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FIRMS' USE OF OUTSIDE  
CONTRACTORS: THEORY AND EVIDENCE

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**ABSTRACT**

A firm's decision to contract out for business support services may be influenced by the wage and benefit savings it could realize, the volatility of its output demand and the availability of specialized skills possessed by the outside contractor. Analysis of newly-available establishment-level data shows that all three of these factors help to explain observed contracting behavior. The reported empirical findings are relevant both for understanding the recent growth in business support service contracting and for understanding firms' relationships with their own employees.

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## I. Introduction

In recent years, there has been growing interest in what we will term market-mediated work arrangements: contracting out for business support services; subcontracting; and the use of temporary employees. Much of this interest has been attracted by the rapid expansion of employment in the business service sector and by less systematic evidence suggesting that production subcontracting, short-term hiring, the use of on-call workers and a variety of similar arrangements have become more common as well.<sup>1</sup>

Many observers have viewed these developments with concern. Knowing more about why employers have turned to market-mediated work arrangements can help to answer the question of whether this concern is warranted. Consider, for example, the decision to contract work out rather than to have it performed in house. To the extent that employers contract out to cut wage and benefit costs for non-core employees or use outside contractors to buffer the regular work force from fluctuations in demand, it may be the case that the growth in outside contracting has contributed to an increasingly unequal distribution of income in the economy. In contrast, to the extent that the use of such arrangements reflects the provision of specialized services by contractors who are able to realize economies of scale that would not be available in house, no such conclusion would seem warranted.

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<sup>1</sup>See Abraham (1990) for a review of evidence on these trends. All of the arrangements mentioned have in common the use of outsiders to perform tasks that could in principle have been assigned to regular employees of the organization. This same group of arrangements, together with part-time work, are sometimes referred to as "contingent work" (see, for example, Belous (1989)), but that term carries connotations that may be unwarranted.

A natural way to learn about employers' motivations for contracting out is to study the organizational and environmental correlates of reliance on outside contractors. Evidence that, for example, high wage employers are more likely than low wage employers to contract out low skill tasks would be suggestive of the importance of labor cost savings as a motivation for contracting. Similarly, a positive association between the volatility of output demand and contracting activity would imply that outside contractors play a buffering role. The economies-of-scale explanation for contracting leads one to look for associations between establishment and/or market size and the volume of contracting activity.

Information on the conditions associated with adoption of market-mediated work arrangements also may contribute to a better understanding of firms' relationships with their own regular employees. In addition to shedding light on why employers turn to outside contractors, evidence that high-wage employers are more likely than low-wage employers to contract out low-skill tasks would be suggestive of the importance of equity considerations in the determination of relative wages within internal labor markets. Similarly, evidence that the volatility of an establishment's work load is an important determinant of contracting activity would be suggestive of the value that employers attach to being able to offer stable employment to their regular work forces.

The present paper focuses on employers' use of outside contractors to perform a variety of business service activities. Alternative hypotheses concerning employers' reasons for contracting out are outlined in Section II. Section III describes our strategy for differentiating among these hypotheses empirically and the establishment-level data set that we use to implement this strategy. This data set contains information on whether and to what extent each included establishment contracts out for each of five specific services, as well as a considerable amount of information on other

establishment characteristics. Our econometric specification is detailed in Section IV, and our findings concerning the factors that lead employers to contract out for different services are reported in Section V. Section VI discusses the implications of our findings and offers some concluding observations.

## II. Reasons for Contracting Out

At least three general considerations may affect an employer's decision to contract out rather than to have work performed in house. First, contracting out may be a way for high wage organizations to take advantage of low market wage rates for certain types of low skill work. Second, the desire to smooth the work load of the regular work force may encourage organizations to contract out peak period tasks, while simultaneously discouraging them from contracting out tasks that could be scheduled to keep the regular work force occupied during off-peak periods. Finally, a decision to contract out may not reflect labor market or industrial relations considerations at all, but rather the existence of scale economies accruing to specialized providers of particular services. We discuss these motivations in turn.

### Wage and Benefit Savings

Much of the popular discussion of firms' increasing propensity to contract out has emphasized the potential for cutting costs by contracting out to firms that offer less generous wage and benefit packages. Explaining why an employer might want to contract out is straightforward in the case of a unionized firm that pays wages set by contract at levels higher than the firm would otherwise choose to pay, though it should be noted that a strong union may be able to block the reassignment of work to outsiders.

A similar argument can be made concerning firms that pay high wages for "efficiency wage" reasons. Efficiency wage models suggest

several reasons for employers to pay their employees above-market wages: because doing so gives those employees an incentive to work harder than they otherwise would have done; because it reduces turnover rates; because it allows the employer to attract job applicants of higher average quality; or because it enhances the good will employees feel toward the employer.<sup>2</sup>

While paying high wages to the firm's "core" work force may be a sensible strategy, there is little obvious return to paying high wages to workers who are easily monitored, easily replaced, and/or performing work that is peripheral to the organization's main objectives. There is, for example, no obvious reason why any firm should wish to pay its janitors above-market efficiency wages. This suggests that, even in the nonunion sector, high-wage firms may find it attractive to contract out at least some activities.

This reasoning implicitly assumes that high-wage organizations do not have the option of pursuing a differentiated compensation strategy, paying core workers well and paying other workers only market wages. In the union sector, the firm clearly does not have the freedom to set relative wages for different jobs in this fashion. Even in the nonunion sector, workers' ideas about internal equity may well be such that if some workers are highly paid, all must be highly paid. In separate analyses of Area Wage Survey data, both Blau (1977) and Groshen (1986) conclude that establishments that pay high wages to workers in some occupations tend to pay high wages to workers in other occupations as well. Evidence that high-wage firms are more likely to contract out low-skill, peripheral tasks would constitute additional evidence for the importance of internal equity constraints on the relative wages paid to workers within any particular internal labor market.

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<sup>2</sup>Yellen (1985), Katz (1987) and Weiss (1991) survey the efficiency wage literature.

## Smoothing the Work Load of the Regular Work Force

A second consideration that is likely to influence an organization's contracting decisions is the effect that contracting out will have on the regular work force's load. All else the same, it seems reasonable to suppose that most organizations would prefer to maintain a reasonably steady flow of work. Accommodating an uneven demand for the organization's products or services may entail a variety of costs, including costs associated with carrying more workers on the payroll than are needed during slow periods and/or costs associated with varying the size of the regular work force.

Contracting decisions may influence the flow of in-house work in at least two ways. Firms may be able to smooth the flow of in-house work either by contracting out peak period tasks or by rescheduling certain tasks that otherwise might have been assigned to an outside contractor to be performed by the regular work force during slow periods.

