth rate (t-1) $gtvs_{it-1}$ $= lvvs_{it-1} - lvvs_{it-2}$	0.0703** [2.25]	0.0244** [2.26]	0.00628 [0.60]
$D1$: =1 for plants born pre 1975	-0.0831*** [3.02]	-0.0351*** [3.87]	-0.0170** [2.07]
$D2$: =1 for plants affiliated w/ multi-unit firms	0.0896** [1.96]	0.0390** [2.31]	0.0258* [1.72]
3-digit SIC dummies	Yes	Yes	Yes
Survey year dummies	Yes	Yes	Yes
Observations	5,545	5,545	2,117

Table 4 Effect of other variables

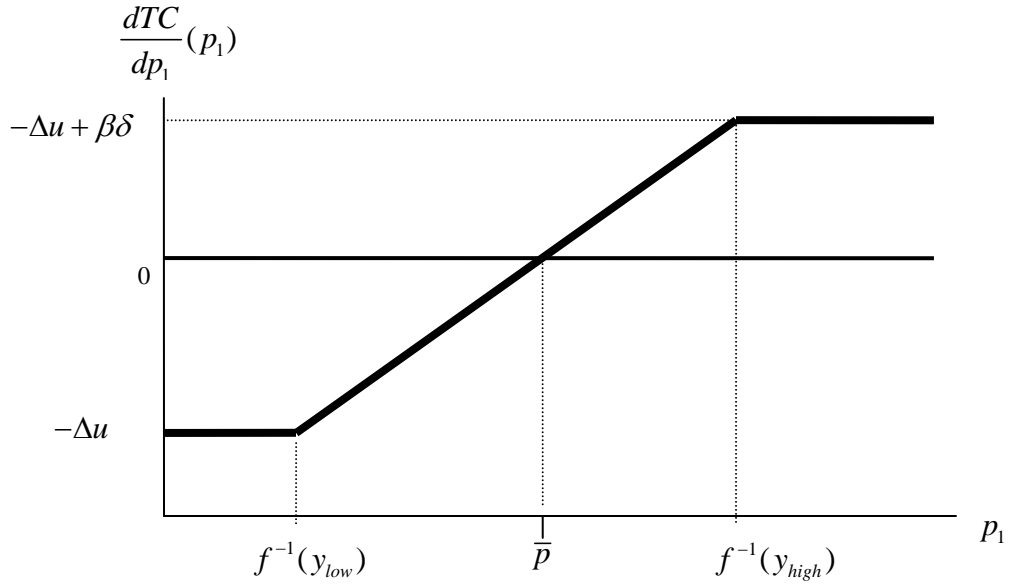
	Effects of wage variables (plant level)			Effect of other 3-digit SIC level variables		
	Probit	Tobit	OLS	Probit	Tobit	OLS
	D=1 for plants w/ temps	Temp Share	Temp Share	D=1 for plants w/ temps	Temp Share	Temp Share
	(1)	(2)	(3)	(4)	(5)	(6)
Expected growth $g_{it}^{e,Q4}$ $= E_t[lv_{it+1}] - lv_{it}^{AQ4}$	-0.0566*** [3.70]	-0.0219*** [4.27]	-0.00953** [2.05]	-0.0454** [2.07]	-0.0184*** [3.56]	-0.00642 [1.06]
Volatility measure σ_i	0.0631 [1.24]	0.0464*** [2.73]	0.0497*** [3.23]	0.000193 [0.00]	0.0334** [1.99]	0.0605*** [3.50]
Plant size lv_{it}^{AQ4}	0.0567*** [9.21]	0.0172*** [8.42]	0.00127 [0.67]	0.0713*** [6.91]	0.0249*** [13.99]	0.00492* [1.81]
Growth rate $gtvs_{it}$ $= lv_{it} - lv_{it-1}$	0.1627*** [6.16]	0.0637*** [7.34]	0.0271*** [3.18]	0.161*** [5.37]	0.0666*** [7.45]	0.0271*** [3.23]
Growth rate (t-1) $gtvs_{it-1}$ $= lv_{it-1} - lv_{it-2}$	0.0372 [1.46]	0.0207** [2.45]	0.0148* [1.93]	0.0396 [1.36]	0.0209** [2.39]	0.0142* [1.74]
D1: =1 for plants born pre 1975	-0.0705*** [5.74]	-0.0310*** [7.45]	-0.0180*** [5.03]	-0.0718*** [3.65]	-0.0330*** [7.88]	-0.0182*** [4.46]
D2: =1 for plants affiliated w/ multi-unit firms	0.0493** [2.14]	0.0115 [1.44]	-0.00577 [0.80]	0.0542* [1.88]	0.0125 [1.56]	-0.0106 [1.10]
ln. straight rate wage rate for perm workers	-0.210*** [10.51]	-0.0856*** [12.78]	-0.0398*** [6.41]	-0.191*** [4.93]	-0.0745*** [11.78]	-0.0249*** [3.11]
Supplemental labor costs per \$1 perm wage	-0.259*** [4.37]	-0.0994*** [4.80]	-0.0471** [2.46]	-0.265*** [2.61]	-0.108*** [5.20]	-0.0474** [2.07]
Unionization rate				-0.328** [2.18]	-0.105*** [5.41]	-0.0184 [0.62]
Job-to-job transition rate				-3.53 [1.35]	-0.429 [1.12]	1.14* [1.81]
Fourth-quarter seasonal factor				0.644** [2.47]	0.266*** [5.33]	0.118* [1.86]
3-digit SIC dummies	Yes	Yes	Yes	No	No	No
Survey year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	8,142	8,142	3,793	8,142	8,142	3,793

