NBER WORKING PAPER SERIES

EFFICIENT CONTRACTS WITH COSTLY ADJUSTMENT: SHORT-RUN EMPLOYMENT DETERMINATION FOR AIRLINE MECHANICS

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Working Paper No. 1931

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
May 1986

I am grateful to Robert LaLonde for his assistance in gathering the data in this paper, and to Orley Ashenfelter, Jim Brown, John Pencavel, John Taylor, and an anonymous referee for comments on earlier drafts. The research reported here is part of the NBER's research program in Labor Studies. Any opinions expressed are those of the author and not those of the National Bureau of Economic Research.

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ABSTRACT

This paper presents an empirical analysis of firm-specific employment and wage outcomes for mechanics in the domestic airline industry. A dynamic contracting model is presented that incorporates both costly employment adjustment and potential gaps between contract wage rates and the opportunity value of workers' time. The model gives a useful description of the employment-output linkage in the data, but is less successful in capturing the dynamic relation between employment, contract wage rates, and wage rates outside the airline industry.

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The search for a credible interpretation of observed employment patterns has lead to widespread interest in the notion of efficient labor contracts.[1/] In contrast to traditional auction models of the labor market, which relate fluctuations in employment directly to changes in wage rates, contracting models permit a more flexible link between wage payments and employment determination. According to the simplest version of the efficient contracting hypothesis, in fact, the level of employment maximizes the joint income of workers and the firm, while the level of wages represents a pure transfer between them. If this "strong form" efficiency hypothesis is correct, then it calls into question a wide variety of policy conclusions based on the assumed distortionary effects of union wage differentials and short-term wage rigidities.[2/]

A simple test of the efficient contracting hypothesis is provided by a firm-level employment equation that includes both the wage rate at the firm and some measure of the alternative wage available to workers.[3/] According to the strong form efficiency hypothesis, the joint income of workers and the firm is maximized when the marginal value product of labor equals its outside opportunity wage. If this hypothesis is correct, employment is independent of firm-specific wage rates and depends only on the alternative wage rate. In the traditional labor demand model, by comparison, the firm's profits are maximized when the marginal value product of labor equals the firm-specific wage. If this model is correct, then employment is independent of alternative wage rates and depends only on the firm's wage rate. Finally, in a general contracting model, labor is allocated between outside opportunities and contract employment on the basis of a shadow value that varies with both firm-specific and alternative wage rates.

In a dynamic setting, however, tests of even simple efficient contract models are complicated by the fact that alternative wage rates may help to predict future contract wage rates. Suppose for example that employment adjusts toward a target level that depends on a weighted average of future contract wage rates. In this case, even if desired employment is independent of alternative wages, current and lagged alternative wages rates may enter the employment equation as predictors of future contract wages.

In a dynamic model it is therefore necessary to sort out two competing routes for the alternative wage to influence the level of contract employment: (i) directly, through the appropriate expression for the shadow value of labor; and (ii) indirectly, through the statistical link between current alternative wage rates and expected future contract wage rates.

This paper presents an empirical analysis of the potential links between wage rates and employment for mechanics in the domestic airline industry. The data consist of quarterly observations on employment, output and wages for seven major airlines, drawn from the period prior to deregulation of the industry. Wage rate information is taken from union contracts covering mechanics at each of the seven airlines, while employment and output data are taken from Civil Aeronautics Board records.

The first section of the paper presents a preliminary analysis of the data using unrestricted vector-autoregressions. The analysis reveals a striking similarity between the serial correlation properties of these micro-level data, and the properties of more familiar aggregate data. The analysis also shows that aggregate manufacturing wage rates are an important determinant of both employment levels and wage rates for airline mechanics. On the assumption that the manufacturing wage rate represents the alternative wage rate for airline mechanics, the observed link between mechanics' employment and manufacturing wages can be attributed either to efficient contracting considerations, or to the fact that manufacturing wages help predict future contract wage rates, or both.

The second section of the paper presents a simple intertemporal contracting model in which it is possible to disentangle these two effects. The model assumes that employment and wages are selected to minimize the cost of aircraft maintenance, subject to a utility constraint for mechanics. Adjustment costs are introduced on the firm's side to generate an employment function with serial persistence and gradual adjustment to output shocks. Two specifications of workers' preferences are presented that yield alternative expressions for the shadow value of labor in an optimal contract. The traditional labor demand model and the strong form efficient contracting model are obtained as special cases of the general model.

The model yields a partial-adjustment employment equation that expresses current employment in terms of lagged employment, lagged departures and lagged wage rates. The model generates testible restrictions across the employment equation and the forecasting equations for output and wages, and summarizes the employment effect of alternative wage rates in terms of two components: a direct effect on the desired level of employment; and on indirect effect on forecasts of future contract wages.

The third section of the paper presents the results of fitting the model to data on departures, wages, and employment for the seven airline firms. The empirical analysis is generally unsupportive of either the strong form efficient contracting model or the labor demand model. Both models are rejected in favor of a more general contracting model in which the opportunity cost of employment is a weighted average of the contract wage and the alternative wage. The parameter estimates for all three models are poorly determined, however, and the implied reduced forms fail to reconcile all the dynamic linkages between contract wages, alternative wages, and employment.

I. Preliminary Data Analysis

The data in this paper consist of quarterly observations on employment and wages for aircraft mechanics employed in the domestic operations of seven airlines: American, Braniff, Continental, Eastern, Trans World, United, and Western.[4/] Employment, earnings, and flight data were collected from various Civil Aeronautics Board (CAB) sources for the period 1969-I to 1976-IV.[5/] Wage rates were collected from union contracts summarized in Current Wage Developments and the Bureau of National Affairs' Daily Labor Report.[6/]

Mechanics at these airlines are represented by three unions: the Transport Workers Union (TWU) at American; the Teamsters (IBT) at

Western; and the Machinists (IAM) at the other five airlines. Although the IAM bargained individually with these five airlines during the sample period, contract terms and expiration dates differed little between them. Differences among the IAM contracts were due mainly to delays in signing new contracts at the individual airlines.[7/]

Table 1 presents annual data on nominal and real wage rates for airline mechanics at the various firms between 1969 and 1976.[8/] There were only small and unsystematic differences between wage rates negotiated by the three unions. Compared to other workers, however, airline mechanics earned relatively high wage rates during this period: 50 to 60 percent higher than average straight-time hourly earnings in manufacturing, for example, and about 25 percent higher than average hourly earnings reported by maintenance mechanics in manufacturing. Airline mechanics also earned a small premium (5 to 15 percent) over unionized mechanics at the major aircraft companies.

Airline mechanics' nominal wage rates are established in two or three year contracts that typically include both noncontingent deferred increases and cost-of-living allowance clauses. During the sample period new agreements were negotiated in 1969 (from March to December, depending on airline), 1971-72 (from May 1971 to December 1972), 1973-74 (from November 1973 to August 1974), and 1975-76 (from December 1975 to September 1976). Because of deferred increases and cost-of-living adjustments, however, the relation between contract negotiations and real wage rates is indirect. Real wage rates increased over the term of the 1969 contracts, for example, but were more or less constant between

1973 and 1976.

The behavior of real contract wage rates is analyzed more formally in Table 2. Column (1) presents a simple second-order autoregression (AR(2)) fit jointly to the logarithms of contract wage rates for all seven airlines, with unrestricted constants, trends and seasonal dummy variables for each airline.[9/] As is apparently true for aggregate real wage rates, the contract wage for airline mechanics is approximately a first-order autoregressive process, with something less than a unit autoregressive coefficient.[10/] For purposes of comparison with the results from a longer sample period, column (6) of the Table presents the same representation of contract wage rates fit to an extended sample period (1964 to 1978). The addition of seven extra years of data has no appreciable impact on the estimated coefficients, however.

The second, third and fourth columns of Table 2 contain estimates of real wage regressions that include lagged values of manufacturing wages and consumer prices. Each of these two aggregate series has strong causual links to contract wages. The point estimates in column (2) show that a permanent one percent increase in manufacturing wages leads to an eventual increase in contract wages on the order of one percent, while the estimates in column (3) suggest that a permanent increase in prices leads to a permanent decrease in contract wages. In column (4) of Table 2, both prices and manufacturing wages are entered in the regression for contract wages. Although the statistical significance of the individual coefficients is mixed, a test that lagged consumer prices improve the forecast of contract wages, given lagged manufacturing wages, is marginally significant, while a test for lagged manufacturing wages, given lagged prices, is not quite significant at conventional levels. Parallel results for the longer sample period (in columns (7), (8), and (9)) lead to very similar conclusions.