Modeling the use of outside contractors by a firm that faces an exogenously given but fluctuating flow of work to be performed is relatively straightforward.<sup>3</sup> Any such model must assume that the contractor's charges exceed the organization's own direct production costs, at least for some levels of in-house production; otherwise, it would be efficient for the organization to contract out all of its activities and cease to exist. Even if the contractor's per unit charges are higher than in-house production costs, however, contracting out peak load work may be an attractive alternative to hiring sufficient workers onto the firm's payroll to cover peak demand. Building an in-house work force large enough to meet peak demand is apt to imply that some of those hired are idle during slow periods and/or that the firm incurs significant hiring and firing costs as it

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<sup>3</sup>See, for example, Abraham (1988).

adjusts the level of employment to increases and decreases in output demand. Provided that contracting costs are small relative to the costs of adjusting in-house employment levels, the strategic use of outside contractors to meet peak period demand may be cost effective. This line of reasoning implies that reliance on outside contractors will be greater the more variable or uncertain the demand for the organization's products or services.<sup>4</sup>

An important assumption underlying the preceding argument is the exogeneity of the temporal flow of work to be performed. In fact, the timing of certain activities may be at least somewhat flexible. In some cases, work might either be contracted out or performed by the regular work force during off-peak periods. Cleaning and maintenance tasks are examples of activities that might fall in this category. This implies that organizations with more variable demand for their products or services might well be less likely to contract out certain tasks.<sup>5</sup>

Whether an organization with volatile demand can be expected to be more likely or less likely to contract out a particular activity thus depends upon whether the work to be done varies directly with the overall level of production or whether it can be rescheduled for off-peak periods.

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<sup>4</sup>Hamermesh (1993) surveys the literature pertaining to adjustment costs and the dynamic behavior of employment. Firms also may use hours, inventory or backorder adjustments to accommodate an uneven work load. The availability of these choices will affect firms' specific decisions but not the conclusion that, all else the same, one would expect greater reliance on contractors by organizations facing more variable or more uncertain demand.

<sup>5</sup>Again, the extent to which this is so will depend upon the costs associated with all potential adjustment strategies, including not only the costs of varying the level of employment but also the costs of varying hours, inventory stocks and/or backorder queues.



So long as it is costly to accommodate an uneven flow of work, organizations with more volatile demand should be more likely to contract out in the former case and less likely to contract out in the latter case. In either event, evidence of a systematic relationship between the volatility of demand for an organization's output and the propensity to contract out at least for certain services supports the inference that varying the size of the regular work force is costly.

### Specialized Services

A final important reason for contracting with outsiders is that they may have specialized equipment or skills that the home organization lacks. The essential consideration here is the degree to which there are economies of scale in the provision of the service in question. For example, it may not be cost-effective for a small or medium sized organization to provide a full range of computer support activities in house. Even if the firm could keep one or more computer specialists busy, much of the day-to-day work would likely be rather routine. More complex problems would be outside the experience of the in-house staff. The firm might well be better off relying on the resources and experience of a computer services firm when there is complex work to be done. This motivation is distinguished from the two previous motivations by the fact that technological considerations, rather than labor market or industrial relations imperatives, are operative.

### III. Establishment Characteristics and Contracting Out

The theoretical discussion just concluded implies that establishments may contract out for several different reasons. These alternative motivations for contracting out have clear implications concerning the sorts of establishments one would expect to contract out. If reducing costs were the primary motivation for contracting out a particular activity, one would expect high wage establishments to be more likely than

low wage establishments to contract out. Even holding wage costs constant, union work rules might act like higher wages to raise labor costs and thus increase the likelihood of contracting out; on the other hand, a union may be able to prevent an employer from contracting out. To the extent that contracting decisions are driven by employers' desire to smooth the regular work force's load, one would expect to find an association between the seasonality or cyclical nature of demand and the propensity to contract, though that association might be either positive or negative. If the demand for the service in question is tied to the overall level of production at the establishment, one would expect establishments facing seasonal or cyclical demand to be more likely to contract out for it. In contrast, if the service in question involves work that could be rescheduled for off-peak periods, one would expect establishments facing seasonal or cyclical demand to be less likely to contract out for it. Finally, contracting out for a particular service may reflect the contractor's possession of specialized equipment or skills that cannot be maintained economically within the establishment. Small establishments should be more likely to contract out for this reason. In addition, if specialized service firms are more likely to be viable in markets where there is a large potential market for their services, establishments in metropolitan areas should be more likely to have access to such services and thus more likely to contract out for them.

Given these expected associations, a reasonable strategy for assessing the factors that influence employers' contracting decisions is to examine the relationship between establishments' contracting behavior and their characteristics. In addition to containing information on contracting out, a data set suitable for this purpose also should contain information on establishment characteristics such as: the establishment wage level; whether the establishment is or is not unionized; whether the establishment's work

load is seasonal or cyclical; the size of the establishment; and whether the establishment is located in a metropolitan area.

Data from a special set of questions on contracting out added to the thirteen manufacturing Industry Wage Surveys (IWS's) conducted by the Bureau of Labor Statistics between June 1986 and September 1987 provide information employers' propensity to contract out for each of a set of business services, together with considerable additional information on the responding establishments.<sup>6</sup> We use this data set to examine the relationship between contracting decisions and establishment characteristics.

The unit of observation in the IWS is the establishment. The establishments surveyed are a stratified random sample of establishments in each of the included industries with employment that exceeds a minimum threshold, which ranges from twenty to one hundred employees. Respondents were asked about their contracting out for each of five services: janitorial services; machine maintenance services; engineering and drafting services; accounting services; and computer services.<sup>7</sup>

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<sup>6</sup>The thirteen industries for which contracting questions were added to the standard IWS battery are corrugated and solid fiber boxes; structural clay products; pressed or blown glass and glassware; cigarette manufacturing; grain mill products; iron and steel foundries; ship building and repairing; industrial chemicals; men's footwear; women's footwear; pulp, paper, and paperboard mills; upholstered wood household furniture; and nonupholstered wood household furniture. Similar questions on contracting out also were included on the IWS for utilities. We opted to restrict our analysis to manufacturing industries.

<sup>7</sup>The section of the survey interviewers' guide containing the contracting questions is reproduced in Appendix A. The survey questionnaire also included categories for trucking, secretarial and "other" services. In the case of trucking services, particularly long-haul trucking services, there is reason to think that labor market considerations play only a secondary role in the contracting decision. Contracting for secretarial services was not analyzed because of the close substitutability of temporary secretarial staff

Respondents at establishments that used or had used a particular service were asked to report the fraction of that service currently contracted out, the fraction contracted out in 1983, and the fraction contracted out in 1979. Their answers were coded as follows: none; 1-25 percent; 26-74 percent; 75-99 percent; 100 percent; or some contracted out, but percent unknown. All of our analyses exclude both establishments that did not use a particular service and establishments reporting that another unit of the company was responsible for providing the service.

The distribution of the contracting out responses for establishments that used and were responsible for providing each service all three reporting years (1986/87, 1983 and 1979) is shown in table 1. Employers who use outside contractors to perform janitorial work most commonly rely on them to supply all, rather than only a share, of their janitorial services. This is exactly the pattern that one would expect if the primary motivation for contracting out were to reduce wage and benefit costs, but not the pattern that would be expected if contracting were intended to smooth an establishment's work load or to take advantage of an outsider's specialized expertise. In contrast, employers who use outside contractors to perform the other listed tasks most commonly rely upon them for only a share of the service required.