[]: Robust z-statistics for Probit, t-statistics for Tobit, and robust t-statistics for OLS (errors are clustered for plants in the same three-digit SIC for Columns 4 and 6); * significant at 10%; ** significant at 5%; *** significant at 1%

Table 5 Results with geography controls

	Results with a dummy for plants in urban areas			Results with PMSA dummies for plants in urban areas		
	Probit	Tobit	OLS	Probit	Tobit	OLS
	D=1 for plants w/ temps	Temp Share	Temp Share	D=1 for plants w/ temps	Temp Share	Temp Share
	(1)	(2)	(3)	(4)	(5)	(6)
Expected growth $g_{it}^{e,Q4}$ $= E_t[lvs_{it+1}] - lvs_{it}^{AQ4}$	-0.0669*** [5.32]	-0.0287*** [6.14]	-0.0118*** [2.83]	-0.0789*** [4.92]	-0.0301*** [5.53]	-0.00778 [1.49]
Volatility measure σ_i	0.0645 [1.49]	0.0479*** [3.06]	0.0469*** [3.38]	0.111** [2.01]	0.0658*** [3.60]	0.0498*** [2.75]
Plant size lvs_{it}^{AQ4}	0.0302*** [6.30]	0.00891*** [4.98]	-0.00159 [0.97]	0.0181*** [2.90]	0.00336 [1.56]	-0.00244 [1.19]
Growth rate $gtvs_{it}$ $= lvs_{it} - lvs_{it-1}$	0.158*** [7.37]	0.0672*** [8.52]	0.0271*** [3.59]	0.179*** [6.76]	0.0670*** [7.47]	0.0205** [2.28]
Growth rate (t-1) $gtvs_{it-1}$ $= lvs_{it-1} - lvs_{it-2}$	0.0625*** [2.97]	0.0293*** [3.80]	0.0152** [2.20]	0.0862*** [3.17]	0.0347*** [3.94]	0.0138* [1.72]
$D1$: =1 for plants born pre 1975	-0.0827*** [8.02]	-0.0378*** [9.85]	-0.0206*** [6.31]	-0.0737*** [5.34]	-0.0330*** [6.93]	-0.0215*** [4.77]
$D2$: =1 for plants affiliated w/ multi-unit firms	0.0342* [1.82]	0.00678 [0.95]	-0.0117* [1.86]	0.0468** [2.02]	0.0155* [1.88]	-0.00524 [0.67]
$D3$ =1 for urban plants	0.0320*** [2.82]	0.0199*** [4.65]	0.0151*** [4.42]			
3-digit SIC dummies	Yes	Yes	Yes	Yes	Yes	Yes
Survey year dummies	Yes	Yes	Yes	Yes	Yes	Yes
PMSA dummies	No	No	No	Yes	Yes	Yes
Observations	10,964	10,964	4,513	7,621	7,621	3,274

