Abstract.

Flexibility is of great interest to policy makers and in the popular policy debate, unions are believed to be a main impediment to achieving it. However, these beliefs are not based on firm empirical foundations. Using a new dataset on U.S. three digit manufacturing industries from 1971 – 1994, we quantify, for the first time, Stigler's concept of output flexibility, estimate input flexibility and quantify the effects of unionization on both. We find that on average unionization reduces input flexibility by about 50%, raises average costs by about 3% but reduces output flexibility by just 0.35%.

JEL codes: J5, L2, L6

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I. Introduction.

Over the past thirty years, OECD countries have adopted a variety of policies to promote flexibility in the labor markets. It is commonly believed that one of the main impediments to better functioning labor markets arises from specific wage-bargaining institutions, including trade unions. Consistent with this view, the group of OECD countries has agreed, from the 1960s, on general policies aimed at increasing labor market flexibility to adjust to market forces. Such policies focus on reducing labor costs by limiting the wage-productivity gap, balancing the demand for job security with the firms’ demand for economic efficiency, increasing flexibility in working time and limiting the application of rules and regulations (OECD, 1986).

This paper provides the first quantification of the effect of unionization on flexibility. First we explicitly model, in a cost function, two facets of this multidimensional concept. Output flexibility (following Stigler (1939)) is the plant’s ability to expand or contract from its minimum average cost per unit output. Input flexibility is the ease with which plants can adjust inputs in response to price and output changes. Using a new dataset on input consumption, prices, and unionization, for U.S. three digit manufacturing industries across three decades from 1971 - 1994, we estimate cost functions, with and without unionization. The cost functions feature a relatively broad set of margins by which the firm can adjust inputs in response to shocks. We conclude unionization reduces input flexibility by about 50%, but increases average costs by 3% and the slope of the average cost curve at the minimum cost output by just 0.35%.

These results are significant as, though various strands of labor economics suggest various broad effects of unionization on flexibility, this paper provides a first quantification of the total effect. Second, the results suggest that unionization does not reduce output flexibility to the extent suggested in the popular policy debate, although the effects on input flexibility appear
considerable. Finally, the approach we take in the analysis is significantly different in that, inspired by the recent literature on operating margins and on the effects of trade unions, a broader range of results are compiled.

The U.S. manufacturing industry over the last three decades provides a particularly good case study in which to evaluate the effects of unionization on flexibility. This period has notoriously witnessed a sharp decline in US trade unionism and a rapid change in trade regimes towards more competitive markets. In particular, increasing pressure of both domestic and international competition and, as suggested by the labor economics literature, falling unionization rates should raise output flexibility. A cross industry study is particularly suitable for analyzing this problem. Labor policy changes are typically economy wide – so general evaluation is required. Furthermore, particular industries vary both in their exposure to these changes and the ability to respond. So, the information from the study of a single industry is limited.

It is important to incorporate in the analysis the broad range of margins which the firm can adjust (and unions affect) in response to price and demand shocks. First, in the short run output may be adjusted by using a range of margins of adjustment including labor margins such as employment and overtime, but also inventories and more traditional input margins (Ramey (1989), Topel (1982)). Second, an abundant empirical literature has shown trade unions influence employment levels, overtime, productivity, work rules just to name a few, all of which directly impact upon the costs of production (Mayshar and Halevi (1997), Eberts and Stone (1991), Earle and Pencavel (1990)). The cost function depends on both the levels of margins of adjustments and the adjustment costs associated with changes from these levels (Ramey (1989), Bresnahan
and Ramey (1994)). By explicitly modeling the firm’s choice of different margins, this paper directly analyzes the impact of trade unions on short-term flexibility.

The rest of the paper is organized as follows. In section two the notion of flexibility is reviewed and the concepts of output and input flexibility are made more precise by drawing on the operating margins literature. Then the large empirical literature on what unions do is drawn on to suggest the effects of unionization on flexibility. Section three develops the theoretical model within which input and output flexibility are formalized, and outlines the adjustments required for estimation. Section four presents the data. Section five contains the estimation results. Section six concludes the paper.

II. What is Flexibility?

As the OECD (1986) publications illustrate, it is not difficult to understand why the term “labor market flexibility” has been at times obscure and incoherent. Labor market flexibility is a multidimensional concept that in general measures the ability of an economic system to rapidly respond and adjust to shocks. Thus, in some contexts, labor market flexibility has meant the ability to adjust labor costs and employment conditions to improve economic efficiency. In recent times the demand for flexibility has translated into a demand for new work practices and patterns, which aim to increase physical and functional mobility of labor and to relax job security regulation (Hamermesh, 1993).

From a microeconomic perspective, flexibility measures the ability to deal with all forms of turbulence in the firm’s environment – primarily, but not only, demand fluctuations (Carlsson, 1989). In a pioneering paper Stigler (1939) explored the notion of output flexibility by associating it with the shape of the cost curves. For flexibility Stigler meant the possibility for the firm to be passably efficient over a range of probable output as “were it not for flexibility
built into plants, output in excess of optimum would involve prohibitive marginal costs” (Stigler (1939, p. 316)).

Figure 1 illustrates output flexibility as defined by Stigler. Two technologies are summarized by the average cost curves AC and AC’. If the firm believes its probable outputs lie between w and z then technology AC’ is preferable. But if the range of probable outputs lies between a and b, then technology AC may well be preferable as, on average, average cost (or as specified by Aranoff (1992) the expected average cost) may be lower. For cost curves as depicted by Stigler, flexibility is measured by the slope of the average cost curve around its minimum point (Marshak and Nelson, 1962). Though the choice of the degree of flexibility is discussed in Marshak and Nelson (1962) and later work by Mills (1984) and Hiebert (1989), output flexibility is left effectively unspecified as a variable – at best specified as the parameter on q$^2$ in the cost function. Note an important feature of this characterization is that flexibility is not determined solely by the production technology of the firm but is also determined by prices.