Finally, column (5) of Table 2 reports the coefficients of lagged employment in forecasting contract wages. The point estimate suggest that increases in employment lead to small increases in real contract wages, although a test of the hypothesis that employment fails to Granger-cause wages is not significant at conventional levels.[11]

The general pattern of employment for airline mechanics is illustrated in Figure 1, which gives a time-series plot of departures and employment at American Airlines. In addition to mechanics' employment, the figure shows quarterly employment levels for pilots and flight attendants. One of the most interesting features of the data is the extent to which employment of these three groups of workers is smoothed vis-a-vis departures. At one extreme, the number of employed pilots is very stable and shows little relation to output. At the other, the number of flight attendants is quite variable over time. Mechanics fall somewhere between these two groups. Fluctuations in departures translate into dampened fluctuations in the number of employed mechanics.

Data on flying operations and mechanics' employment are summarized by airline in Table 3. The airlines fall naturally into two groups: the four largest firms--American, Eastern, Trans World and United, and the three smaller firms. Interestingly, the number of mechanics per unit of output is quite different between the larger and smaller airlines. Relative to the employment levels at the smaller airlines, the larger airlines have 60 to 70 percent more maintenance employees per departure (or per available seat mile). To some extent this may reflect a greater reliance on outside contractors to perform specialized maintenance operations at the smaller airlines. Smoothing of employment relative to departures is indicated by the smaller coefficient of variation of employment for all the airlines except Continental and United. A similar conclusion emerges from a comparison between detrended and deseasonalized employment and departures. With the exception of United Airlines, the standard deviation of the logarithm of employment is about two-thirds as large as the standard deviation of the logarithm of departures, when both series have been fitted to a linear trend and quarterly dummy variables.

Table 4 presents a more formal analysis of employment variability and its relation to departures and wages. The first column of the Table presents a simple AR(2) specification of employment, fit jointly to the seven airlines with firm-specific trends, constants, and seasonals. Employment of airline mechanics displays the hump-shaped moving average representation that characterizes many aggregate employment time series.[12/] The response to a unit innovation in employment persists for roughly 10 quarters. As one might expect from Table 3, there is some heterogeneity across the airlines in the autoregressive representation of employment, particularly between United and the other six carriers. An F-test that the coefficients are the same across the seven airlines yields a probability value of just under .001.

Column (2) of Table 4 presents the coefficients of two lagged values of departures in explaining maintenance employment at the seven airlines. The coefficients are individually significant at conventional levels, although their joint contribution, summarized by the probability value in row 9c of the Table, is only marginally significant. The third and fourth columns of Table 4 examine the role of lagged contract wages and lagged manufacturing wages in predicting employment. The evidence that contract wages influence employment is relatively weak, although the evidence for manufacturing wages is stronger. Finally, the fifth column of the Table includes both wage measures together. In this equation increases in contract wages have a significantly negative effect on employment, whereas increases in manufacturing wages lead to an eventual increase in employment.[13/]

The results in column (5) are apparently robust to several alternative definitions of the opportunity wage for airline mechanics. In particular, if the manufacturing wage is replaced by the average wage of maintenance mechanics in manufacturing (interpolated from annual BLS Area Wage Survey data) or the wage rate for licensed mechanics at Boeing (available from the BLS wage chronology series) the coefficients are very similar in size and magnitude to those in Table 4, although less precisely estimated. I also constructed airline-specific measures of the opportunity wage based on earnings of maintenance mechanics and unemployment rates in cities where each airline has its major maintenance base.[14/] These alternative wage measures give the same pattern of results as the manufacturing wage rate, although each can be rejected as a significant determinant of maintenance employment after controlling for the manufacturing wage rate. In this paper I therefore use the manufacturing wage as the alternative wage rate for airline mechanics.

Table 5 examines the contribution of several additional explanatory variables for maintenance employment. In each case, the employment equation contains two lagged values of the explanatory variable listed in the column heading, together with lagged values of employment, departures, contract wages, and manufacturing wages. The first four columns present employment equations that include alternative aggregate variables: consumer prices, real national income, an index of CAB-regulated passenger fares, a jet fuel price index, and an index of parts prices. None of these variables significantly improves the predicition of employment, maintaining lagged departures and wage rates. The next five columns of the Table report employment regressions that include additional airline-specific measures of output: available seat miles, revenue-passenger miles, domestic flight hours, and total flight hours (including domestic and international flight hours). Apart from available seat miles, however, none of these output measures is an important determinant of employment, once the level of departures is taken into account. Departures and available seat miles are highly colinear, and the sums of the coefficients on departures and seat miles are very nearly equal to the corresponding coefficients of departures when seat miles are excluded from the regression. Since the coefficients of the other variables are not much affected by the presence or absence of seat miles in the employment equation, I use departures as the sole measure of airline output in the remainder of the paper. Finally, while the results are not recorded in the table, I have also computed employment regressions that include airline-specific fleet composition variables.[15/] Although these measures of firm-specific capital stock are marginally significant determinants of employment, their inclusion has no effect on the nature of the results in Table 4 or 5.

The analysis of employment in Tables 4 and 5 is restricted to the number of mechanics on airline payrolls in each quarter. A more complete description of labor inputs, however, requires information on hours per employed worker. Although CAB records do not include any measure of hours per worker, a noisy indicator of hours is available from data on average payroll cost per worker. Specifically, the ratio of payroll cost per worker to the contract wage rate represents the sum of straight time hours per worker, average overtime hours per worker (weighted by the overtime wage premium) and fringe benefit costs per worker (expressed as a fraction of the straight time wage rate).[16/] A regression of this hours index on contemporaneous employment and departures reveals no significant correlation with either variable.[17/] This absence of correlation suggests that measured hours variation can be safely ignored in the study of employment and output.

The interpretation of employment equations that include lagged output variables, such as those in Tables 4 and 5, depends critically on the time-series representation of output. Table 6 presents several alternative representations of the level of departures activity at the seven airline firms. In each case the logarithm of departures is regressed on two lagged values of departures and two lagged values of the explanatory variable listed in the column heading. The coefficient estimates of a univariate forecasting equation (in the first column of the Table) show that departures have a monotonically declining moving-average representation, rather than the hump-shaped representation that characterizes employment. The second column presents the coefficients of lagged employment in a forecasting equation for departures, as well as the probability value of the associated exclusion test. The hypothesis that departures are exogenous to maintenance employment is not rejected at conventional significance levels. The remaining columns of Table 6 present the coefficients of three alternative aggregate variables in the departures equations: real output, manufacturing wages, and consumer prices. None of these is significantly related to departures activity, however, controlling for lagged departures.

To conclude this preliminary data analysis, the main conclusions may be summarized as follows:

(1) the serial correlation properties of firm-specific employment and wage data for airline mechanics are very similar to the properties of aggregate data. Airline mechanics' real wage rates follow a first-order autoregressive process, while their employment levels follow a second-order process.

(2) in the period under study wage rates of airline mechanics were very similar across firms and uncorrelated with firm-specific employment levels. Real wage rates were significantly correlated with lagged manufacturing wage rates and lagged consumer prices.

(3) Employment of airline mechanics is correlated with lagged values of contract wage rates and lagged values of wage rates outside the airline sector. The separate effects of these two wage rates are well-determined and in opposite directions. The employment effect of outside wage rates is apparently

> robust to alternative definitions of the outside wage, although average hourly earnings in manufacturing has the strongest correlation with employment of airline mechanics.

Building on these conclusions, the next section presents an intertemporal contracting model that provides a framework for testing between alternative models of the link between wage rates and employment.