For all five services, the data provide evidence of an increased propensity to contract out among establishments requiring the specified service. Over the 1979 to 1986/87 period, the proportion of user establishments reporting that they contracted out at least some janitorial work grew by 18 percent; at least some machine maintenance work, by 6

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for contracted secretarial services and the lack of explicit definitions to help survey respondents distinguish between the two. Few respondents indicated that their firms contracted out for services other than those specifically listed and no information on these other services was coded.

percent; at least some engineering and drafting work, by 12 percent; at least some accounting services work, by 11 percent; and at least some computer services work, by 21 percent.

Comparison of these numbers to the growth in employment in the corresponding business service industries suggests that changes in firms' contracting practices account for a substantial part of the continuing growth in the service sector employment share. Payroll employment at establishments supplying services to buildings (primarily janitorial services), for example, grew by 41 percent between 1979 and 1986. Over the same time period, total nonagricultural employment grew by only 11 percent, so that building services employment grew by 30 percent more than would have been expected solely as a consequence of growth in the scale of the economy. If the only change that had occurred over the period had been an 18 percent increase in the share of employers choosing to contract for building services, the excess growth of building services employment would have about been about 60 percent as large as that actually observed, with the remainder of the excess growth attributable to changes in the mix of activity in the economy. Similar calculations suggest that changes in employer contracting practices account for about half of the 21 percent excess growth in engineering and architectural services employment; about a third of the 34 percent excess growth in accounting, auditing and bookkeeping employment; and about a fifth of the 112 percent excess growth in computer and data processing services employment.<sup>8</sup>

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<sup>8</sup>Payroll employment statistics published by the Bureau of Labor Statistics indicate that, during the period from 1979 to 1986, engineering and architectural services employment grew by 32 percent; accounting, auditing and bookkeeping employment by 45 percent; and computer and data processing employment by 118 percent. Our calculations concerning the share of excess employment growth accounted for by changes in contracting practices assume both that the changes in those practices

Brief definitions of the explanatory variables used in our analysis are given in table 2. The first characteristic that we believe might affect an establishment's propensity to contract out is whether it is a high-wage or a low-wage organization. Because differences in average wages may reflect either differences in wage rates for similar work or differences in the skill level of the work performed, the average hourly wage rate could be a misleading indicator of an establishment's position in the wage hierarchy. For example, an establishment employing highly skilled individuals might be classified as a high-wage establishment when in fact it paid only average wages for employees of that skill level. Our wage level measure is constructed in a way that should avoid this problem.

The IWS data contain information on the wage rate paid to all workers in a subset of the detailed occupations represented at establishments in the sample. The occupation subset varies across industries, so that using the wage rate for any particular occupation would have precluded pooling data from different industries.<sup>9</sup> Instead, we constructed a measure of the average wage paid to all individuals in a set of occupations that we determined had similar skill requirements. To do this, we first matched IWS occupational definitions to corresponding Dictionary of Occupational

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reported in our sample are similar to those that have occurred in the economy more generally and that the average share of its needs for which a contracting firm outsources has been roughly constant over time. We have no way of checking the first assumption; the second appears to be broadly consistent with the data reported in table 1. Calculations are not reported for machine maintenance services because they cannot be identified with establishments in any one industry category.

<sup>9</sup>All of the surveys ask for information on the wages paid to janitors and truck drivers, but janitorial and trucking services often are contracted out.

Titles (DOT) occupational definitions.<sup>10</sup> We then used data available from the National Crosswalk Service Center that link each DOT occupation to a vector of information on its skill requirements. This permitted us to identify sets of occupations coded as requiring the same level of general educational development (GED) with respect to reasoning, math, and language, and a similar level of specific vocational preparation (SVP), required for "average" performance in the occupation.

Each of the three GED dimensions is coded on a six point scale, with one the lowest and six the highest; specific vocational preparation is coded on a nine point scale, with one the lowest and nine the highest. All occupations used in constructing our wage variable had GED scores of two for reasoning, one for math and one for language, and an SVP score of either two or three.<sup>11</sup> We also experimented with a wage measure defined using data for the set of occupations with GED scores of four for reasoning, three for math and three for language, and an SVP score of five, six, seven or eight; using this alternate wage measure had no important effect on our findings.

A second characteristic that we believe might influence an establishment's contracting decisions is the volatility of demand for its output. Unfortunately, the IWS data set provides no information on

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<sup>10</sup>IWS/DOT matches for the occupations in two of our industries have also been performed independently by Charles Brown (see Brown (1989)). Our matches and his were virtually identical.

<sup>11</sup>Definitions for both the GED and SVP scores are reproduced in Appendix B. In upholstered wood furniture, for example, the included occupations were cushion stuffing machine operators; plastic top installers; machine offbearers; furniture rubbers; and furniture packers. In iron and steel foundries, the included occupations were core assemblers and finishers; electric furnace tenders; metal pourers; sand slinger operators; shakeout workers; forklift operators; and other power truck operators.

establishment sales and information on employment levels only for the survey date. Our proxies for the seasonality and the cyclicalness of an establishment's work load use employment data for the detailed SIC industry to which the establishment belongs. The thirteen IWS's used in our analysis include establishments in thirty separate four-digit SIC industries. For twenty-four of these four-digit industries, we were able to obtain seasonally unadjusted monthly employment data for the period from 1972 through 1989. Employment data for the remaining six of these four-digit industries were available as three aggregates, each consisting of two of the six industries. Our proxy for the seasonality of an establishment's work load is the standard deviation of the estimated coefficients from a regression of the change in  $\ln(\text{employment})$  in the establishment's four-digit industry on a set of twelve month dummies. We define cyclicalness as the coefficient from a regression of the seasonally adjusted  $\ln(\text{employment})$  change in the detailed industry to which the establishment belongs on the seasonally adjusted change in  $\ln(\text{total nonagricultural payroll employment})$ .

The remaining explanatory variables are taken directly from the IWS data files. We code an establishment as unionized if a majority of the production workers at the establishment are covered by a collective bargaining agreement and as nonunion otherwise. We also code a metropolitan/nonmetropolitan location dummy and, based on employment levels, a set of establishment size dummies.

#### IV. Econometric Specification

The standard ordered probit model offers an efficient approach to the analysis of ordered categorical data not scaled in any intrinsically meaningful way. In our data, IWS respondents at establishments using a particular service report whether the establishment contracts out none, 1-25 percent, 26-74 percent, 75-99 percent, or 100 percent of the service in



question, or that some of the service is contracted out but they cannot say how much. One econometrically significant feature of these data is that employers' responses concerning their contracting behavior are defined with respect to a meaningful cardinal scale. In addition, whereas the first five contracting out categories are clearly ordered, the last is not. We begin here with a brief review of the standard ordered probit model as it might be applied to our data, and then explain how we have modified the standard model to accommodate the special features of those data just described.

Let  $Y_i$  represent establishment  $i$ 's underlying propensity to contract out for a particular activity, here defined in terms of the share of the activity that is contracted out, and assume that:

$$(1) \quad Y_i = \tau + X_i\beta + \epsilon_i$$

where  $\tau$  is a parameter,  $X$  is a vector of organizational characteristics,  $\beta$  is a parameter vector and  $\epsilon$  is a normally distributed error term with mean zero and standard deviation  $\sigma$ .  $Y_i$  is not observed. Instead, we know only into which of the contracting out categories defined above a particular establishment falls.