Of course fluctuations in demand represent only one aspect of the environment of firms that calls for flexibility. By elaborating on Stigler’s notion to include other sources of turbulence, Jones and Ostroy (1984) defined flexibility as “a property of initial conditions”, meaning the possibility to move to various “second period positions”. The notion of flexibility is complicated by the awareness that a system’s adjustment to shock may differ depending on whether the event is foreseeable or unforeseeable (Klein, 1984). Thus Klein’s Type I flexibility refers to the firm’s positioning itself in such a way it can provide a short-term response to risk. Type II flexibility instead refers to the firm’s ability to make good use of “newly disclosed opportunities” that arise by unprogrammable change in market conditions, for instance due to advances in technology.
Having in mind that the time frame used to adjust to market changes affect the type of adjustment the plant is able to make, Gustavsson (1984) distinguishes between the operational or short-term flexibility, the tactical or medium-term flexibility and the strategic or long-run flexibility. Operational flexibility and tactical flexibility are similar to the extent that both can be used to adjust the production level in front of unexpected changes.²

It should be evident that, although there is no one-to-one correspondence between the various notions of flexibility, Stigler’s characterization of a flexible plant would belong to Klein’s Type I flexibility and to Gustavsson’s operational or tactical flexibility. It is these notions of flexibility, output flexibility from now on, that is the first notion of flexibility that we will refer to.

Even so, this discussion does not seem to capture any sense of flexibility in allocating inputs – which is of great interest to both the firm and union. To introduce input flexibility, we draw upon recent work by Bresnahan and Ramey (1994) who identified several margins by which inputs at an automobile producer could be adjusted to yield greater output. Output can be increased by altering each of these margins and cost minimization is achieved by using the lowest cost margin to be adjusted. This is captured by output flexibility as described above. But, the operating margins literature is also suggestive of a second type of flexibility – input flexibility – in response to input price changes, rather than changes in output. In particular, the greater the ability of the firm to adjust each of these margins in response to price changes, the greater the input flexibility of the firm. The natural measure of input flexibility is the price elasticity of demand for each margin. There is a general empirical literature on issues associated with some of the margins that will be considered in this paper (Bils (1987), Hamermesh (1993),
Ramey (1989), Topel (1982)), but most of this literature does not consider the effect of trade unions on their adjustment. It is to the labor literature that we turn to for further assistance.

A. What Do Trade Unions Do (To Flexibility)?

To our knowledge there has not been a direct theoretical analysis of the effect of unionization on output flexibility – though there has been empirical work on the effects of unionization on some of the margins considered in this paper. It was traditionally believed that the main effect of unions was to increase wages and this result has been well-established (see Lewis (1986) for an extensive survey of the U.S. literature). The wage effect seems to vary across industries and has not varied systematically with the perceived strength of unions (Pencavel, 1991). Consistent with the empirical regularity on union wage effects, unionized plants tend to have lower employment (see Booth (1995) for a review of this literature) and higher capital-labor ratios (Brown and Medoff, 1978). This reflects the firm’s ability to adjust the use of different margins as their relative price changes. Hoxby (1996) and Eberts and Stone (1991) also find evidence of input allocation effects.

The resulting effects on labor productivity follow less straightforwardly from microeconomic theory and the conflicting evidence in the empirical literature reflects this (Brown and Medoff (1978), Clark (1980), Eberts and Stone (1991), Hoxby (1996) and in particular Freeman and Medoff (1984) for the main production function studies). It is suggested that unions may directly reduce productivity through work rules and the like (Eberts and Stone, 1991) While most studies report trade unions having positive effects on productivity, this result has been contrasted with a perceived negative influence of unionism on total factor productivity (Hirsch and Link, 1984).
Unionization directly impacts upon costs of production and adjustment costs by affecting the non-wage component of labor earnings. Plants with unions tend to have higher labor fixed costs, such as pensions and health benefits (Freeman and Medoff, 1984) and other fringe benefits (Trejo, 1993). Fixed costs of employment encourage firms to seek adjustments in the labor inputs first by changing hours of work per employer rather than by hiring and firing workers. As surveyed by Trejo (1993), unionized workers work longer hours, although they often receive compensating higher wages for this (Earle and Pencavel, 1990). Furthermore, the higher regular hours worked by union workers, as a result of higher fixed costs, increase the likelihood that extra hours would be the more expensive overtime hours. Using the 1985 May CPS, Trejo (1993) finds that unionization results in less overtime, lower overtime hours and a greater premium, though compliance may vary over time.  

Of great relevance to output flexibility is the empirical literature on how unionization affects the adjustment of these margins and their price. There is evidence that unionism tends to reduce the responsiveness of wages to changes in the demand level, for instance during the business cycle (Pencavel, 1991). Furthermore, trade unions affect employment adjustments. For instance, unionization increases the use of layoffs (defined as suspensions without pay initiated by the employer and lasting or expected to last more than seven days) (Freeman and Medoff, 1982 and 1984). Unions also reduce quits and discharges and the probability of new hires while increasing the probability of recall following temporary layoffs. This suggests that unions reduce hour adjustments relative to employment adjustments, but this evidence is not conclusive.  

Similarly, on hours, unions have been found to affect the premium paid for extra shifts – there is no legally required shift premium, which creates an even greater role for unions to play in bargaining for this premium. Kostiuk (1990) finds the gross premium for shift-work was not
large, but it becomes more substantial after controlling for labor quality differences. Furthermore, Kostiuk documents that the premium to union workers, excluding non-high school graduates, at least doubles that for non-unionized workers.

To summarize there is considerable evidence of the unions’ adjusting the prices of the various margins available to the firm. Output flexibility, as defined by Stigler, as well as being intuitively appealing, provides a framework within which the effect of unions can be analysed. In particular, flexibility may be reduced by non-linear pricing of labor, resulting from union bargaining, along the different margins to produce additional output. Likewise, input flexibility may also be affected by union bargaining. What we do not know is how much, if any, input and output flexibility the plant loses as a result of unionization.