Figure 1. The determination of the cap on permanent workers: Two-period model



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Appendix

A. A More General Model

Here, we consider the case in which the plant's horizon is infinite and the exogenous levels of required outputs over time are i.i.d. random variables. The plant's optimal policy is essentially identical to the solution of the first period of the two period model.²⁵

The intuition is that given future optimal behavior, the choice of p_τ at time τ determines the number of permanent workers fired at time $\tau+1$. However, subsequent layoffs depend on the independent choice of $p_{\tau+1}$, $p_{\tau+2}$, etc. and not p_τ . Thus in considering the optimal choice of permanent employment level at τ , future firing cost considerations are identical to those in the first period of the two-period model. That is, the marginal expected discounted firing cost associated with an increase in p_τ is $\beta\delta G(f(p_\tau))$. Given that a plant starts with a level of permanent workers in the previous period such that $p_{\tau-1} < \bar{p}$, the marginal change in expected costs from employing an additional permanent worker differs only slightly from the two-period case. This is because, if $p_\tau < p_{\tau-1}$, then increasing p_τ reduces firing costs in the current period.²⁶ Thus, in the i.i.d. case,

$$\frac{dTC}{dp_\tau}(p_\tau) = -\Delta u - \delta I[p_\tau < p_{\tau-1}] + \beta\delta G(f(p_\tau)) \text{ , where } I[p_\tau < p_{\tau-1}] \text{ , is an indicator}$$

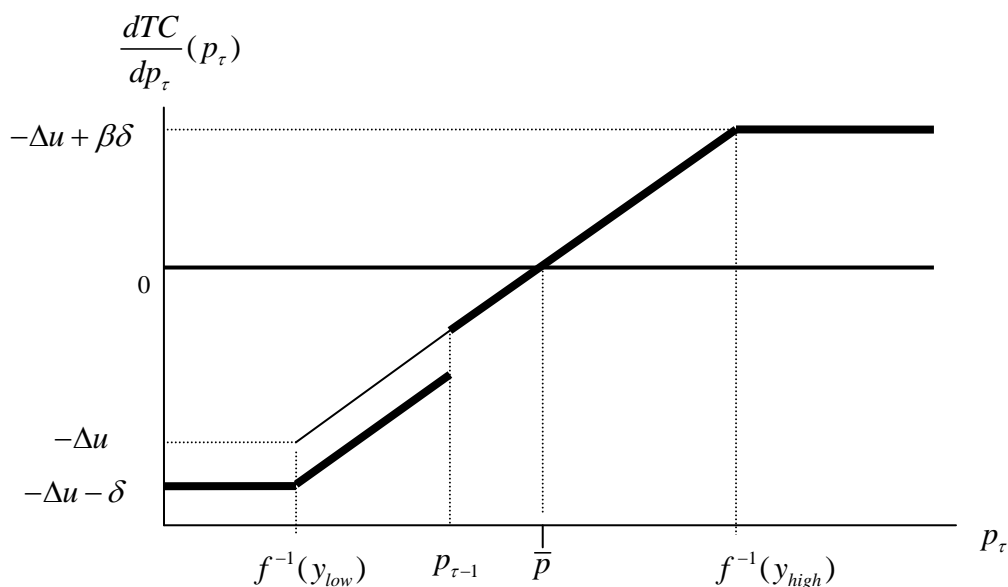
function for $p_\tau < p_{\tau-1}$. This function has a discrete jump at $p_\tau = p_{\tau-1}$. However, it is still

²⁵ The only qualification is that the plant must start with a level of permanent workers that is less than or equal to, the cap derived in the two-period model Section 2. As long as this is the case, it is optimal to follow the rule that $p_\tau^* = \min(f^{-1}(y_\tau), \bar{p})$. If this were not the case (i.e., the plant started with $p_{\tau-1} > \bar{p}$), it is possible that the optimal level is such that $p_\tau > \bar{p}$. However, once a realization of the y_τ comes in below $f(\bar{p})$, the rule $p_\tau^* = \min(f^{-1}(y_\tau), \bar{p})$ becomes optimal for the rest of time.