For the moment, ignore both the scale that underlies our contracting out categories and the existence of the sixth contracting out category (some of the service in question contracted out, but how much not reported). Define a set of four constants such that  $\alpha_1 < \alpha_2 < \alpha_3 < \alpha_4$ . Establishment  $i$  is observed in category 1 (none of the service contracted out) if:

$$(2) \quad Y_i < \alpha_1;$$

in category 2 (1-25 percent contracted out), category 3 (26-74 percent contracted out), or category 4 (75-99 percent contracted out) if:

$$(3) \quad \alpha_{J-1} < Y_i < \alpha_J,$$

$J=2,3$ , or  $4$ ; and in category 5 (100 percent contracted out) if:

$$(4) \quad Y_i > \alpha_4.$$

The contribution to likelihood for an establishment in category 1 is:

$$(4) \quad P1_i = P(\tau + X_i\beta + \epsilon_i < \alpha_1) = F[(\alpha_1 - \tau - X_i\beta)/\sigma],$$

where  $F$  is the standard cumulative normal density. The contribution to likelihood for an establishment in category 2, category 3 or category 4 is:

$$(5) \quad PJ_i = P(\alpha_{j-1} < \tau + X_i\beta + \epsilon_i < \alpha_j) = \\ F[(\alpha_j - \tau - X_i\beta)/\sigma] - F[(\alpha_{j-1} - \tau - X_i\beta)/\sigma],$$

$J=2,3$ , or  $4$ ; and the contribution to likelihood for an establishment in category 5 is:

$$(6) \quad P5_i = P(\tau + X_i\beta + \epsilon_i > \alpha_4) = 1 - F[(\alpha_4 - \tau - X_i\beta)/\sigma]$$

The likelihood function for the model as a whole combines the contributions to likelihood for the observations in the different categories in the standard fashion. Note that, in this model, neither the  $\alpha_j$ 's nor the  $\beta$ 's are identified. Instead, only  $(\alpha_j - \tau)/\sigma$ ,  $J=1,2,3$ , or  $4$ , and the ratios of the elements of  $\beta$  to  $\sigma$  can be recovered.

In our data set, where the contracting out categories are defined with reference to the contracting out of specified shares of a particular activity, the  $\alpha_j$ 's are known:  $\alpha_1$  is zero;  $\alpha_2$  is 0.25;  $\alpha_3$  is 0.75; and  $\alpha_4$  is 1.00. These values imply a set of constraints on the relative magnitudes of the  $(\alpha_j - \tau)/\sigma$  terms estimated in the standard ordered probit model. In particular, they imply that:

$$(7) \quad \hat{\alpha}_2 = \hat{\alpha}_1 + 0.25*(\hat{\alpha}_4 - \hat{\alpha}_1)$$

and

$$(8) \quad \hat{\alpha}_3 = \hat{\alpha}_1 + 0.75*(\hat{\alpha}_4 - \hat{\alpha}_1)$$

where  $\hat{\alpha}_j$  represents  $(\alpha_j - \tau)/\sigma$ . In our estimating equation, we impose these constraints; in effect, we estimate only  $\hat{\alpha}_1$  and  $\hat{\alpha}_4$ .

Note that knowing the values of the  $\alpha_j$ 's also means that, once  $\hat{\alpha}_1$  and  $\hat{\alpha}_4$  have been estimated, both  $\sigma$  and  $\tau$  are identified. Having an estimate of  $\sigma$  permits us to recover  $\beta$ . Being able to identify all of the parameters in the model turns out to be useful. In particular, it permits us

to estimate the expected share of a given activity contracted out by an establishment with specified characteristics. Our estimate of this share, denoted SHAREHAT, is:

$$(9) \quad \text{SHAREHAT} = P[(-\tau - X\beta)/\sigma < \epsilon/\sigma < (1 - \tau - X\beta)/\sigma] * \\ \{ \tau + X\beta + E[\epsilon / (-\tau - X\beta)/\sigma < \epsilon/\sigma < (1 - \tau - X\beta)/\sigma] \} \\ + P[\epsilon/\sigma > (1 - \tau - X\beta)/\sigma] * 1.00.^{12}$$

Given estimates of the model parameters and recognizing that the expected value of  $\epsilon$  in the first term is just  $\sigma$  times the expected value of a truncated standard normal variate, this is straightforward to calculate.

The second modification we make to the standard ordered probit model is to introduce the appropriate contribution to likelihood term for establishments in the sixth contracting out category, those in which there is some contracting out but the respondent cannot say how much. This is simply:

$$(10) \quad P_{6i} = P(\tau + X_i\beta + \epsilon_i > 0) = 1 - F[(-\tau - X_i\beta)/\sigma].$$

The likelihood function used in our estimation combines the contributions to likelihood for the observations in each of the six different categories in the standard fashion.

## V. Determinants of the Propensity to Contract Out

The results of fitting the modified ordered probit model just described with our contracting out data, reported in table 3-1 and table 3-2, point to a variety of underlying influences on contracting out decisions.

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<sup>12</sup>Depending upon the realized value of  $\epsilon$ , an establishment with given characteristics may contract out for none, some or all of a particular service. The expected share of a service for which the establishment contracts is the weighted sum of the expected shares in each of these three cases, with weights equal to the probability of each case occurring. The expression shown in the text contains no term for the no-contracting case because that term equals zero.

Each of these models includes our wage level variable, a union dummy, a metropolitan area dummy, and a set of establishment size dummies. The models in table 3-1 also include the seasonality and cyclicity proxies described earlier. We substitute industry dummies, corresponding to the IWS industries surveyed, for these seasonality and cyclicity proxies in table 3-2. These industry dummies control for unmeasured industry-specific characteristics that might influence the propensity to contract out for different sorts of services. The sample size varies by service because our analysis for each service is restricted to establishments that actually use the service and have responsibility for ensuring its provision.

Table 4-1 and table 4-2 summarize the change in the proportion of contracting out activity resulting from a change in each of the explanatory variables for the models reported in table 3-1 and table 3-2, respectively. The first row of each table reports the proportion of the service contracted out by an establishment that pays the wage corresponding to the mean of our  $\ln(\text{wage})$  variable, faces the mean degree of seasonality and cyclicity, is nonunion, is located in a nonmetropolitan area, and employs fewer than 50 employees. The following rows describe how the proportion contracted out changes if one of the base characteristics changes. For example, the table 3-1 coefficients imply that an establishment that pays a wage that puts its  $\ln(\text{wage})$  one standard deviation above the mean contracts out for 5.2 percent more of its janitorial services than does the base establishment.<sup>13</sup>

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<sup>13</sup>The precise numbers shown in table 4-1 and table 4-2 are based on the assumption that the constraints imposed in estimating our modified ordered probit models are valid. We also have estimated unconstrained versions of the same models; the estimated  $\alpha$ 's are somewhat different, but the estimated coefficients and significance levels for the explanatory variables of interest are virtually identical to those in the models we report. These results are available upon request. Although standard likelihood ratio tests would lead us to reject the constrained specifications in favor of those that