III. The Modeling and Estimation Strategy.

To quantify the effect of unionization on flexibility, we specify a cost function that both captures the effects of unionization and yields estimable input demand equations. Because the empirical literature suggests unions affect both the prices of the different margins, and the technology (through work rules etc.), we work with a cost function. In particular, we derive a system of estimable input demand equations, from which we extract estimates of demand elasticities and average cost curves. Extracting structural parameters, though, requires extending an earlier result of Ramey (1989).

A. The Cost Function for a Non-Unionized Plant.

As in the earlier theoretical literature on output flexibility, we begin with a plant cost function that is quadratic in output (Marschak and Nelson, 1962). Unlike the earlier literature, a set of inputs is also specified – energy, employment, overtime hours, raw materials and inventories, while capital is specified as a fixed input. In this framework, output flexibility is
determined both by the prices of adjusting each margin and the technological parameters of the plant. The general form of the plant cost function is \( C = C(p; k, q) \), where \( p \) is the 5x1 vector of input prices for the five margins, \( k \) is the capital stock of the firm, and \( q \) the output of the plant.

There are two non-standard features of this cost function - the different margins of labor and, second, inventories. Employment (number of production workers) and overtime hours are included separately in the cost function for three reasons. First, the price differs across the margins of adjustment. The price of employment is equal to the product of the hourly wage for standard hours and the weekly standard hours per worker. Overtime hours, by law, are paid at a premium of at least 50% over the standard hourly rate. Second, the productivity and even the nature of tasks of overtime and standard hours may be different (Hart (1987, p102-104). Third, unions have distinct effects on each margin.

Inventories are included in the cost function for, as argued by Ramey (1989), in the short run firms can draw on inventories to respond to short run changes in demand, rather than adjusting other factors. Hence, inventories, including raw materials and work-in-progress and finished goods, are treated as a factor of production and included in the short-run cost function.

We follow Ramey (1989) in characterizing the plant cost function by a Generalized McFadden (GM) restricted cost function. The plant GM cost function can, with a few additional assumptions, be estimated from aggregate data. As we introduce unionization systematically into the cost function, these aggregation properties are useful for us. Then Shepherd’s Lemma can be applied to specify input demand equations. This yields a system of equations from which demand elasticities and average cost equations can be compiled. Importantly, estimating a cost function avoids the problems with using a profit equation as assumptions do not have to be made
on the degree of market power. Plants minimize costs conditional on output, regardless of market structure.

The restricted Generalized McFadden cost function is as follows:

\[
C_i = \sum_{j=1}^{s} \left( \alpha_j + \tau_{uj} t \right) p_j + Q_i \left\{ \sum_{k=2}^{s} \sum_{j=2}^{s} \gamma_{kj} \frac{p_k p_j}{2p_1} + K_i \sum_{j=1}^{s} \kappa_j p_j + \sum_{j=1}^{s} \left( \tau_{1j} t + \tau_{2j} t^2 \right) p_j \right\} 
+ Q_i \sum_{j=1}^{s} \theta_j p_j + \sum_{j=1}^{s} \epsilon_{uj} p_j
\]

(1)

where \( Q_i \) is firm output and \( t \) is a time trend, introduced to capture technological change. One feature of this functional form is that one input is treated asymmetrically, in this case, energy. Applying Shephard's Lemma yields a set of five demand equations. For the \( i \)th plant the energy demand equation is:

\[
E_i = \alpha_1 + \tau_{u1} t - Q_i \left\{ \sum_{k=2}^{s} \sum_{j=2}^{s} \gamma_{kj} \frac{p_k p_j}{2p_1} - K_i \kappa_1 - \tau_{11} t - \tau_{21} t^2 \right\} + \theta_i Q_i^2 + \epsilon_{u1}
\]

(2)

For the other four inputs (\( n = 2 \) (employment), 3 (overtime hours), 4 (raw materials) and 5 (inventories) the demand equation takes the following form:

\[
X_{in} = \alpha_n + \tau_{un} t + Q_i \left\{ \sum_{j=2}^{s} \gamma_{nj} \frac{p_j}{p_1} + K_i \kappa_n + \tau_{1n} t + \tau_{2n} t^2 \right\} + \theta_i Q_i^2 + \epsilon_{un}
\]

(3)

B. The Cost Function for The Unionized Firm.

The empirical literature on unionization suggests unionization affects the cost function in the following ways:

1. Unionized workers receive a premium on the standard hourly wage
2. Unionized workers are more likely to receive at least the legal overtime premium
3. Unionized workers receive greater premium for later shifts
4. Productivity of unionized workers may differ from non-unionized workers.
These effects are captured in the cost function by introducing a set of union premium coefficients, \( \mu_\alpha, \mu_\gamma, \mu_\kappa, \mu_\theta \). These premium coefficients combine both price and technological effects, as permitted by the data. The cost function is as follows:

\[
C_i = \sum_{j=1}^{5} (\kappa_j + \mu_{\alpha j} + \tau_{\alpha j} t_j) p_j + \sum_{k=2}^{5} \left[ \sum_{l=2}^{5} (\eta_{ij} + \mu_{\gamma j} \eta_{ij}^2) \frac{p_k p_j}{p_i} + K_i \sum_{j=1}^{5} (\kappa_j + \mu_{\kappa j}) p_j \right] + Q_i \left[ \sum_{j=1}^{5} (\tau_{1 j} + \tau_{1 j}^2) p_j \right] + Q_i \sum_{j=1}^{5} (\theta_j + \mu_{\theta j}) p_j + \sum_{j=1}^{5} \epsilon_j p_j
\]

Input demands for the unionized plant are derived once again using Shephard's Lemma and are of the same form as the set of equations (2) – (3), with the addition of the premium terms. Note, there is an implicit assumption that a plant is either unionized or non-unionized. This is broadly consistent with the institutional arrangements for U.S. production workers – though it would be less appropriate for a more general set of workers or for plants in the U.K. or Australia where craft unionism is more widespread.

C. Aggregation: The Industry Model.

Ideally, we would then estimate this model on plant level data. However, plant level data matched up with unionization status does not exist. Hence we work with detailed industry level data described in section IV. The next step is then to aggregate the plant model to an industry model.