II. Contractual Employment with Costly Adjustment

This section presents a simple extention of the static efficient contracting model to an intertemporal setting. Adjustment costs are introduced on the firm's side in order to generate an employment function with serial persistence and cumulative rather than instantaneous responses to changes in output or wages. The resulting function expresses optimal employment in terms of lagged values of employment, output, and wages, and provides a convenient framework for testing alternative models of employment determination. Both the labor demand model of employment determination, in which the employer takes contract wages as given, and the strong-form efficiency model, in which the marginal product of labor is equated to the alternative wage rate, are obtained as special cases of the model. In contrast to tests of the efficient contract hypothesis based on a static employment function, the time series correlations of employment and wages are modelled explicitly, and used to disentangle the forecasting role of alternative wages from any efficient contracting effects.

For simplicity, the dynamic relationship between output, wages, and employment is assumed to arise solely from the demand side of the contract. Workers are modelled as having separable preferences over time, with no interaction between lagged values of wages or employment and the ranking of current wage-employment pairs. While this assumption simplifies the analysis and interpretation of the dynamic employment function, it restricts the role of lagged wages and employment in generating current employment, and represents an obvious channel for further research.[18/]

The first step in specifying the contractual employment function for airline mechanics is to specify the link between flight activity, maintenance activity, and employment. Airline mechanics service and inspect aircraft between departures ("line service") and also rebuild and overhaul aircraft components at major service intervals.[19/] In either case a variety of substitutes is available for in-house mechanics' services, including outside subcontractors and purchases of new parts and equipment. In addition, airlines can substitute mechanics' services over time by adding to or running down the stock of airworthy equipment. For simplicity, however, I assume that a given level of flight activity in the t^{th} quarter, F_t , requires a proportional input of maintenance activities. I also assume that that maintenance is produced by a combination of in-house employment N_t and other inputs M_t according to a Cobb-Douglas production function

$$F_t = A\, N_t^{\gamma_1} M_t^{\gamma_2} \;,$$

where γ_1 and γ_2 are positive constants and A is a constant depending on aircraft type and route structure. The direct cost of maintaining a level of flight activity F_t with a labor force of N_t

mechanics is therefore

$$(1) \quad w_t N_t + q_t \, r \, (N_t \, , \, F_t) \; ,$$

where w_t is the contract wage for mechanics, q_t is the price of other maintenance inputs, and $r(N_t , F_t) = A^{\frac{1}{\gamma_2}} N_t^{\frac{-\gamma_1}{\gamma_2}} F_t^{\frac{1}{\gamma_2}}$ is the input requirement function for nonlabor inputs, given labor inputs N_t and output F_t .

In addition to these direct costs, I assume that the firm bears an adjustment cost $J(N_t, N_{t-1})$ in period t that depends on the level of employment in t and $t-1$. This adjustment cost captures both hiring and firing costs, and the cost of rearranging flight schedules as the number of employees available for line service at each airport is adjusted over time.

The final ingredient of the employment contract is the specification of workers' preferences. I assume that preferences in each period are represented by a function of contract wages, employment, outside or alternative wages a_t , and a random preference shock $\nu_t : U(N_t, w_t, a_t, \nu_t)$. Two functional forms are considered for U . In the first case, assume that N_o workers are attached to the firm, and that workers are allocated randomly in each period between contract employment and alternative employment with probabilities N_t/N_o and $1-N_t/N_o$ respectively. If $v(x, \nu_t)$ is a von-Neumann-Morgenstern utility function defined on the level of earnings x , then preferences of a representative worker are summarized by:

$$(2)\quad U(N_t,\ w_t,\ a_t,\ \nu_t) = \frac{N_t}{N_o}\, v(w_t,\ \nu_t) + (1 - \frac{N_t}{N_o}) v(a,\ \nu_t)\ .$$

In the second case, following Pencavel (1984), assume that workers' preferences can be summarized by a Cobb-Douglas function of employment and the gap between contract and alternative wages:

$$(3)\quad U(N_t,\ w_t,\ a_t) = k(\nu_t)\ N_t^{\theta_1} (w_t - a_t)^{\theta_2}\ .$$

Both of these specification contain as a special case the "excess earnings" objective $N_t(w_t-a_t)$ associated with an income-maximizing union.[20/]

Under the assumption that current and future flight activity are exogenous to maintenance employment, an optimal contract minimizes the expected present value of employer's costs, subject to an expected utility requirement for workers. Assuming that employers and workers have a constant discount rate β $(\beta<1)$, the level of employment and wages in period t solves

$$(4)\quad \min_{w_t, N_t}\ E \sum_{j=o}^{\infty} \beta^j\ [w_{t+j}\ N_{t+j} + q_{t+j}\ r(N_{t+j},\ F_{t+j}) + J(N_{t+j}\ ,\ N_{t+j-1})]$$

subject to:

$$E \sum_{j=o}^{\infty} \beta^j\ U(N_{t+j},\ w_{t+j},\ a_{t+j},\ \nu_{t+j}) \geqslant U_o\ .$$

In these expressions expectations (denoted by E) are taken over the joint distribution of the entire sequence of future flight activity, input prices, alternative wages, and preferences shocks. The solution to this constrained optimization problem can be obtained as the solution to the

Lagrangean expression

$$(5)\quad \min_{w_t, N_t} \quad E \sum_{j=o}^{\infty} \beta^j \left[w_{t+j} \quad N_{t+j} + q_{t+j} \; r(N_{t+j}, F_{t+j}) + \right.$$
$$\left. J(N_{t+j}, N_{t+j-1}) - \mu U(N_{t+j}, w_{t+j}, a_{t+j}, \nu_{t+j}) \right],$$

for some positive constant μ .

In contrast to the efficient contracting model, which views employment and wages as jointly determined, the traditional labor demand model treats employment as determined unilaterally by the firm, taking contract wages as given. In this case observed employment solves the employer's cost minimization problem

$$(6)\quad \min_{N_t} \quad E \quad \sum_{j=o}^{\infty} \beta^j \; [w_{t+j} \; N_{t+j} + q_{t+j} \; r(N_{t+j}, F_{t+j}) + J(N_{t+j}, N_{t+j-1})],$$

directly, subject to the forecasting equations for flight activity, input prices, and contract wages. A comparison of equations (5) and (6) reveals two important differences between the efficient contract and labor demand models. First, the efficient contract model treats wages and employment as jointly endogenous. Second, while alternative wages enter the contracting model directly through workers' preferences, in the labor demand model the only role of alternative wages is in the forecasting equation for future contract wages.

Before deriving the employment functions associated with the contracting and labor demand models it is useful to characterize the wage function implied by the efficient contracting model. In particular, it is interesting to ask if a contracting model which considers wages and employment as jointly determined can even lead to the prediction that wage outcomes are independent of previous employment levels. The empirical analysis in the first section of this paper suggests that this is an important characteristic of contract wage rates for airline mechanics.

The first-order condition for wages in period $t+j$ for the contracting model (5) is:

$$(7) \quad N_{t+j} - \mu \, U_w(N_{t+j}, w_{t+j}, a_{t+j}, \nu_{t+j}) = 0 \; .$$

From this equation it is evident that the choice of contract wages in $t+j$ is independent of employment if workers' preferences are linear in employment: say

$$U(N, w, a, \nu) = Nf(w, a, \nu) \; .$$

In that case the first-order condition (7) has the simple form

$$\mu \, f_w(w_{t+j}, a_{t+j}, \nu_{t+j}) = 1 \; ,$$

with the implication that contract wages are determined in each period independent of employment or wage choices in any other period. Since the evidence in the previous section suggests that contract wages are unrelated to past employment, the assumption that workers' preferences are linear in employment is plausible as well as convenient, and will be adopted here. The expected-utility preference specification (3) imposes linearity a priori.[21/] For the Cobb-Douglas specification (4), linearity implies a within-period objective of the form $N_t(w_t-a_t)^{\theta}$, where $\theta = \theta_2 > 0$ may be either greater than or less than unity.