If the primary motivation for contracting out for a particular service were to save on wage costs, one would expect high wage establishments to be more likely to contract out than low wage establishments. Our results strongly support the view that wage savings are a key factor in contracting out for janitorial services, the one obviously low-skill activity included in the set of services we study. In both of the equations that we fit for janitorial services, the wage variable has a sizeable and statistically significant coefficient. As already noted, the conclusion that labor cost savings motivate contracting out for janitorial services is consistent with the fact that most establishments that do any contracting for janitorial services contract out all of this work. It is also consistent with calculations using Current Population Survey data from the mid-1980s showing that building services personnel employed in the business service sector receive substantially lower wages, and also are substantially less likely to be covered by health insurance and pension plans, than are building services personnel employed in, for example, the manufacturing sector (Abraham (1990)).<sup>14</sup>

Somewhat surprisingly, the table 3-1 coefficients also imply that having a high relative wage raises the proportions of engineering and

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allow the  $\alpha$ 's to be estimated freely, we have chosen to focus on the constrained models because doing so allows us to give the reader a sense of the practical significance of the estimated effects. This would otherwise be quite difficult to do.

<sup>14</sup>Similar calculations comparing the wages and benefits of janitors in the business service sector to those of janitors in high wage industries also support the conclusion that high-wage firms could substantially reduce their wage and benefit costs by contracting out this work. In these calculations, high wage industries are those with industry dummy coefficients in a standard  $\ln(\text{wage})$  regression that imply wages in the top quarter of the employment-weighted industry wage distribution. Details are available upon request.

drafting services and machine maintenance services that are contracted out. This result is surprising because these activities involve tasks that one would suspect are difficult to monitor, are performed by workers who are likely to be relatively difficult to replace, and are likely to be central to the establishment's success. The positive association between the wage variable and contracting out for these services disappears, however, when industry dummies are introduced into the estimating equation in table 3-2. This suggests that the former results may be spurious, reflecting other characteristics of establishments in high wage industries that make them more likely to contract out machine maintenance and engineering and drafting work.

An interesting, albeit unanticipated, finding is that the relative wage variable takes on negative and statistically significant coefficients in both of the accounting service equations, and negative, though not statistically significant, coefficients in the computer services equations. One possible interpretation of these negative coefficients is that internal equity constraints operate not only to preclude high wage establishments from paying low wages for peripheral, easily monitored work, but also to preclude low wage establishments from paying high wages for highly skilled work even when it might be attractive to do so.

We had no clear expectation concerning the sign of the union variable's coefficients. On the one hand, union work rules may operate like high wages to raise labor costs, giving unionized employers a stronger incentive to contract out than otherwise similar nonunion employers. On the other hand, unions may be able to negotiate agreements that prevent employers from contracting out. In fact, there is no systematic association between unionization and contracting out in any of the studied services. One caveat to this finding is that, as previously noted, our unionization variable captures only whether a majority of a plant's production workers

are organized. Data on the presence of a white-collar union, which might more directly affect contracting for office services, are unavailable.

Standard stories concerning the buffer role played by outside contractors would lead one to expect that establishments with seasonal or cyclical work loads should contract out more work at peak periods. On the other hand, if certain types of work can easily be scheduled for off-peak periods, establishments facing seasonal or cyclical demand may be less likely to contract out such work since performing it may help to keep their work forces busy during otherwise slow periods.

Our results indicate that establishments in industries with seasonal or cyclical work loads contract out significantly less of their janitorial and machine maintenance work. This finding seems reasonable, since components of both activities can be shifted towards off-peak periods. Indeed, Fay and Medoff (1985) report that, in a sample of establishments that they queried concerning labor adjustment during cyclical downturns, a substantial fraction report assigning cleaning and maintenance work to production workers who otherwise would be less than fully occupied.<sup>15</sup> There is also some evidence that cyclical establishments contract out less of their engineering and drafting work. However, cyclical establishments contract out more of their accounting services, tasks which arguably vary directly with demand fluctuations. All of these results must be interpreted with some caution, however, since our seasonality and cyclicity proxies are based on industry-level data, so that we could not examine the effects of

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<sup>15</sup>In the Fay and Medoff sample, the percentage of respondents reporting the assignment of various categories of work to production workers during cyclical downturns is as follows: 36 percent, maintenance of equipment; 24 percent, overhaul of equipment; 37 percent, cleaning; and 35 percent, painting.

seasonality or cyclicity holding other unobserved industry characteristics constant.

A final explanation for contracting out is that contract service firms may enjoy economies of scale in the provision of specialized services not available to the contracting establishment. Contract service firms are most likely to realize such economies if they locate near a large client base. This suggests that establishments in metropolitan areas may contract out more owing to better access to contract services. One also would expect large establishments to be less likely to contract out for this reason than small establishments, since a large establishment is more likely to be able provide services in house on an economical scale.

Our results suggest that, for four of the five services we have studied, economies of scale are an important factor in the decision to contract out. For machine maintenance services, engineering and drafting services, accounting services and computer services, larger establishments are less likely to contract out. A metropolitan location substantially increases contracting out for both accounting and computer services, but not for either machine maintenance or engineering and drafting services. This pattern may reflect the industry-specific nature of the latter activities. A measure of whether an establishment is located close to other establishments in the same industry might be a better predictor of contracting out for machine maintenance and engineering and drafting services. The best such variable that we were able to construct did not prove to be statistically significant in the equations for either of these services, but even our best



measure was still quite crude.<sup>16</sup> Economies of scale do not seem to be an important determinant of contracting out for janitorial services.

## VI. Conclusion

The picture of employers' motives for contracting out that emerges from our analysis is rather more complex than that given in the typical popular account. Indeed, observed contracting behavior seems to reflect a mixture of all three of the influences mentioned at the beginning of the paper. Contracting for janitorial services -- the only low-skill activity included in the set of services we have studied -- appears to be motivated primarily by a desire to reduce hourly labor costs. The major correlates of contracting out for machine maintenance, engineering and drafting, accounting and computer services identifiable in our data are smaller establishment size and, for the latter two listed services, location in a metropolitan area. Both are consistent with the existence of important economies of scale in the provision of these services. Establishments in more cyclical industries are more likely to contract out for accounting services. Interestingly, however, firms with more volatile demand appear to be less likely to contract out for janitorial and machine maintenance services, suggesting that establishments may be discouraged from using outside contractors by the desire to reserve certain tasks to be performed by the regular work force during off-peak periods. These findings run counter to the standard buffering story about contracting out.

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<sup>16</sup>This measure was a dummy variable equal to one if the establishment was located in an area, as defined by the Bureau of Labor Statistics, containing at least ten establishments in the same industry, and zero otherwise. Some of these areas were individual cities, but others were as large as an entire state.