If assumptions (A.1) to (A.4), stated below, hold, then plant input demand equations, derived from a Generalized McFadden cost function, can be estimated using aggregate industry data (Ramey, 1989).

(A.1) The plant specific component of the error term is distributed independently across plants. The average of the error term across plants is thus equal to an industry specific error component.

(A.2) Firms face identical input prices.
(A.3) The variance of output $\sigma^2_Q$ is constant across firms within each industry.

(A.4) The covariance of output and capital across firms $\sigma_{Q,K}$ is constant within each industry.

However, we are aggregating across two types of plants – unionized and non-unionized. So additional assumptions are required for estimation from industry data. In particular, if in addition assumptions (A.5) to (A.6) stated below hold, then unionized and non-unionized plant demand functions are estimable from industry data.

(A.5) The variance of output and the covariance of output and capital in the unionized sector of the industry, $\sigma_{Q,U}, \sigma_{Q,K,U}$ respectively, are constant within each industry.

(A.6) $Q_U = sQ, K_U = sK, N_U = sN$, where $s$ is the share of employment in unionized firms where $Q$ is industry output, $K$ is industry capital and $N$ is the number of plants in the industry and $Q_U, K_U$ and $N_U$ are the relevant aggregates across unionized plants.$^6$

Before stating the system of demand equations for estimation, two further complications must be dealt with. First, we do not have separate estimates for the share of unionized plants in the industry and the share of unionized workers in the industry, $s_N$ and $s$ respectively. Thus we estimate $s$ and assume that the two are equal so their ratio cancels out. Second, aggregation yields, in each demand equation, a set of constant terms that cannot be separately identified upon estimation. Hence we estimate a set of structural and reduced form parameters, as demonstrated in the set of equations (5) - (6). All structural parameters retain the notation introduced in the previous sections. Reduced form parameters, resulting from merging the constants with the industry fixed effects, are denoted $\beta_{n,m}$ where $n$ indexes the equation and $m$ the reduced form parameter in the $n^{th}$ equation. Once again, there are two types of demand equations for estimation. In particular, suppressing the industry and time subscripts, for energy, the estimable demand equation is:
\[ \bar{E} = \alpha_1 + \tau_{x_1} \bar{t} + \mu_{x_1} \bar{s} - \bar{Q} P_1 (\gamma_1) I^t - P_1 (\mu_{p_1}) I' \bar{t} \bar{Q} + \kappa_1 \bar{Q} \bar{K} + \mu_{x_1} \bar{s} \bar{Q} \bar{K} + \theta_1 \bar{Q}^2 + \mu_{x_1} \bar{s} \bar{Q} + \tau_{x_1} \bar{t} \bar{Q} + \tau_{21} t^2 \bar{Q} + \beta_{11} D_n + \beta_{12} D_n s + \nu_1 \]  

(5)

For the other four inputs, the input demand equations take the form of:

\[ \bar{X}_n = \alpha_n + \tau_{x_2} \bar{t} + \mu_{x_2} \bar{s} + \bar{Q} P_n (\gamma_n) I^t + P_n (\mu_{p,n}) I' \bar{t} \bar{Q} + \kappa_n \bar{Q} \bar{K} + \mu_{k,n} \bar{s} \bar{Q} \bar{K} + \theta_n \bar{Q}^2 + \mu_{x,n} \bar{s} \bar{Q}^2 + \tau_{1n} t^2 \bar{Q} + \tau_{2n} t^2 \bar{Q} + \beta_{1n} D_n + \beta_{2n} D_n s + \nu_n \]  

(6)

where the upper barred variables are industry-specific per plant averages, \( n=2,3,4,5 \) indicates the \( n \)th input, and \( D_n \) takes the value one if the relevant industry is considered.

Furthermore, \( P_n (\gamma_n) = \frac{\gamma_{nj} P_j}{P_1} I_{j=2}^5 \) is a 1x4 row vector of prices in the demand function of the \( n \)-th margin, \( n=2,3,4,5 \), \( P_1 (\gamma_1) = \frac{\gamma_{kj} P_j P_k}{2(P_1)^2} \) with \( j=2,\ldots,5 \) and \( k=2,\ldots,5 \) is the row vector of prices in the demand function for energy, and \( I \) is a vector of ones (1x10 for equation (5), 1x4 for the set of equations (6)). \( P_n (\mu_{p,n}) \) and \( P_1 (\mu_{p,1}) \) are defined similarly with the union premiums replacing the \( \gamma_s \).

IV. The Data.

The system of input demand equations derived in the previous section are estimated using an unbalanced panel of three digit manufacturing industries (Census Industry Classification) from 1971 – 1994 for the U.S. The data is collected by the authors, mostly from four sources: (1) NBER Productivity Database (Bartelsman and Gray (1996), Bartelsman, Becker and Gray (1998)) – compiled from the U.S. Annual Survey and Census of Manufactures; (2) Current Population Survey (CPS) (Bureau of Labor Statistics, 1999); (3) Employment and Earnings (Bureau of Labor Statistics, various) and (4) County Business Patterns (U.S. Census Bureau).

For 1971 – 1978, the May CPS was collected from the NBER web site and for 1979 – 1997,
outgoing rotations were purchased from Unicon (Current Population Surveys, 1979 – 1997)). For a complete account of dataset construction see Magnani and Prentice (2000). In section A, the variables and their definitions are presented. Then, issues relating to their construction are discussed.

A. Definitions and Sources.

In Table 1, the dependant variables and their sources are presented. In Table 2, the explanatory variables and their sources are presented. Then construction of the estimates of unionization rates and reconciling the different industry classification schemes across sources and over time are discussed.

[Tables 1 and 2 Here]

There are two central problems in constructing this dataset. First, unlike other variables industry unionization rates are not collected by a central authority. Second, the four main sources are not compatible in terms of industry classifications.