²⁶ In the two-period case, we implicitly assumed that the plant started the first period with no perms. Thus, we did not have to consider the effect of its decision on the number of permanent workers laid off in the first period.

strictly increasing and given that $p_{\tau-1} < \bar{p}$, it still is equal to zero at $p_{\tau} = \bar{p}$ (See Appendix Figure 1).

Appendix Figure 1: Determination of the Cap on Permanent Workers: Infinite Horizon i.i.d.



B. Our sample based on the PCU data

In the questionnaire, plants are asked to report, for each shift, the total number of production workers, temporary production workers, total hours worked by production workers, hours worked by temporary workers, and overtime hours. We consider that a plant operates a given shift if it reports positive total production workers for the shift, who are defined to include temporary workers in the instructions for the questionnaire given to the plant. Among plants operating a particular shift, however, many left the information for temporary production workers unfilled, and often, such plants do not provide a temporary worker number for any shift. In such a case, it is not clear whether the plant did not use temporary workers or did not

fill out the item. We consider that they did not fill out the item, since the instructions for the PCU survey explicitly instructs them both in words and with visual examples of the tables to write zero when plants operate a given shift but do not use temporary workers. We exclude such plants with missing temporary employment data for any of their active shifts (i.e., shifts for which the plant reports positive total number of production workers).

In addition, by the definition given in the instructions, when a given shift exists, the total number of production workers should be greater than or equal to the number of temporary workers. We exclude plants with any inconsistency regarding these figures. We also exclude a few plants reporting the same number for both total and temporary workers for some shifts. It is possible that these shifts are actually supported by only temporary workers. However, such incidents are rare and we cannot tell whether these are miss data entry.

Once we clean the PCU data, we limit the sample to those for which we can estimate our key variables based on the ASM and the CM as discussed in the main text. Based on the method discussed in Section 3, for a plant to be included in estimation, the plant has to appear in consecutive three years more than once in ASM-CM panel. We limit our sample to plants that appear in three years consecutively at least three times to avoid outliers. Some further outliers based on other variables are excluded.

Appendix Table 1

Analyses with the control of a contemporaneous shock

	Probit (dF/dX)	Tobit	OLS
Dependent Variable	D=1 for plants w/ temps	Temp Share	Temp Share
	(1)	(2)	(3)
Expected growth $g_{it}^{e.Q4}$ $= E_t[lvvs_{it+1}] - lvvs_{it}^{AQ4}$	-0.0572*** [4.61]	-0.0245*** [5.26]	-0.00989** [2.39]
Contemporaneous shock $= E_{t-1}[lvvs_{it}] - lvvs_{it}^{AQ4}$	0.0924*** [3.99]	0.0408*** [4.71]	0.0176** [2.10]
Volatility measure σ_i	0.0578 [1.34]	0.0475*** [3.02]	0.0496*** [3.56]
Plant size $lvvs_{it}^{AQ4}$	0.0347*** [7.31]	0.0109*** [6.12]	-0.000910 [0.56]
Growth rate (t-1) g_{it-1} $= lvvs_{it-1} - lvvs_{it-2}$	0.0392* [1.89]	0.0196** [2.57]	0.0116* [1.69]
$D1$: =1 for plants born pre 1975	-0.0849*** [8.25]	-0.0388*** [10.10]	-0.0209*** [6.41]
$D2$: =1 for plants affiliated w/ multi-unit firms	0.0278 [1.48]	0.00351 [0.49]	-0.0136** [2.17]
3-digit SIC dummies	Yes	Yes	Yes
Survey year dummies	Yes	Yes	Yes
N. of observations	10,964	10,964	4,513

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