One natural question to ask is why, as seems to be the case, employers should have become more likely than in previous years to contract out. Although this is not a question that our data allow us to address directly, our findings are suggestive of the sorts of factors that one might expect to have been important. In the case of janitorial services, and likely other low-skill services as well, the most obvious potential explanation for growing reliance on outside contractors is an increasing gap between labor costs at contracting firms and the market price of labor available to perform a particular task. Somewhat surprisingly, given the growth in the overall dispersion of wage rates during the 1970s and 1980s, our analysis of Current Population Survey data for this period reveals no consistent widening of the gap between the wages of low-skill workers such as janitors and guards employed in high-wage sectors versus the wages of workers in the same occupations employed in the business service sector. There is also no evidence that the relative probability of a low-skill business service employee being covered by a health or pension plan fell during the 1980s. In all years for which we have data, however, low-skill workers in high wage sectors were substantially more likely to be covered by health and pension plans than their counterparts in the business service sector, and it is well known that employer health insurance costs rose rapidly during the 1980s. These increases may well have strengthened the incentive to contract out low-skill tasks.<sup>17</sup>

In the case of the other services we have studied, the most natural explanation for the observed increase in the propensity to contract would seem to be an increase in the comparative advantage enjoyed by specialized service establishments as compared to in-house providers of the same

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<sup>17</sup>The Current Population Survey tabulations described in the text are available upon request.

services. The growing employment base in many metropolitan areas may have fostered the establishment of new firms providing a greater variety of specialized services. In addition, improvements in the communications infrastructure may have allowed firms to sell certain services to clients in a wider geographic area, thereby allowing greater specialization and the realization of greater economies of scale in the provision of these services.

Previous discussions of the increased use of market-mediated work arrangements more generally have emphasized the growing volatility of output demand and/or the growing costs of hiring and firing regular employees (see, for example, Abraham (1990)). The present paper's findings, however, suggest that these developments, while most likely having encouraged the growth of temporary help agencies and possibly other sorts of market-mediated work arrangements, may have inhibited rather than encouraged the growth of business service contracting.

In addition to being of interest because it helps us to understand the contracting out phenomenon, evidence on which employers use outside contractors is of interest for the light it sheds on the underpinnings of the regular employment relationship. Our findings concerning the relationship between an establishment's wage level and its contracting behavior corroborate other evidence suggesting that internal equity considerations constrain the relative wages paid to employees within a single internal labor market. Absent some constraint on relative wages, there would be no reason to expect any difference in the contracting behavior of high-wage and low-wage establishments. Our finding that high-wage establishments are more likely to contract out for janitorial services suggests that these establishments cannot easily pay low wages to janitors on their own payrolls. Similarly, the finding that low-wage establishments are more likely to contract out for certain types of high-skill services suggests that

these establishments cannot easily pay high wages to workers in selected occupational groups.

Our findings concerning the relationship between the volatility of the demand faced by an establishment and the propensity to contract reinforces the prevalent view of labor as a quasi-fixed, rather than a variable, factor of production. If the level of employment could be adjusted costlessly, there would be no reason to expect any systematic association between the volatility of the demand for an establishment's output and the propensity to contract. We find, however, that establishments facing more volatile demand are less likely to contract out for janitorial and machine maintenance services, and infer that at these establishments more of this work is performed in house during slow periods. Such behavior is indicative of the value that employers attach to maintaining stable relationships with their regular employees. Our findings thus reinforce one of the central messages of the growing literature on the dynamic demand for labor, while simultaneously suggesting that a complete model of firms' employment decisions will need to consider a wider range of strategic options than typically have been considered in the literature to date.

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Table 1. Distribution of Contracting Out Responses for Establishments that Use the Service

Service	Year Service Needed	Sample Size <sup>a</sup>	Some of Service Contracted Out	Percentage of Service Contracted Out				
				1-25%	26-74%	75-99%	100%	>0% but Unknown
Janitorial	1979	2207	20.2	3.4	2.0	1.5	12.5	0.8
	1983		21.7	3.7	2.1	1.6	13.6	0.7
	1986/87 <sup>b</sup>		23.9	4.0	2.4	1.6	15.2	0.7
Machine Maintenance	1979	2194	26.6	16.5	2.8	1.2	2.8	3.2
	1983		27.2	17.2	2.9	1.2	2.7	3.2
	1986/87		28.2	17.9	3.0	1.2	2.8	3.3
Engineering and Drafting	1979	1797	16.6	9.2	2.2	0.7	2.3	2.3
	1983		17.1	9.7	2.1	0.6	2.5	2.3
	1986/87		18.6	10.7	2.6	0.7	2.5	2.2
Accounting	1979	1994	14.8	7.3	2.8	1.1	1.6	2.0
	1983		15.7	8.0	2.9	1.2	1.6	2.1
	1986/87		16.5	8.4	2.9	1.1	1.8	2.3
Computer	1979	1677	15.6	4.1	2.3	1.3	5.5	2.4
	1983		17.1	4.8	2.6	1.4	5.7	2.5
	1986/87		18.9	6.2	2.9	1.4	5.8	2.6

<sup>a</sup>Complete data are available for 2700 establishments. Sample size varies by service because only establishments that use that particular service are included. Establishments that do not need the service, have the service performed by another unit of the same company, or that did not respond to the contracting out question for 1979, 1983, or 1986 are not included.

<sup>b</sup>The survey year varies by industry, over the period from June 1986 through September 1987.

Table 2: Definitions of Explanatory Variables  
Used in Ordered Probit Models

LN(WAGE)	Log of establishment's average wage for workers in a range of occupations, the average performance of which requires relatively low-level reasoning, language and math skills acquired through formal education, informal education and experience, and specific vocational preparation of more than a short demonstration but no more than 3 months.
UNION	Dummy variable, =1 if the majority of production workers in the establishment is covered by a collective bargaining agreement, =0 otherwise.
SEASONAL	Standard deviation of the coefficients from a regression of the change in ln(employment) in the establishment's four-digit industry on a set of twelve month dummies.
CYCLICAL	Coefficient from a regression of the change in seasonally adjusted ln(employment) in the establishment's four-digit industry on the change in seasonally adjusted ln(total nonagricultural payroll employment).
METRO	Dummy variable, =1 if establishment is located in a centralized urban area of at least 100,000 people, or in a county or group of contiguous counties with a central city of at least 50,000 people, =0 otherwise.
ESTSIZE1	Dummy variable, =1 if establishment employs 50-99 workers, =0 otherwise.
ESTSIZE2	Dummy variable, =1 if establishment employs 100-249 workers, =0 otherwise.
ESTSIZE3	Dummy variable, =1 if establishment employs 250 or more workers, =0 otherwise.

Industry dummies, =1 if establishment is in the four-digit SIC or group of four-digit SICs which comprise the IWS industry, =0 otherwise.



Table 3-1. Modified Ordered Probit Model of the Decision to Contract Specification without Industry Controls<sup>a</sup>

	<u>Janitorial Services</u>	<u>Machine Mainten- ance Services</u>	<u>Engineering and Drafting Services</u>	<u>Accounting Services</u>	<u>Computer Services</u>
LN(WAGE)	.655 (.144)	.254 (.131)	.572 (.167)	-.566 (.149)	-.115 (.160)
UNION (yes=1)	.028 (.075)	.027 (.067)	.055 (.089)	-.051 (.088)	.035 (.092)
SEASONAL	-22.861 ( 5.888)	-11.854 ( 5.108)	-6.954 (7.195)	-7.065 (6.358)	1.595 (6.280)
CYCLICAL	-.091 (.039)	-.077 (.035)	-.123 (.046)	.113 (.046)	-.023 (.044)
METRO (yes=1)	.026 (.077)	.009 (.075)	-.023 (.089)	.337 (.094)	.330 (.096)
ESTSIZE1 (yes=1)	.270 (.114)	-.102 (.093)	-.273 (.123)	-.352 (.107)	-.118 (.123)
ESTSIZE2 (yes=1)	.130 (.108)	-.315 (.090)	-.344 (.114)	-.541 (.100)	-.340 (.115)
ESTSIZE3 (yes=1)	.093 (.119)	-.324 (.105)	-.336 (.131)	-.817 (.122)	-.575 (.129)
Sample size	2008	1997	1625	1814	1535

<sup>a</sup>Standard errors are shown in parentheses.