To construct industry unionization rates, we built on earlier work which constructed what have been standard sources for estimates. For industry unionization rates from 1971 to 1972, we use earlier estimates of union coverage by Freeman and Medoff (1979) compiled from the pooled BLS 1968, 1970 and 1972 Expenditures for Employee Compensation surveys. For 1973 – 1981, we use annual estimates compiled by Freeman and Medoff (1979) and Kokellenberg and Sockell (1985), computed from pooled May CPS (the only round including a union membership question). For 1983 – 1994, we estimated annual rates directly from the outgoing rotations of the CPS (each of which included a union coverage question). Estimates of rates based on the membership question were scaled to be compatible with the earlier and subsequent union
coverage rates. There are other small coverage differences between the sources. The estimates for 1981 and 1982 are obtained by interpolation.

The second problem is reconciling the data from the four sources. Incompatibilities arise for two reasons. First, the CPS three digit industries are compiled according to the Census Industry Classification (CIC) while industries in the other sources are compiled according to the Standard Industrial Classification (SIC). Second, the two classifications change three times during the period. Each of the three CICs during the period are constructed from a contemporary SIC. Aggregation and matching though is complicated by the considerably different dates at which each classification was changed. For example the CIC used in 1982 was based on the 1967 SIC, which had not been used for at least five years in any of the other sources. These problems were resolved in two steps. First, we constructed an extended CIC (ECIC) of 93 industries, based on the three CICs used during the sample period. Industries appearing substantially the same over the period are given one code. New industries and discontinued industries are each given their own codes. Then, we aggregated the data based on the (typically finer) SICs to construct aggregate ECIC industries. Where matching series could not be constructed, mainly due to missing series in Employment and Earnings, these observations were omitted.

The final dataset featured 1472 observations for 105 industries. The extra industries resulted from series for ECIC industries not being compatible across periods e.g. before and after 1983 when the CIC switched from being based on the 1967 SIC to the 1972 SIC. As presented in Magnani and Prentice (2000), the series has a good coverage of industries and periods. Each year features between 52 and 67 (out of 93) ECIC industries. Sixty three industries are in the sample for at least half of the periods. Finally, there is also a good sample of high and low unionization
rate industries, both in cross section and over time. Table 3 presents the summary statistics of the data.

[Table 3 Here]

V. Estimation results.

We estimate two versions of the model. Model one (set of equations (5)-(6)) features three margins of adjustment available at the plant level, namely total employment level $L$, energy $E$ and total overtime hours $O$. Model two features all margins of adjustment.\(^7\) We estimate each system using Three-Stage-Instrumental-Variables. As well as the exogenous variables in the system we include instruments for wage rates (following the labor literature) and shipments (following Ramey (1989)).\(^8\) The only restrictions imposed on the equation are those required for symmetry across equations.

First we note that the cost functions satisfy the usual test for concavity in input prices for a GM cost function.\(^9\) However, as the coefficients are numerous and not always immediately interpretable, we focus on the elasticities. The elasticities are calculated at the sample average for all explanatory variables, including shipments, capital. The Non-Unionized elasticities are calculated with $s$, the unionization rate, set equal zero. The elasticities under unionization are calculated with $s$ set equal to the sample average. These are summarized in Table 4.

[Table 4 here]

First, note that in all but one insignificant case the own price elasticities have the correct sign. In addition, the elasticities do not seem to differ greatly across the two models. Relatively few of the coefficients in model two were significant, but explanatory power remained high suggesting multicollinearity is a problem. Hence, standard errors for the elasticities were not calculated for model two. For model one, standard errors could be calculated for all but three cases (one not reported).\(^{10}\) For the two labor margins all price elasticities were significantly
different from zero. Next, as well as discussing the elasticities in more detail we focus on two measures of short-term flexibility, namely input flexibility, i.e., the ability of the plant to adjust the use of a given margin in front of price changes, and output flexibility, the ability of the firm to contract or expand the output level without incurring a prohibitive cost increase. The greater the own price elasticity of demand, the greater the input flexibility. The smaller the slope of the average cost curve around its minimum point, the greater the output flexibility.

A. Unionization and Input Flexibility.

Table 4 demonstrates unionization is consistently associated with smaller elasticities of demand. In particular, nearly all price elasticities under unionization are about half the size of those calculated with zero unionization. With input demand elasticities with respect to output, the results are a bit more mixed. In general, though, unionization is associated with less input flexibility. Next, we discuss each set of elasticities in more detail.

First consider the elasticities for the demand for employees. The demand for employees negatively responds to a rise in its own price and increases with overtime wage. Indeed, the own price elasticities with no unionization are much larger than in earlier studies (see Hamermesh (1993: Tables 3.2, 3.3)), while the own price elasticity of employment under unionization is comparable to those found in other studies that have used equation systems. For instance, in model one a 10 percent increase in the wage per employee lowers the demand for workers by 13.5 percent without unionization, and by 4.8 percent with unionization. The large size of these elasticities is plausible as the cost function features the relatively close substitutes of employment and overtime. The elasticities of employment demand to output are positive and they are bigger in size under unionization. This finding is consistent with union preferences for
high employment levels. A 10 percent increase in unionization increases employment by between 2.0 percent (in the five-margin model) and 3.8 percent (in the three-margin model).

Next, consider the elasticities of demand for overtime hours. The own price elasticity of demand for overtime resulting from the estimation of the five-margin model is –0.86 (with zero unionization) and –0.36 under unionization. Interestingly these results are consistent with recent estimates of the price elasticity of demand, obtained from individual data, for daily overtime by Hamermesh and Trejo (2000) who find an elasticity of –0.5. The smaller elasticities under unionization reflect the more constrained environment in which unionized plants operate, particularly when it comes to substitute away from labor. The negative overtime elasticity with respect to output may indicate that because of the high price of overtime, the firm substitutes away from this margin when the normal output level increases to choose less expensive margins, e.g., regular employment. The elasticities of overtime with respect to unionization are negative in all specifications. As unionization raises the probability that the firm will pay entirely the 50 percent premium for overtime labor services (Trejo, 1993), under unionization this margin is less likely to be used. In particular, a 10 percent increase in unionization decreases the demand for overtime by 1.8 percent in the five-margin model and by 3.5 percent in the three-margin model.