Specializing the first-order condition (7) to these two preference specifications leads to

(8a) $\mu\, v_w(w_{t+j},\, \nu_{t+j}) = 1$,

in case of expected utility preferences, and

(8b) $k(\nu_{t+j})\ \mu\theta(w_{t+j} - a_{t+j})^{\theta-1} = 1$,

in case of Cobb-Douglas preferences. The expected utility specification implies that real contract wages are constant over time, apart from changes in the preference shock ν or random measurement errors. The Cobb-Douglas specification, on the other hand, suggests that contract wages maintain a constant (absolute) differential over alternative wages. For example, if $k(\nu_t) = \nu_t^{1-\theta}$ and ν_t is first-order autoregressive, then equation (8b) implies

$$w_t = \delta_1\, w_{t-1} + a_t - \delta_1\, a_{t-1} + \nu_t'$$

where δ_1 is the first-order autocorrelation coefficient of ν_t and $\nu_t' = \nu_t - \delta_1 \nu_{t-1}$ is serially uncorrelated. Comparison of this equation with the fitted regressions in the first section of this paper suggests that the first-order condition (8b) may provide a useful model of the contract wage determination process for airline mechanics.

The assumption that worker's preferences over employment and wage outcomes are linear in employment simplifies the analysis of contractual employment setting. Let w_{t+j}^* represent the solution to equation (8a) or (8b). Since contract wages are unrelated to past employment decisions, the optimal level of contract employment in t solves

$$(9) \quad \min_{N_t} \; E \sum_{j=0}^{\infty} \beta^j \, [w^*_{t+j} \; N_{t+j} + q_{t+j} \; r(N_{t+j}, F_{t+j}) + J(N_{t+j}, N_{t+j-1}) - \mu \; U(N_{t+j}, w^*_{t+j}, a_{t+j}, \nu_{t+j})]$$

subject to the forecasting equations for flight activity, alternative wages, preference shocks, and optimized contract wages.[22/] If employment fails to Granger-cause wages, the contract employment function can be obtained by taking the contract wage as exogenous. In this case the labor demand model of employment determination (6) is a special case of the contracting model (9) with $\mu=0$.

In order to derive the contract employment function when there are costs of changing employment from period to period it is convenient to procede in two steps. The first step is to derive the optimal employment level in the absence of adjustment costs. The second step is to derive the actual employment decision by comparing the costs of changing employment over time with the cost of sub- or super-optimal employment in each period.[23/] For simplicity these two cost components are expressed as quadratic functions of the logarithm of employment, yielding an employment function that is linear in the logarithms of employment, output, and wages.

The optimal employment choice in the absence of adjustment cost can be obtained from the first-order condition for the contracting problem (9), setting the adjustment cost component to zero:

$$(10)\quad w_{t+j} + q_{t+j}\, r_N(N_{t+j}, F_{t+j}) - \mu\, U_N(N_{t+j}, w_{t+j}, a_{t+j}, \nu_{t+j}) = 0.$$

For the expected utility specification of worker's preferences, this first-order condition implies

$$-q_{t+j}\, r_N(N_{t+j}, F_{t+j}) = w_{t+j} - \mu(v(w_{t+j}) - v(a_{t+j})),$$

where for simplicity I have suppressed the dependence of v on the preference shock ν_t . The term on the left-hand side of this equation represents the marginal value product of labor, measured by the savings in nonlabor input costs as employment is increased by one unit. The marginal value product of labor is equated to the current contract wage, minus a premium that depends on the gap between contract and alternative wages. Using the properties of the optimal contract wage (equation (8a)), the appropriate shadow value of mechanics' labor is

$$S_{t+j} \equiv w_{t+j} - \mu(v(w_{t+j}) - v(a_{t+j})) = w_{t+j}\left(1- \frac{v(w_{t+j})-v(a_{t+j})}{w_{t+j}\; v_w(w_{t+j})}\right) .$$

If the expected utility function v is linear in earnings, then the expression for the shadow value of labor reduces to a_{t+j} - the alternative wage rate. More generally, using a second-order expansion for $v(a_{t+j})$ around w_{t+j} , the shadow value of labor in the absence of adjustment costs is approximately

$$(11a)\quad S_{t+j} \cong a_{t+j}(1+\delta\pi) - \delta\pi\, w_{t+j} ,$$

where δ is the coefficient of relative risk aversion of the utility function v $(\delta \geqslant 0)$ and π represents the average markup of the optimal contract wage over the alternative wage.[24/] If workers' preferences have the expected utiltiy form, the shadow value of labor in an optimal contract is decreasing in the contract wage. As noted by McDonald and Solow (1981), this specification of worker preferences implies that efficient combinations of employment and wages are positively correlated across otherwise identical contracts.

For the case of Cobb-Douglas preferences the first-order condition for employment in the absence of adjustment costs is

$$- q_{t+j}\, r_N(N_{t+j}, F_{t+j}) = w_{t+j} - \mu\, k(\nu_{t+j})(w_{t+j} - a_{t+j})^{\theta} .$$

Again, the shadow value of labor in the optimal contract is lower than the contract wage. Using the first-order condition (8b) for the optimal contract wage in period $t+j$, the shadow value of labor is:

$$\text{(11b)} \quad s_{t+j} = a_{t+j} \frac{1}{\theta} + w_{t+j} \left(1 - \frac{1}{\theta}\right) .$$

For values of θ less than unity, this expression is identical to (11a). For values of θ in excess of unity, however, the Cobb-Douglas specification implies that S_t is increasing in both the contract and the alternative wage.

In view of the similarity of (11a) and (11b) it is straightforward to derive the optimal level of employment in period t for either specification of workers' preferences. Assuming that arithmetic and geometric averages of contract and alternative wages are equal, the logarithm of the appropriate shadow value of labor is:

$$(12)\ \log S_t = \alpha \log w_t + (1-\alpha) \log a_t \ ,$$

where $\alpha = 1-1/\theta$ in the Cobb-Douglas specification of worker preferences, and $\alpha = -\pi\delta$ in the expected utility specification. In a strong-form efficient contract where workers' objectives are summarized by the value of "excess earnings" $N_t(w_t-a_t)$, $\alpha=0$. In the labor demand model, on the other hand, the relevant opportunity cost of labor is the contract wage and $\alpha=1$. Substituting equation (12) into the first-order condition for employment in the absence of adjustment cost and taking logarithms yields the optimal employment level

$$(13)\quad \log N_t^* = \text{constant} + b_1 \log F_t + b_2 \log w_t + b_3 \log a_t + b_4 \log q_t \ ,$$

where $b_1 = 1/(\gamma_1+\gamma_2)$, $b_2 = -\alpha\gamma_2/(\gamma_1+\gamma_2)$, $b_3 = -(1-\alpha)\gamma_2/(\gamma_1+\gamma_2)$, and $b_4 = \gamma_2/(\gamma_1+\gamma_2)$. In effect, N_t^* is the level of employment observed on the firm's labor demand curve when output is F_t and the wage rate is a weighted average of the alternative wage a_t and the contractual wage w_t .[25/]

The cost of maintaining a level of flight activity F_t with a labor force $N_t \neq N_t^*$ can be obtained from a second-order expansion of the appropriate cost function. Let

$$c(N_t) = w_t N_t + q_t\, r(N_t, F_t) - \mu\, U(N_t, w_t, a_t)$$

denote the cost (net of the contribution to workers' utility) of maintenance activities in quarter t , excluding adjustment costs. Using the fact that $c'(N_t^*) = 0$,

$$c(N_t) \cong c(N_t^*) + (N_t - N_t^*)\, c'(N_t^*) + \frac{1}{2}\,(N_t - N_t^*)^2\, c''(N_t^*)$$

$$\cong c(N_t^*) + \frac{1}{2}\, c_{1t}(\log N_t - \log N_t^*) \ ,$$

where c_{1t} represents a second-order expansion coefficient when deviations of N_t from N_t^* are taken in proportionate terms.[26] I assume that this approximation continues to hold when c_{1t} is replaced by its sample average value c_1 .

The optimal employment choice in period t can be obtained by combining the preceding expression with the adjustment cost terms $J(N_{t+j}, N_{t+j-1})$. For convenience I assume that the costs of changing the labor force are related to the proportional change in employment by:

$$J(N_{t+j}, N_{t+j-1}) = \frac{1}{2}\, c_2\, (\log N_{t+j} - \log N_{t+j-1})^2 \ .$$

The assumption of equal adjustment costs for equiproportional increases and decreases in employment is particularly restrictive, but is required for empirical tractibility.