Table 3-2. Modified Ordered Probit Model of the Decision to Contract Specification with Industry Controls<sup>a</sup>

	<u>Janitorial Services</u>	<u>Machine Mainten- ance Services</u>	<u>Engineering and Drafting Services</u>	<u>Accounting Services</u>	<u>Computer Services</u>
LN(WAGE)	.600 (.172)	.094 (.153)	.190 (.201)	-.569 (.166)	-.134 (.193)
UNION (yes=1)	-.005 (.080)	.070 (.070)	.103 (.095)	-.056 (.092)	-.011 (.099)
METRO (yes=1)	.029 (.081)	.134 (.080)	.051 (.092)	.332 (.100)	.382 (.105)
ESTSIZE1 (yes=1)	.265 (.115)	-.096 (.095)	-.255 (.126)	-.333 (.110)	-.107 (.125)
ESTSIZE2 (yes=1)	.122 (.113)	-.364 (.095)	-.256 (.118)	-.576 (.105)	-.319 (.124)
ESTSIZE3 (yes=1)	.053 (.135)	-.434 (.117)	-.278 (.146)	-.873 (.134)	-.553 (.149)
Sample size	2008	1997	1625	1814	1535

<sup>a</sup>In addition to the variables listed, each model included twelve industry dummies. Standard errors are shown in parentheses.

Table 4-1. Changes in Proportion of Activity Contracted  
Due to Changes in Establishment Characteristics,  
Specification without Industry Controls

	<u>Janitorial Services</u>	<u>Machine Mainten- ance Services</u>	<u>Engineering and Drafting Services</u>	<u>Accounting Services</u>	<u>Computer Services</u>
Base establishment proportion of activity con- tracted <sup>a</sup>	.127	.124	.096	.082	.125
Change in proportion contracted associated with one standard deviation increase in:					
LN(WAGE)	.052	.016	.035	-.024	-.008
SEASONAL	-.032	-.015	-.007	-.007	.002
CYCLICAL	-.017	-.013	-.017	.016	-.004
Change in proportion contracted associated with change to:					
UNION	.006	.005	.009	-.007	.007
METRO	.005	.002	-.004	.058	.079
ESTSIZE1	.065	-.018	-.036	-.039	-.022
ESTSIZE2	.029	-.049	-.044	-.053	-.056
ESTSIZE3	.020	-.050	-.043	-.066	-.081

<sup>a</sup>The base establishment pays the mean ln(wage), faces the mean degree of seasonality and cyclicity, is nonunion, is located in a nonmetropolitan area, and employs fewer than fifty workers.

Table 4-2. Changes in Proportion of Activity Contracted Due to Changes in Establishment Characteristics, Specification with Industry Controls

	<u>Janitorial Services</u>	<u>Machine Maintenance Services</u>	<u>Engineering and Drafting Services</u>	<u>Accounting Services</u>	<u>Computer Services</u>
Base establishment proportion of activity contracted <sup>a</sup>	.129	.107	.071	.083	.115
Change in proportion contracted associated with one standard deviation increase in:					
LN(WAGE)	.048	.005	.009	-.024	-.008
Change in proportion contracted associated with change to:					
UNION	-.001	.012	.014	-.008	-.002
METRO	.006	.023	.007	.057	.089
ESTSIZE1	.064	-.015	-.027	-.038	-.019
ESTSIZE2	.027	-.048	-.027	-.055	-.050
ESTSIZE3	.011	-.055	-.029	-.069	-.074

<sup>a</sup>The base establishment pays the mean ln(wage), faces the mean degree of seasonality and cyclicity, is nonunion, is located in a nonmetropolitan area, and employs fewer than fifty workers. The calculations reported also assign the average value of the industry effects included in the model to the base establishment.

## Appendix A: Contracting Out Survey

### C. ESTABLISHMENT CONTRACTING HISTORY

Does this establishment contract out the services listed on the next page? Code for the percent of the service contracted out currently (1986) and for 1983 and 1979.

Do not accept guesses from the respondents, but do not spend too much time probing to get the information. We anticipate a high number of codes 6 or N (data not available) for 1979, especially. This is all part of the test and will help the Office of Wages and Industrial Relations in their analysis of data availability.

Estimates may take many forms. Usually, however, it will be either a dollar value of the contracted service or an estimate of the percent of the work contracted out by the establishment. If the estimate is a dollar amount, compute a ratio of the contract value compared with the total cost of the service to the establishment.

For example: a \$50,000 contract to design a system compared with the total systems budget of \$150,000 will mean that 1/3 of the service is contracted out. (Use code 3.) Estimates may also be in numbers of workers (e.g., 2 janitors are contract workers and 3 janitors are employed by the establishment; the establishment contracts out 2/5 or the work, or 40%. Use code 3.) Specify in Remarks the basis for the estimates: Contract value, number of persons, or some other measure.

#### Code

- 1 - Yes, 100 percent of the service is contracted out
- 2 - Yes, 75-99 percent of the service is contracted out
- 3 - Yes, 26-74 percent of the service is contracted out
- 4 - Yes, 1-25 percent of the service is contracted out
- 6 - Yes, but the percent contracted out is not available
- 7 - The service is performed or contracted out by another unit of the same company
- 8 - This service is not needed by the establishment
- 9 - No, none of this service is contracted out
- N - Data not available

NOTE: Use code 7 whenever the establishment does not have responsibility for the service (e.g., the service is provided by the central office of the establishment) even though the respondent may know the percent of the service contracted out.

SERVICE

CONTRACTING HISTORY

	1986	1983	1979
TRUCKING (local and long distance delivery)	<u>(38)</u>	<u>(39)</u>	<u>(40)</u>
MACHINE MAINTENANCE SERVICE (maintains PRODUCTION equipment only)	<u>(41)</u>	<u>(42)</u>	<u>(43)</u>
JANITORIAL SERVICE (cleans the plant)	<u>(44)</u>	<u>(45)</u>	<u>(46)</u>
ACCOUNTING SERVICE (performs typical accounting and bookkeeping functions, such as payroll. This work may be computerized.)	<u>(47)</u>	<u>(48)</u>	<u>(49)</u>
COMPUTER SERVICE (develops software; performs programming, analysis, coding, keying and data processing functions)	<u>(50)</u>	<u>(51)</u>	<u>(52)</u>
SECRETARIAL SERVICE (performs secretarial, word processing, and filing services)	<u>(53)</u>	<u>(54)</u>	<u>(55)</u>
ENGINEERING OR DRAFTING SERVICE (performs engineering, engineering support and drafting services)	<u>(56)</u>	<u>(57)</u>	<u>(58)</u>
OTHER SERVICES (Answer for 1986 only)	<u>(59)</u>		

If there are other services contracted out, specify the kind of service in Remarks. (Examples are Food Service, Guard Service, etc.)