Finally, consider the demand elasticities for energy, inventories and raw materials. Energy appears to be a complementary input with respect to regular labor services, raw materials and inventories, but it is substitutable with overtime hours. A comparison of the results obtained with the three margins model and with the five margins model shows that the own and cross price elasticity of energy are much larger in model two than in model one, reflecting the availability of a wider set of margins to substitute for in the five margin model. In both models, the demand for energy increases with the output level and more so under unionization, a fact that
reflects a higher capital-labor ratio. Unionization increases the demand for energy and much more so in the five-margin model. This result may reflect the higher capital labor ratio. Finally output has a positive effect on the demand for raw materials and on the demand for inventories.

In summary Table 4 illustrates the following results:

1. Under unionization there are lower own and cross price elasticities of input demand than with zero unionization. This is consistent with union rules or bargaining resulting in input decisions that are less responsive to changes in market variables. This is particularly the case with respect to adjustments of labor (Freeman and Medoff, 1982).

2. Unionization significantly impacts upon the scale of use of these margins. In particular it increases the use of labor and energy, but lowers the use of overtime, a result that appears to be consistent with unions’ effect on the overtime premium.

3. The results found in this study are largely consistent with the ones reported in previous studies or explainable. This supports the reliability of our findings.

B. Unionization and Output Flexibility.

In this subsection we first derive the expressions that are used to evaluate output flexibility. Then we calculate the slope of the average cost curves at their empirical minimums. We demonstrate that though unionization does reduce output flexibility, the effect is not large.

From the cost function (4) we derive the expression for average costs in the unionized plant:

\[
AC = \frac{\sum_{j=1}^{n} \left((\alpha_j + \mu_{uj})p_j + \delta_j p_j + \tau_{uj} \lambda_j + \varepsilon_j p_j\right)}{Q} + \left\{ \sum_{j=2}^{n} \sum_{j=2}^{n} \left(\gamma_{ij} + \mu_{ij}\right) \frac{p_k p_j}{2p_i}\right\} + K \sum_{j=1}^{n} \left(\kappa_j + \mu_{uj}\right) p_j + \sum_{j=1}^{n} \left(\tau_{1j} t + \tau_{2j} t^2\right) p_j + Q \sum_{j=1}^{n} \left(\theta_j + \mu_{uj}\right) p_j
\]

(7)
where the term $\delta_j$ is the industry-specific fixed effect estimated through the $j^{th}$-factor demand equation. Following Stigler (1939) a measure of flexibility is the slope of the average cost function. Taking the first derivative of average cost yields the following expression:

$$\frac{\partial AC}{\partial Q} = -\sum_{j=1}^{n} \left( (\alpha_j + \mu_{aj} + \tau_{aj}^t) p_j + \epsilon_j p_j \right) Q + \sum_{j=1}^{n} \left( \theta_j + \mu_{\theta j}^t \right) p_j$$

(8)

To measure the impact of unionization on output flexibility the relative slope differential is defined as

$$\left( \frac{\partial AC}{\partial Q} \right)_{\text{unionized}} - \left( \frac{\partial AC}{\partial Q} \right)_{\text{non-unionized}} \right) \div \left( \frac{\partial AC}{\partial Q} \right)_{\text{non-unionized}}$$

. The smaller this ratio the more flexible the technology.

Operationally, we use the estimated coefficients derived from demand functions (5)-(6) (including the fixed effects) and the industry-specific sample averages for capital, prices and time, to simulate average cost for unionized and non-unionized plants. To obtain smooth cost functions, the simulated average costs are then regressed over output and its square using the sample industry-specific time varying data on production levels. Finally, the predicted average costs obtained using the output coefficients are connected to draw the industry-specific curves and to compute the average costs and slope differentials between unionized ($s=1$) and non-unionized plants ($s=0$) for each of the 105 industry groups.

Both earlier work, surveyed in section two, and the computed elasticities suggest the average cost curves of unionized plants would be higher and steeper than those of non-unionized plants. And this was the case, though perhaps not to the extent expected. The simulated average cost functions featured a variety of shapes – downward sloping, upwards sloping and u-shaped. For industries with average unionization rates above 60%, all average cost curves are upward
sloping. For industries with average unionization rates below 30%, there is the greatest variety. Examples of the different types are presented in Figures 2 – 7.

For all industries, the unionized plants had average cost curves above non-unionized plant. Evaluating the differential at the empirical minimum cost output (for the solely upward or downward sloping curves, the output at which average cost was lowest), average cost is between 0.2 and 11 percent higher. On average the cost differential is 3 percent. Next, we compare the relative slope of the average cost curve at the minimum cost output, there is a range of outcomes, from -11 percent to +9 percent. On average, though, the relative slope differential is 0.35 percent. In other words, unionization, on average, reduces output flexibility by about 0.35 percent.

In summary, these empirical results support the hypothesis that trade unions increase per unit costs and make adjusting output more costly. However, both the union-induced loss of output flexibility and the effects on average costs in general seem to be small.

The relatively small effects of unionization on flexibility could be due to three reasons. First, the measures of input and output flexibility are computed at different levels of production. The demand elasticities, for input flexibility are computed at the industry-specific average while output flexibility is calculated at the efficient level of output (over the observed range). The convexity of the cost curve implies that the slope differential is much higher away from such a point.