With this setup, it is straightforward to derive the dynamic employment equation for airline mechanics. The choice of current employment minimizes the following quadratic expression:

$$(14) \quad E\sum_{j=0}^{\infty} \beta^j \left[c(N_{t+j}^*) + \frac{1}{2}\, c_1(\log N_{t+j} - \log N_{t+j}^*)^2 + \frac{1}{2}\, c_2(\log N_{t+j} - \log N_{t+j-1})^2\right] .$$

The solution to this class of problems is well-known and can be summarized by the partial adjustment equation

$$(15)\ \log N_t = \lambda \log N_{t-1} + (1-\lambda)(1-\lambda\beta)\sum_{j=0}^{\infty} (\lambda\beta)^j E_t \log N^*_{t+j} ,$$

where λ is a root to the quadratic equation

$$\lambda^2 - (\frac{1+\beta+c_1/c_2}{\beta}) \lambda + \frac{1}{\beta} = 0$$

lying between 0 and 1 . According to equation (15), observed employment represents a weighted average of last period's employment and the discounted average of expected future values of N^*_t . The adjustment parameter λ reflects the relative size of the coefficients c_1 and c_2 . The larger is c_2 , the most costly is labor force adjustment, and the larger is λ .27/

The solution for N_t can be obtained by substituting from equation (13) for $\log N^*_t$ into (15). The resulting expression translates $\log N_t$ into a function of $\log N_{t-1}$, and discounted averages of expected future values of $\log F_t$, $\log w_t$, $\log a_t$, and $\log q_t$. These expressions can in turn be written as functions of current and past values of wages and departures, and current and past values of all variables useful in predicting wages or departures.

The presence of unobserved error components in the static employment function (13) introduces an additional consideration into the formulation of the dynamic employment function. Suppose that equation (13) contains a stochastic productivity effect ϵ_t . Then, excluding constants, the dynamic employment function is:

$$(16)\ \log N_t = \lambda \log N_{t-1}$$
$$+ (1-\lambda)(1-\lambda\beta)\sum_{j=0}^{\infty} (\lambda\beta)^j E_t[b_1 \log F_{t+j} + b_2 \log w_{t+j}$$

$$+ b_3 \log a_{t+j} + b_4 \log q_{t+j} + \epsilon_{t+j}] .$$

An empirically useful hypothesis is that the error component ϵ_t is first-order autoregressive.[28/] In particular let

$$\epsilon_t = \rho \, \epsilon_{t-1} + \xi_t ,$$

where ξ_t is serially uncorrelated, and strictly exogenous to flight activity, employment or wages. Then

$$(1-\lambda\beta) \sum_{j=0}^{\infty} (\lambda\beta)^j \, E_t \, \epsilon_{t+j} = \frac{1-\lambda\beta}{1-\lambda\beta\rho} \, \epsilon_t ,$$

which introduces a first-order autoregressive error into the dynamic employment function (16), and generates a second-order autoregressive representation of employment.

The terms on the right-hand side of equation (16) depend on the definitions and forecasting equations for alternative wages, flight activity, nonlabor input prices, and contract wages. On the basis of the evidence reported in Section 1, I assume that the alternative wage for airline mechanics is represented by the average hourly wage rate in manufacturing (apart from trend and seasonal factors). As a measure of flight activity I use the level of domestic departures. Finally, for lack of suitable data, I assume that nonlabor input prices (q_t) are captured by trend and seasonal factors. This assumption is especially problematic if the main substitute for in-house employment is contract maintenance, and if the price of contract maintenance is correlated with mechanics' wage rates.

Building on the results in Section 1 I adopt the following second-order autoregressive forecasting system for detrended and deseasonalized departures, manufacturing wages, contract wages, and consumer prices:

$$\text{(17a)} \quad \log F_t = \phi_1 \log F_{t-1} + \phi_2 \log F_{t-2} + u_{1t} ,$$

$$\text{(17b)} \quad \log a_t = \alpha_1 \log a_{t-1} + \alpha_2 \log a_{t-2} + \alpha_3 \log p_{t-1} + \alpha_4 \log p_{t-2} + u_{2t}$$

$$\text{(17c)} \quad \log w_t = \delta_1 \log w_{t-1} + \delta_2 \log w_{t-2} + \psi_1 \log a_{t-1} + \psi_2 \log a_{t-2} + \psi_3 \log p_{t-1} + \psi_4 \log p_{t-2} + u_{3t}$$

$$\text{(17d)} \quad \log p_t = \pi_1 \log p_{t-1} + \pi_2 \log p_{t-2} + \pi_3 \log a_{t-1} + \pi_4 \log a_{t-2} + u_{4t} ,$$

where the vector of residuals $(u_{1t}, u_{2t}, u_{3t}, u_{4t})$ is assumed to be serially uncorrelated. In this forecasting system aggregate prices and manufacturing wages depend on their own lagged values and lagged values of each other, while departures are forecast by a univariate second-order autoregression. Contract wages depend on their own lagged values as well as lagged values of manufacturing wages and consumer prices. The forecasting equation for contract wages can be interpreted as a log-linear approximation to the first-order condition (7) for optimal contract wages, although I do not restrict the coefficients of the equation in any way. The evidence that alternative wages help forecast contract wages is more consistent with the Cobb-Douglas preference specification than the expected utility specification, although neither model provides a ready interpretation of the role of prices in forecasting contract wage rates.[29/]

The system of second-order forecasting equations (17) generate the following expressions:

$$\text{(18a)}\quad (1-\lambda\beta)\sum_{j=0}^{\infty}(\lambda\beta)^j E_t \log F_{t+j} = B_{11}\log F_t + B_{12}\log F_{t-1} ,$$

$$\text{(18b)}\quad (1-\lambda\beta)\sum_{j=0}^{\infty}(\lambda\beta)^j E_t \log a_{t+j} = B_{21}\log a_t + B_{22}\log a_{t-1} + B_{23}\log p_t + B_{24}\log p_{t-1} ,$$

$$\text{(18c)}\quad (1-\lambda\beta)\sum_{j=0}^{\infty}(\lambda\beta)^j E_t \log w_{t+j} = B_{31}\log w_t + B_{32}\log w_{t-1} + B_{33}\log a_t + B_{34}\log a_{t-1} + B_{35}\log p_t + B_{36}\log p_{t-1} ,$$

where the B_{ij} are known functions of the coefficients in equations (17a)-(17d). Substituting these equations into (16), performing a transformation to eliminate serial correlation in the productivity shock ϵ_t, and using (17a)-(17d) to substitute for current values of departures, prices and wages in terms of lagged values and innovations in these variables yields the reduced form employment equation implied by the model. This reduced form contains two lagged values of employment, and each of the exogenous variables (including contract wages), as well as a residual that is a combination of the unanticipated productivity shock ξ_t and the current forecast errors u_{1t}, u_{2t}, u_{3t}, and u_{4t}. The coefficients of the reduced form equation depend on the coefficients of equations (16) and (18), the adjustment parameter λ, and the serial correlation coefficient ρ of the unobserved productivity shock.[30/]

The dynamic properties of employment, however, depend solely on λ and ρ. The first-order autoregressive coefficient of employment is the sum of λ and ρ, while the second-order autoregressive coefficient is the negative of their product.

To illustrate the implications of the model for the reduced form employment equation, it is useful to consider the two polar models of employment determination: the labor demand model in which the relevant opportunity cost of contract labor is the contract wage; and the strong-form efficient contract model in which the relevant opportunity cost is the alternative wage rate. In the labor demand model $b_3 = 0$ in equation (16) and the alternative wage effects employment only through the forecasting equation for contract wages. If future contract wages depend positively on manufacturing wages, for example, then employment should depend negatively on manufacturing wages, at least in the long run. The evidence in Tables 2 and 4, however, shows that manufacturing wages have a positive long-run impact on contract wages, and a <u>positive</u> long-run effect on employment. In the strong-form efficient contract, on the other hand, N_t^* is independent of contract wages and depends only on the level of alternative wages. This model is also rejected by the unrestricted employment regressions in Table 4, which show a negative impact of contract wages on employment, holding constant manufacturing wages. More formal tests between these two polar models, and tests of the overidentifying restrictions implied by the general contracting model, are presented in the next section.