Remarks: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Appendix B: Scale and Definitions of Skill Factors  
Used in Constructing Wage Variable

**GENERAL EDUCATION DEVELOPMENT (GED)**

General Education Development embraces those aspects of formal and informal education which contribute to the worker's reasoning development, ability to follow instructions and acquisition of language and mathematical skills. This general education derives from experience and self-study, as well as elementary school, high school, or college.

**Reasoning Development**

**Level 1:** Apply common sense understanding to carry out simple one- or two-step instructions. Deal with standardized situations with occasional or no variables in or from these situations encountered on the job.

**Level 2:** Apply common sense understanding to carry out detailed but uninvolved written or oral instructions. Deal with problems involving a few concrete variables in or from standardized situations.

**Level 3:** Apply common sense understanding to carry out instructions furnished in written, oral or diagrammatic form. Deal with problems involving several concrete variables in or from standardized situations.

**Level 4:** Apply principles of rational systems (eg., bookkeeping, internal combustion engines, electric wiring systems, house building, nursing, farm management, and navigation) to solve practical problems and deal with a variety of concrete variables in situations where only limited standardization exists. Interpret a variety of instructions furnished in written, oral, diagrammatic or schedule form.

**Level 5:** Apply principles of logical or scientific thinking to define problems, collect data, establish facts and draw valid conclusions. Interpret an extensive variety of technical instructions in mathematical or diagrammatic form. Deal with several abstract and concrete variables.

**Level 6:** Apply principles of logical or scientific thinking to a wide range of intellectual and practical problems. Deal with nonverbal symbolism (formulas, scientific equations, graphs, musical notes, etc.) in its most difficult phases. Deal with a variety of abstract and concrete variables. Apprehend the most abstruse classes of concepts.

## Mathematical Development

**Level 1:** Add and subtract two-digit numbers. Multiply and divide 10s and 100s by 2, 3, 4, 5. Perform the four basic arithmetic operations with coins as part of a dollar. Perform operations with units such as cup, pint and quart; inch, foot, and yard; and ounce and pound.

**Level 2:** Add, subtract, multiply and divide all units of measure. Perform the four operations with like common and decimal fractions. Compute ratio, rate and percent. Draw and interpret bar graphs. Perform arithmetic operations involving all American monetary units.

**Level 3:** Compute discount, interest, profit and loss; commission, markup and selling price; ratio, proportion and percentage. Calculate surfaces, volumes, weights and measures. Algebra: Calculate variables and formulas; monomials and polynomials; ratio and proportion variables; square roots and radicals. Geometry: Calculate plane and solid figures; circumference, area and volume. Understand kinds of angles and properties of pairs of angles.

**Level 4:** Algebra: Deal with system or real numbers; linear, quadratic, rational, exponential, logarithmic, angle and circular functions and inverse functions; related algebraic solution of equations and inequalities; limits, continuity, probability and statistical inference. Geometry: Deductive axiomatic geometry, plane and solid; rectangular coordinates. Shop math: practical application of fractions, percentages, ratio and proportion, mensuration, logarithms, slide rule, practical algebra, geometric construction and essentials of trigonometry.

**Level 5:** Algebra: Work with exponents and logarithms, linear equations, quadratic equations, mathematical induction, binomial theorems and permutations. Calculus: Apply concepts of analytic geometry, differentiation and integration of algebraic functions with applications. Statistics: Apply mathematical operations to frequency distributions, reliability and validity of tests, normal curve, analysis of variance, correlation techniques, chi-square application and sampling theory, and factor analysis.

**Level 6:** Advanced calculus: Work with limits, continuity, real number systems, mean value theorems and implicit function theorems. Modern algebra: Apply fundamental concepts of theories of groups, rings and fields. Work with differential equations, linear algebra, infinite series, advanced operations methods and function of real and complex variables. Statistics: Work with mathematical statistics, mathematical probability and applications, experimental design, statistical inference and econometrics.



## Language Development

**Level 1:** Reading: Recognize meaning of 2,500 two- or three-syllable words. Read at rate of 95-120 words per minute. Compare similarities and differences between words and between series of numbers. Writing: Print simple sentences containing subject, verb, object, and series of numbers, names and addresses. Speaking: Speak simple sentences using normal word order and present and past tenses.

**Level 2:** Reading: Passive vocabulary of 5,000-6,000 words. Read at rate of 190-215 words per minute. Read adventure stories and comic books, looking up unfamiliar words in dictionary for meaning, spelling and pronunciation. Read instructions for assembling model cars and airplanes. Writing: Write compound and complex sentences, using cursive style and proper end punctuation, and employing adjectives and adverbs. Speaking: Speak clearly and distinctly with appropriate pauses and emphasis, correct pronunciation, variations in word order, using recent, perfect and future tenses.

**Level 3:** Reading: Read a variety of novels, magazines, atlases and encyclopedias. Read safety rules, instructions in the use and maintenance of shop tools and equipment, and methods and procedures in mechanical driving and layout work. Writing: Write reports and essays with proper format, punctuation, spelling and grammar, using all parts of speech. Speaking: Speak before an audience with poise, voice control and confidence, using correct English and well-modulated voice.

**Level 4:** Reading: Read novels, poems, newspapers, periodicals, journals, manuals, dictionaries, thesauruses and encyclopedias. Writing: Prepare business letters, expositions, summaries and reports, using prescribed format and conforming to all rules of punctuation, grammar, diction and style. Speaking: Participate in panel discussions, dramatizations and debates. Speak extemporaneously on a variety of subjects.

**Levels 5 and 6:** Reading: Read literature, book and play reviews, scientific and technical journals, abstracts, financial reports and legal documents. Writing: Write novels, plays, editorials, journals, speeches, manuals, critiques, poetry and songs. Speaking: Conversant in the theory, principles and methods of effective and persuasive speaking, voice and diction, phonetics and discussion and debate.

## SPECIFIC VOCATIONAL PREPARATION

The amount of time required to acquire the information, techniques and facility needed for average performance in an occupation. This specific training may be acquired in a school, work, military, institutional or vocational environment. It includes practice time needed to apply learning to reach level of average performance. It does not include orientation training required of a fully qualified worker to become accustomed to the special conditions of a new job.

Specific vocational preparation can include vocational education, apprentice training, in-plant training given by the employer as organized classroom study, on-the-job training and essential experience in other jobs.

### Scale:

- 1: short demonstration only
- 2: beyond short demonstration, up to and including 30 days
- 3: more than 30 days, up to and including 3 months
- 4: more than 3 months, up to and including 6 months
- 5: more than 6 months, up to and including 1 year
- 6: more than 1 year, up to and including 2 years
- 7: more than 2 years, up to and including 4 years
- 8: more than 4 years, up to and including 10 years
- 9: more than 10 years