Second, there are several specification issues that may also result in relatively small differentials between high and low unionization periods. First, we do not control for the quality of labor. There is evidence that union members tend to show higher productivity than a randomly selected group of workers. In a related point, unionization may also have offsetting productivity benefits by reducing turnover and providing better information flows to management - as
highlighted in the exit-voice literature (Freeman and Medoff, 1984). Secondly, we cannot rule out the possibility of reverse causation. For instance, supply-demand models of union organizing activities suggest that low per unit costs, due for instance to technological factors not properly captured by the industry-specific fixed effects, encourage unionization by increasing quasi-rents to be extracted (Abowd and Farber, 1990). In effect, the benefits from greater efficiency are extracted by the union. A third set of reasons is that the relatively small differences would be observed because of union strategies. First, over the sample period, with rapidly declining unionization rates, unions may have agreed to flexibility increasing measures as a way to deter management efforts to fight unions. Indeed there is evidence to suggest unions have changed their strategies (Cobble, 1991). So, we are computing the average over a period with initially high flexibility costs, followed by a decline to relatively low flexibility costs. Finally, though, even a powerful union may not wish to reduce output flexibility. Continuing with the theme that unions extract rents from firms, these rents will be maximized if the firm has the maximum flexibility to increase profits and avoid losses. Sorting between these possible explanations is a problem for future work.

7. Conclusive remarks.

No previous study has addressed the issue of how much rigidity trade unions bring to an economic system. This leaves policy makers of OECD countries with little to substantiate their claim that trade union activities are a source of labor market rigidity. We address this question and provide the first quantification of the effect of unionization on flexibility. First, we define precisely the notions of input and output flexibility within a cost function. The cost function includes a more complete set of margins by which the firm can adjust to meet demand changes, and unions can affect. Second, using a new dataset on three digit U.S. manufacturing industries,
we estimate the effect of unionization on flexibility. We estimate that for the U.S. manufacturing sector, over the last three decades, on average, unionization reduces input flexibility by about fifty percent and at the minimum cost output, raised average costs by about 3% and reduced output flexibility by on average 0.35%.

These findings are subject to some qualifications – unions may have offsetting productivity benefits or they may focus on organizing low cost (high rent) firms. This would result in our work underestimating the effects on costs and flexibility. However, union strategy may focus on extracting rents through affecting input allocation decisions rather than by reducing the potentially rent-maximizing output flexibility. Undoubtedly there are some difficulties in capturing and quantifying a multidimensional concept such as flexibility. But overall, our findings suggest some caution for making substantial policy changes on the basis of a stereotypical image of unionism as a source of labor market rigidity.

References


Magnani, Elisabetta, and David Prentice, “The Unionization Trade and Employment Database”, (Sydney, Australia: University of New South Wales, 2000).


### TABLE 1.—DEPENDENT VARIABLES

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>Cost of Electricity and Fuel (in millions of 1987 dollars).</td>
<td>NBER Productivity Database</td>
</tr>
<tr>
<td>Employment</td>
<td>Annual Average Production Workers Employed.</td>
<td>Employment and Earnings</td>
</tr>
<tr>
<td>Overtime hours</td>
<td>Average Overtime Hours for Production Workers, multiplied by Employment.</td>
<td>Employment and Earnings</td>
</tr>
<tr>
<td>Raw materials</td>
<td>Cost of Materials calculated following Bartelsman and Gray (1996).</td>
<td>NBER Productivity Database</td>
</tr>
<tr>
<td>Inventories</td>
<td>Inventories – end of year – (in millions of 1987 dollars).</td>
<td>NBER Productivity Database</td>
</tr>
</tbody>
</table>

All variables are by industry, and are divided by number of plants, from County Business Patterns.

### TABLE 2.—VARIABLES USED TO CONSTRUCT EXPLANATORY VARIABLES

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wage per worker</td>
<td>Average weekly hours multiplied by average hourly earnings divided by the number of production and related workers.</td>
<td>Employment and Earnings</td>
</tr>
<tr>
<td>Wage per standard hour</td>
<td>Wage per worker divided by total hours + 0.5 overtime hours.</td>
<td>Employment and Earnings</td>
</tr>
<tr>
<td>Wage per overtime hour</td>
<td>Wage per standard hour multiplied by 1.5.</td>
<td>Employment and Earnings</td>
</tr>
<tr>
<td>Price of Inventories</td>
<td>Price of Shipments Deflator (1987 = 1).</td>
<td>NBER Productivity Database</td>
</tr>
<tr>
<td>Price of Raw materials</td>
<td>Calculated following Bartelsman and Gray (1996).</td>
<td>NBER Productivity Database</td>
</tr>
<tr>
<td>Price of Energy</td>
<td>1987 = 1.</td>
<td>NBER Productivity Database</td>
</tr>
<tr>
<td>Shipments</td>
<td>Value in millions of 1987 dollars.</td>
<td>NBER Productivity Database</td>
</tr>
<tr>
<td>Capital stock</td>
<td>Value in millions of 1987 dollars.</td>
<td>NBER Productivity Database</td>
</tr>
<tr>
<td>Unionization</td>
<td>Share of Employed production workers covered by a union agreement.</td>
<td>CPS, Freeman and Medoff (1979), Kokellenberg and Sockell (1985)</td>
</tr>
</tbody>
</table>

All variables are by industry and Shipments and Capital stock are divided by the number of plants, County Business Patterns.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy consumed (millions of $/10)</td>
<td>64.4</td>
<td>99.1</td>
<td>1.41</td>
<td>805.3</td>
</tr>
<tr>
<td>Number of production workers</td>
<td>183.6</td>
<td>176.3</td>
<td>15.5</td>
<td>1064.7</td>
</tr>
<tr>
<td>Overtime (overtime hours per week x production workers)</td>
<td>627.0</td>
<td>610.9</td>
<td>20.04</td>
<td>5349.64</td>
</tr>
<tr>
<td>Unionization rate</td>
<td>0.41</td>
<td>0.20</td>
<td>0.02</td>
<td>1</td>
</tr>
<tr>
<td>Shipments (millions of $/10)</td>
<td>3076.4</td>
<td>3155</td>
<td>175.1</td>
<td>26552.4</td>
</tr>
<tr>
<td>Capital (millions of $/10)</td>
<td>1411.7</td>
<td>1495.7</td>
<td>43.2</td>
<td>7978.2</td>
</tr>
<tr>
<td>Price of energy</td>
<td>0.84</td>
<td>0.32</td>
<td>0.16</td>
<td>1.59</td>
</tr>
<tr>
<td>Wage per employee per standard week/10</td>
<td>31.6</td>
<td>6.8</td>
<td>16.2</td>
<td>56.1</td>
</tr>
<tr>
<td>Wage per overtime hour/10</td>
<td>12.7</td>
<td>2.5</td>
<td>6.9</td>
<td>20.7</td>
</tr>
<tr>
<td>Number of plants</td>
<td>4283</td>
<td>5347</td>
<td>79</td>
<td>35683</td>
</tr>
</tbody>
</table>
### Table 4: Own Price Elasticities of Input Demand, Elasticities of Output and Unionization