III. <u>Empirical Analysis of the Dynamic Contracting Model</u>

The model of employment determination developed in the last section consists of the prediction equations for contract wages, alternative wages and departures (equations (17a)-(17d)), together with the reduced form employment equation implied by (16). This section presents estimation results based on fitting this five equation system to aggregate quarterly data on manufacturing wages and consumer prices as well as firm-specific data on contract wages, employment, and departures for the seven airline firms. For simplicity, the firm-specific data are deseasonalized and detrended prior to estimation. This permits unrestricted airline-specific constants, trends, and seasonals to be fitted outside of the main estimation step, at the cost of some potential bias in the estimated standard errors.

In addition, rather than estimate equations for the airline-specific data and the aggregate data simultaneously, I have estimated the manufacturing wage and consumer price equations separately over a longer sample period (1964 III-1978 IV), and then used the estimated parameters as known constants in the calculation of the restricted employment equation. The model is therefore treated as a three-equation system for employment, wages, and departures, with <u>known</u> forecasting equations for aggregate wages and prices.

The employment, wage, and departures equations for each of the seven airline firms (21 equations in all) are fitted to detrended and deseasonalized data by a two-step nonlinear generalized least-squares procedure.[31/] The age estimates minimize the weighted residuals of the 21 equation system, using as weights the inverse covariance matrix formed by the unrestricted least-squares residuals. Following Gallant and

Jorgenson (1979), a goodness-of-fit test is constructed by comparing the weighted sum of squares of the restricted model to the weighted sum of squares of the unrestricted model.

Unrestricted vector-autoregressive representations of airline-specific departures, wages, and employment are presented in the first two columns of Table 7.[32] The first column contains estimates of the three-equation system when lagged prices are excluded from the wage and employment equations, while the second column contains estimates of the system when lagged prices are included in these two equations. The coefficient estimates are very similar to the corresponding estimates in Tables 2, 4, and 6 obtained by fitting the system equation-by-equation to unadjusted data.

The next two columns of Table 7 contain the restricted reduced form parameter estimates associated with the labor demand version of equation (16). The corresponding structural parameter estimates are presented in the first two columns of Table 8. In this version of the contracting model, the appropriate opportunity cost of labor is the contract wage rate, and manufacturing wages enter the employment equation for airline mechanics only in so far as they help to predict future contract wages. The model is therefore an application of Sargents' (1978) dynamic employment demand model to firm-specific data, with output taken as exogenous. The two alternative specfications of the labor-demand model differ by whether or not lagged prices are used to forecast future contract wages and future alternative wages.[33]

The estimated wage elasticities (the parameter b_2) for the labor demand model are small and positive, and insignificantly different from zero. A comparison of the restricted reduced forms in columns (3) and (4) with the unrestricted reduced forms in columns (1) and (2) suggests several difficulties with the restricted fit. First, the labor demand model cannot explain the opposite signs of contract and manufacturing wages in the reduced form employment equation, given that future contract wages are positively correlated with manufacturing wages. Second, in the specification of the model that includes prices in the forecasting equation for contract wages, the relatively small effects of prices on employment are difficult to reconcile with the relatively large effects of prices on expected future contract wages. The goodness-of-fit statistics in the last row of Table 8 suggest that the labor demand interpretation of the employment-wage-output system is strongly rejected by the data.

In contrast to the poor performance of the model in summarizing the effects of wages on employment, the linkage between departures and employment is more successfully explained. The estimated (long-run) output elasticity of employment is between .60 and .80 and is not significantly different from unity. The AR(2) structure of employment is also apparently well-captured by the combination of adjustment costs and first-order serial correlation in demand: a comparison of the restricted and unrestricted reduced form autoregressive parameters reveals only small differences between them.

Parameter estimates for the strong form efficient contract model, which takes the alternative wage rate as the opportunity cost of labor and excludes contract wage rates from the employment equation, are presented in columns (3) and (4) of Table 8. The associated reduced forms are contained in the fifth and sixth columns of Table 7. Again, a comparison of the unrestricted and restricted reduced forms shows that the model has trouble explaining the effects of manufacturing wages on employment. When prices are not used to forecast future manufacturing wage rates, the implied estimate of the elasticity of demand is .29. When prices are included in the wage forecasting equation, on the other hand, the estimated elasticity of demand is -.05. As is the case for the labor demand model of employment determination, the dynamic link between wages and employment is not well explained by the strong form efficient contract model, although the departures-employment relationship is reasonably well explained by either model.

Finally, estimates of a general contracting model that permits the shadow value of labor to depend on a weighted average of contract and alternative wages are presented in the last columns of Table 7 and Table 8. In this general model, prices are included in the forecasting equations for contract wages and manufacturing wages. A version of the model that excluded prices from the wage equations proved to be unidentified.[34/] Although the general contracting model fits better than either polar model, the estimated wage elasticities of employment are poorly determined and not significantly different from zero. Again, the implied reduced-form coefficients of contract and manufacturing wages in the employment equation are different from the unrestricted coefficients, and the goodness-of-fit test against the unrestricted model is highly significant.

The point estimates imply that mechanics' employment responds negatively to increases in their alternative wage rate, as measured by the manufacturing wage rate, and positively to increases in their contractual wage rate. The latter effect, which may be taken as weak evidence for a positive correlation between contract wages and employment, is consistent with either the expected utility preference specification (2) and some degree of risk aversion, or the Cobb-Douglas specification (3) with $\theta < 1$. From equation (13), the elasticity of employment with respect to the contract wage is $b_2 = \alpha\eta$ and the elasticity of contract employment with respect to the alternative wage is $b_3 = (1-\alpha)\eta$, where $\eta = -\gamma_2/(\gamma_1 + \gamma_2)$ is the constant-output employment elasticity associated with the Cobb-Douglas maintenance technology, and α is the relative weight of contract wages in the expression for the shadow value of labor. The point estimates in column (5) of Table 8 imply $\alpha = -.59$ and $\eta = .-64$, although the estimates are extremely imprecise and insignificantly different from zero. For the expected utility specification of workers' preferences, the coefficient $-\alpha$ represents the product of the relative risk aversion coefficient (δ) and the average markup of contract wages over alternative wages (π) . If the latter is about .25, the implied estimate of the relative risk aversion coefficient is about 2.4. For the Cobb-Douglas preference specification the coefficient α is an estimate of $(1-\frac{1}{\theta})$. The implied value of θ is .63. These estimates are not unreasonable, although their imprecision is disturbing, as is the failure of the reduced form of the model to reproduce the unrestricted reduced form of the data.

Overall, none of the models considered in this paper gives a particularly good fit to the data, particularly with respect to the coefficients of contract or manufacturing wages. In addition, the fact that real contract wage rates and real manufacturing wage rates are both heavily influenced by lagged consumer prices is not easily reconciled with the absence of price effects on employment.[35/] A more flexible model of the interactions between contract and alternative wage rates, on one hand, and employment, on the other, is apparently needed to describe the data.

IV. Conclusions

This paper presents an analysis of firm-specific employment and wage outcomes for airline mechanics at seven firms during the period 1969-1976. The data possess many of the familiar properties of aggregate wage and employment data, including second-order serial correlation in employment and first-order serial correlation in real wages. Airline mechanics' employment levels are found to be correlated with both their own wage rates, and with average wage rates outside the airline industry.

A theoretical model is presented that describes the evolution of wages and employment in several alternative settings, including the traditional labor demand setting, where firms take contract wages as exogenous, and an efficient contract setting, where wages and employment are jointly determined to minimize employer costs, subject to a utility requirement for workers. The model incorporates costly adjustment of employment over time and emphasizes that workers' alternative wages can have two effects on employment outcomes: a direct effect on the shadow value of worker's time, and an indirect effect on forecasts of future wage outcomes.

The model gives a straightforward and relatively successful interpretation of the empirical link between airline departures and mechanics' employment. None of the alternative versions of the model, however, successfully captures the links between wages and employment. Both the labor demand model and the simplest efficient contracting model, which equates the marginal product of workers to their alternative wage rate, are rejected in favor of a more general model that includes contract and alternative wages in the employment equation. The parameter estimates for this model, however, are extremely imprecise, and the implied reduced-form employment equation fits poorly relative to an unrestricted autoregression. In spite of the promise that simple contracting models might provide a credible interpretation of observed movements in employment and wages, the covariation of employment and wages in this data remains largely unexplained.