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model One (Three Margins)</th>
<th>Model Two (Five Margins)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-Unionized</td>
<td>Unionization</td>
</tr>
<tr>
<td><strong>Employment with respect to:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wage Rate</td>
<td>-1.35*</td>
<td>-0.48*</td>
</tr>
<tr>
<td>Overtime Rate</td>
<td>1.37*</td>
<td>0.49*</td>
</tr>
<tr>
<td>Output</td>
<td>0.03</td>
<td>0.06*</td>
</tr>
<tr>
<td>Unionization</td>
<td></td>
<td>0.38</td>
</tr>
<tr>
<td><strong>Overtime with respect to:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overtime Rate</td>
<td>-1.01*</td>
<td>-0.37*</td>
</tr>
<tr>
<td>Wage Rate</td>
<td>1.00*</td>
<td>0.36*</td>
</tr>
<tr>
<td>Output</td>
<td>-0.13*</td>
<td>-0.08*</td>
</tr>
<tr>
<td>Unionization</td>
<td></td>
<td>-0.35</td>
</tr>
<tr>
<td><strong>Energy with respect to:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Own Price</td>
<td>-0.06</td>
<td>-0.04</td>
</tr>
<tr>
<td>Wage Rate</td>
<td>-2.37</td>
<td>-1.10</td>
</tr>
<tr>
<td>Overtime Rate</td>
<td>2.43</td>
<td>1.13x</td>
</tr>
<tr>
<td>Output</td>
<td>0.07</td>
<td>0.06x</td>
</tr>
<tr>
<td>Unionization</td>
<td></td>
<td>1.51</td>
</tr>
<tr>
<td><strong>Raw Materials:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Own Price</td>
<td></td>
<td>-0.76</td>
</tr>
<tr>
<td>Output</td>
<td></td>
<td>0.37</td>
</tr>
<tr>
<td><strong>Inventories:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Own Price</td>
<td></td>
<td>-0.11</td>
</tr>
<tr>
<td>Output</td>
<td></td>
<td>0.97</td>
</tr>
</tbody>
</table>

Note: * significant at 5% x: unable to calculate standard error.
Stigler’s (1939) definition of a flexible technology: the ability of a plant to be efficient (low average costs) over the range of probable outputs. The technology represented by AC is efficient over the output range a-b. The technology AC’ is efficient over the range w-z.
**Figure 2.** Low Unionization Industries. Average Cost Curves With and Without Unionization for Industry Group 6 (Furniture and Fixtures, Unionization Rate: 0.19)

**Figure 3.** Low Unionization Rate Industries. Average Cost Curves With and Without Unionization for Industry Group 51 (Miscellaneous Manufacturing Industries, Unionization Rate: 0.18)
FIGURE 4.– MEDIUM UNIONIZATION RATE INDUSTRIES. AVERAGE COST CURVES WITH AND WITHOUT UNIONIZATION FOR INDUSTRY GROUP 14 (FABRICATED STRUCTURAL METAL PRODUCTS, UNIONIZATION RATE: 0.39)

FIGURE 5.– MEDIUM UNIONIZATION RATE INDUSTRIES. AVERAGE COST CURVES WITH AND WITHOUT UNIONIZATION FOR INDUSTRY GROUP 8 (CEMENT, CONCRETE, GYPSUM AND PLASTER PRODUCT, UNIONIZATION RATE: 0.49)
Figure 6.— High Unionization Rate Industries. Average Cost Curves with and Without Unionization for Industry Group 95 (Tanned, Cured and Finished Leather, Unionization Rate: 0.78)

Figure 7.— High Unionization Rate Industries. Average Cost Curves with and Without Unionization for Industry Group 41 (Railroad Locomotives and Equipment, Unionization Rate: 0.72)
Footnotes.

1. Output flexibility has since then been discussed mainly in the context of a theoretical debate on the effect of price variability on profitability (see Hiebert (1989) for the most recent contribution).

2. In particular, operational flexibility implies changes in sequencing and scheduling of production to accommodate sudden shortages of raw materials or parts or to satisfy a rush order. Tactical flexibility enables the firm to deal with changes in the rate of production or in product mix over the course of the business cycle (Gustavsson, 1984).

3. The minimum overtime premium of 50 percent is set by the Fair Labor Standards Act. However, as there is substantial noncompliance (Trejo, 1993) unions act to enforce and bargain for higher premiums.


5. Eberts and Stone (1991) argue that because the firm and union bargain over work conditions, it is not appropriate to model the firm as a strict cost minimizer. However, this argument only holds for a general simple cost function. The firm can be thought of minimizing a restricted cost function, with the restrictions from the agreement with the union, much as the firm can minimize a restricted cost function, when capital or another input is the constraining factor.

6. Note aggregation takes place across quantities e.g. employment. Averages are then obtained by dividing the aggregates by the total number of plants. Workings are available in an appendix available from the authors.

7. Both model one and model two exclude (because of collinearity problems) the dummy variables that interact with s that appear in equations (5)-(6).
8. For the wage rate we use as instruments industry-specific workforce characteristics such as average age, the average years of education, the proportion of workers older than forty, the proportion of workers younger than thirty, the proportion of female and black employees, all compiled from the CPS. For shipments, we use the instruments suggested by Ramey (1989) – measures of defense expenditure, price of crude oil and political dummies.

9. In particular, the principal diagonal of the matrix of second derivatives of the cost function (as specified in Diewert and Wales (1987)) has all negative terms.

10. All problematic (negative) standard errors were for off-diagonal unionized elasticities, for which the standard properties are not guaranteed.