Footnotes

[1/]The theoretical literature on efficient contracting is voluminous: see in particular Leontief (1946), Azariadis (1975), Baily (1974), Gordon (1974), Hall and Lilien (1979), McDonald and Solow (1981), and the recent surveys by Hart (1983) and Rosen (1985). Svejnar (1986) presents an empirical study of efficient wage and employment outcomes. Brown and Ashenfelter (1986), MaCurdy and Pencavel (1986), and Martinello (1985) attempt to test between efficient contracting models and conventional employment-setting models.

[2/]This point was made forcefully by Barro (1977) in a comment on models of nominal wage contracting.

[3/]This is essentially the test procedure adopted by Brown and Ashenfelter (1986). MaCurdy and Pencavel (1986) estimate a capital-labor ratio equation that includes both contract and alternative wage rates.

[4/]Data are also available for three other domestic trunk airlines - Delta, National, and Northwest - as well as for PanAm. Because of the high level of strike activity at National and Northwest, these airlines were excluded from the present study. PanAm differs from the domestic trunks in that a large share of its business is international. For this reason, domestic employment data for PanAm may be misleading, and I chose to exclude it. Delta's mechanics are nonunionized, and as a result no direct measure of contract wage rates is available.

5/Detailed quarterly employment data is unavailable after 1976. Employment and payroll information pertain to maintenance and related workers, as defined by the CAB. This group includes aircraft inspectors and mechanics, as well as cleaners, janitors, and stock clerks. According to CAB records, there were 37,036 maintenance workers in the domestic trunk airlines in the third quarter of 1975. A Bureau of Labor Statistics Industry Wage Survey during August-November 1975 counted 29,518 inspectors and mechanics and 8,588 cleaners, janitors and stock clerks at the domestic trunks, for a total of 38,106 maintenance and related workers. On this basis, approximately 80 percent of maintenance workers are actually airline mechanics or inspectors.

6/Wage rates for mechanics at Western Airlines were obtained from copies of the contracts generously made available to me by the IBT Airline Division.

7/During this period the delay between expiration of old contracts and renegotiation of new contracts was typically six to twelve months.

8/Wage rates in Table 1 are for certified mechanics, excluding premiums for line service work (.10 to .25 per hour during this period) and FAA licenses (.10 to .20 per hour per license). Wage rates for mechanics represented by the IAM are summarized by the wage rates at United Airlines.

9/A simple F-test that the AR(2) coefficients in the wage equation are the same across all seven airlines yields a probability value of

.04. The major difference in coefficients is between American and the other airlines.

10/ See for example Ashenfelter and Card (1982). A similar specification fit to real straight-time average hourly earnings in manufacturing over this sample period yields a first-order coefficient of 1.09 (with a standard error of .20) and a second-order coefficient of -.26 (with a standard error of .20).

11/ The probability value of the test statistic is 0.12.

12/ See Sargent (1978) for example.

13/ A comparable regression of employment on contemporaneous departures, contract wages, and manufacturing wages yields a coefficient for contract wages of -.034 (with a standard error of .045) and a coefficient for manufacturing wages of .061 (with a standard error of .138).

14/ If the appropriate opportunity wage is the wage on an alternative job multiplied by the probability of being offered that job, then an observable proxy for the opportunity wage is (1-U)a , where U is the relevant state unemployment rate and a is the wage rate of maintenance mechanics in the relevant city. The wage index was suggested by Brown and Ashenfelter (1986).

15/ Airline-specific fleet composition data is available on a annual basis from the Federal Aviation Administration <u>Statistical Handbook of Aviation</u>. For purposes of the employment regressions, I interpolated the number of aircraft of each type of airline by quarter, and grouped aircraft into five types.

16/Let E represent payroll cost per worker, let w represent the union wage scale, let h_1 and h_2 represent average straight-time and overtime hours per worker, respectively, and let g represent average fringe benefit costs per worker. then

$$E = wh_1 + w(1+\omega)h_2 + g ,$$

where ω represents the average overtime wage premium. The ratio of payroll cost to the contract wage rate is therefore

$$E/w = h_1 + (1+\omega)h_2 + g/w .$$

17/The coefficient on the logarithm of employment is .06 (with a standard error of .06) and the coefficient on the logarithm of departures is .02 (with a standard error of .05).

18/If workers bear mobility costs of moving between contract and alternative employment than presumably these costs should be internalized in an optimal employment contract. Carruth and Oswald (1985) discuss the formulation of worker's objectives in an intertemporal contracting model.

19/Each of the seven airlines in this study maintains a major maintenance depot where airframes and engines can be dismantled and rebuilt. In the industry as a whole, mechanics are more-or-less evenly split between line serve and major maintenance activities.

20/For the expected utility specification, set $v(x_t, \nu_t) = x_t$. For the Cobb-Douglas specification, set $k(\nu_t) = 1$ and $\theta_1 = \theta_2 = 1$. Income maximization is an appropriate objective for workers as a group if there are no constraints on the internal distribution of earnings or employment opportunities among the group.

21/The expected utility preference specification is linear in employment under the assumption that the probability of employment is proportional to the actual level of employment.

22/Since w_t is a function of a_t and ν_t, say $w_t = g(a_t, \nu_t)$, rational forecasts for w^*_{t+j} satisfy $E\, w^*_{t+j} = E\, g(a_{t+j}, \nu_{t+j})$.

23/Kennan (1978) provides a useful discussion of this two-step procedure.

24/Dropping time subscripts, expand $v(a) = v(w) + (a-w)\, v'(w) + \frac{1}{2}(a-w)^2\, v''(w)$, and write

$$S = w\left(1 - \frac{v(w)-v(a)}{wv'(w)}\right)$$

$$= w\left(1 - \frac{w-a}{w} - \frac{\delta}{2}\left(\frac{w-a}{w}\right)^2\right)$$

where $\delta = wv''(w)/v'(w)$. Next, linearize $\left(\frac{w-a}{w}\right)^2$ around π, where π is the average markup of w over a:

$$\left(\frac{w-a}{w}\right)^2 \cong 2\pi\left(\frac{w-a}{w}\right) - \pi^2 .$$

Subsituting this expression into the expression for S and assuming that π^2 is neglible yields

$$S = a(1 + \delta\pi) - w\delta\pi .$$

25/Equation (13) can also be written in terms of alternative wages and the preference shock variable ν_t using the first-order condition for contract wages. For purposes of forming forecasts of future values of N_t^*, however, it is convenient to express the employment equation in terms of w_t, since the forecasting equation for w_t is directly observable.

26/In the Cobb-Douglas case c_{1t} is proportional to the value of nonlabor inputs at the optimal level of labor inputs.

27/The adjustment parameter λ is related to the ratio of c_1 to c_2 by $\frac{c_1}{c_2} = (1-\lambda)(1-\lambda\beta)\lambda^{-1}$.

28/Sargent (1978) suggests this hypothesis as a means of generating a second-order autoregressive model for employment from a cost-of-adjustment model.

29/The theoretical model assumes that contract wage rates are adjusted every period, whereas mechanics wage rates are set in two or three year nominal contracts. This suggests that there may be a cost of adjusting contract wage rates that is missing from the model.

30/A detailed derivation of the reduced form employment equation is presented in the Appendix.

31/As an alternative to this estimation procedure, the model can also be estimated by applying instrumental variables techniques to the first-order condition for contract employment. The instrumental variables procedure has the advantage that closed-form solutions for the optimal employment choice are not required. The explicit solution procedure adopted here, on the other hand, has the advantage of offering a direct interpretation of the reduced-form system for departures, wages, and employment.

32/These unrestricted representations incorporate a variety of exclusion restrictions (for example, lagged employment is not included in the departures equation). Conditional on these exclusion restrictions, however, the estimates are unrestricted.

33/To estimate the reduced form employment equation I set the quarterly discount rate β to .99. When prices are included in the forecasting equations for wages, I use the following forecasting equations for aggregate manufacturing wages (a_t) and consumer prices (p_t):

$$\log a_t = .70 \log a_{t-1} + .02 \log a_{t-2} - .52 \log p_{t-1} + .47 \log p_{t-2}$$

$$\log p_t = 1.79 \log p_{t-1} - .78 \log p_{t-2} - .11 \log a_{t-1} + .02 \log a_{t-2} .$$

When prices are excluded from the wage forecasting equation, I use the following forecasting equation for manufacturing wages:

$$\log a_t = 1.09 \log a_{t-1} - .26 \log a_{t-2} .$$

34/When prices were excluded from the forecasting equation for contract wages, the sum-of-squares function contained a very flat ridge in the $b_2 - b_3$ plane. The fit of the model was essentially unchanged with b_2 large and negative and b_3 large and positive, so long as their ratio was approximately -.60.

[35] Brown and Ashenfelter (1986) report similar findings in their investigation of wage and employment outcomes for typographers.

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Appendix

Derivation of the Reduced Form Employment Equation

Let $y_t' = (\log F_t, \log F_{t-1}, \log w_t, \log w_{t-1}, \log a_t, \log a_{t-1}, \log p_t, \log p_{t-1})$ represent the vector of current and once-lagged values of departures, contract wages, manufacturing wages, and prices. Equation (8) can be written as $y_t = Ay_{t-1} + u_t$, where $u_t = (u_{1t}, 0, u_{2t}, 0, u_{3t}, 0, u_{4t}, 0)$, and A is a suitably defined matrix of coefficients. Let $e_1 = (1, 0, \ldots, 0)$. Then

$$(1-\lambda\beta) \sum_{j=0}^{\infty} (\lambda\beta)^j E_t \log F_{t+j} = e'(1-\lambda\beta) \sum_{j=0}^{\infty} (\lambda\beta A)^j y_t ,$$

with similar expressions for the forward-moving averages of contract wages and manufacturing wages. Provided that the characteristic roots of A are smaller than $(\lambda\beta)^{-1}$ in modulus, the infinite sum $\sum_{j=0}^{\infty} (\lambda\beta A)^j$ converges. Assuming this to be true, let

$$(1-\lambda\beta) \sum_{j=0}^{\infty} (\lambda\beta A)^j = A^* .$$

According to equation (7),

$$\text{(A.1)} \qquad \log N_t = \lambda \log N_{t-1} + (1-\lambda)[b_1 e_1' A^* + b_2 e_3' A^* + b_3 e_5' A^*] \, y_t + \epsilon_t^* ,$$

where ϵ_t is first-order autoregressive with autoregressive parameter ρ.

$$a^* = b_1 e_1' A^* + b_2 e_3' A^* + b_3 e_5' A^* .$$

Performing a transformation of (A.1) to eliminate the serial correlation in ϵ_t^* yields

$$\text{(A.2)} \qquad \log N_t = (\lambda+\rho) \log N_{t-1} - \lambda\rho \log N_{t-1} + (1-\lambda)a^*y_t - \rho(1-\lambda)a^*y_{t-1} + \xi_t \, ,$$

where ξ_t is serially uncorrelated. Finally, substituting for y_t into (A.2) yields

$$\text{(A.3)} \qquad \log N_t = (\lambda+\rho) \log N_{t-1} - \lambda\rho \log N_{t-1} + [(1-\lambda)a^*A - \rho(1-\lambda)a^*]y_{t-1} + \xi_t^* \, ,$$

where $\xi_t^* = \xi_t + (1-\lambda)a^*u_t$ is serially uncorrelated. In this paper I compute the matrix A^* numerically and use the resulting estimates to compute the coefficients in (A.3) for each value of λ , ρ , b_1, b_2, b_3, and the forecasting coefficients in A .

Figure 1

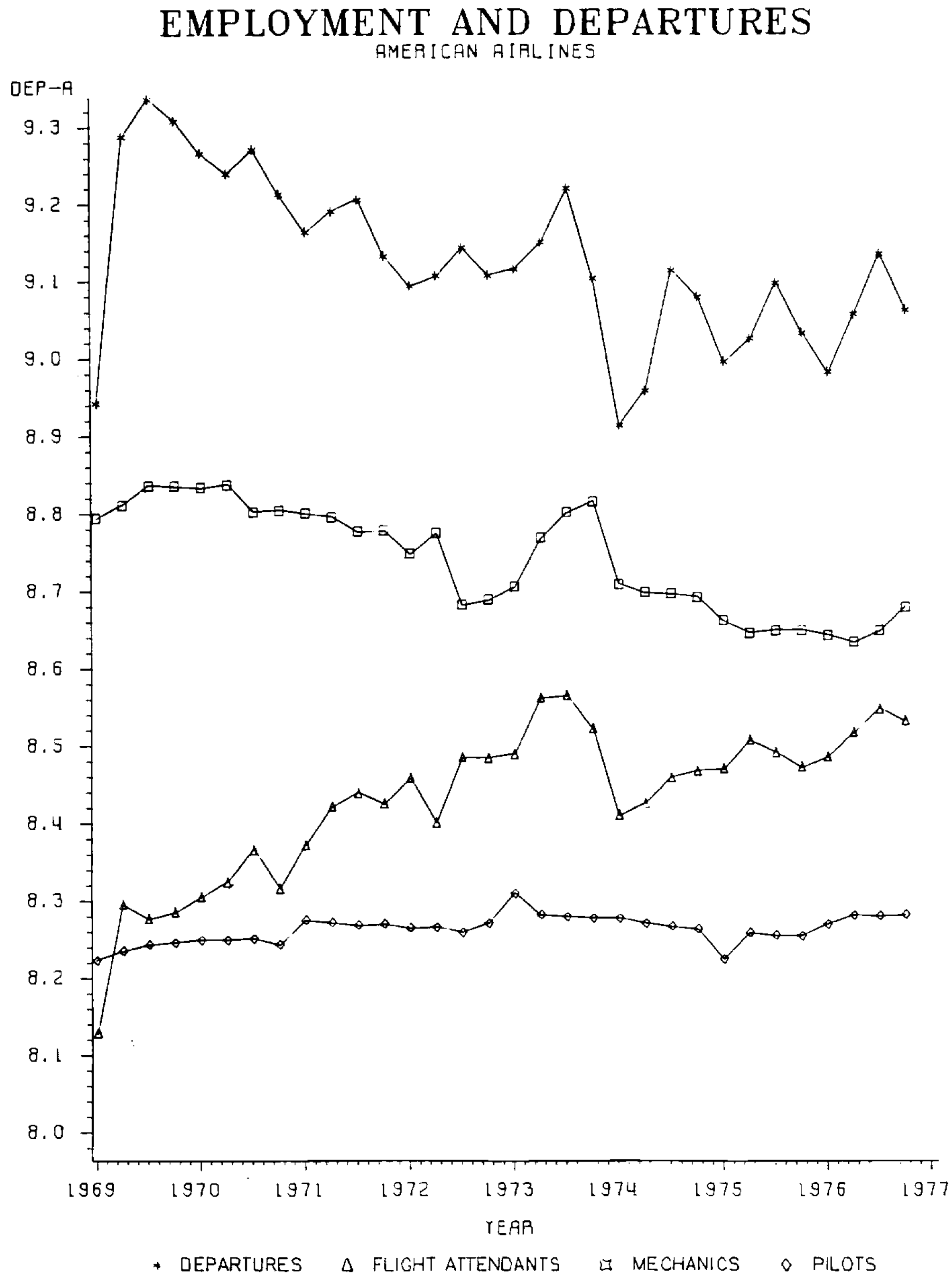
EMPLOYMENT AND DEPARTURES
AMERICAN AIRLINES
DEP-A
9.3
9.2
9.1
9.0
8.9
8.8
8.7
8.6
8.5
8.4
8.3
8.2
8.1
8.0
1969
1970
1971
1972
1973
1974
1975
1976
1977
YEAR
DEPARTURES
FLIGHT ATTENDANTS
MECHANICS
PILOTS

Table 1

Wage Rates for Airline Mechanics and Comparison Groups: 1969-1976

	WAGE GROUP											
	American-TWU a/		United-IAM b/		Western-IBT c/		Maintenance Mechanics in Manufacturing d/		Production Workers in Manufacturing e/		Licensed Mechanics Boeing-IAM f/	
	Nominal	Real	Nominal	Real	Nominal	Real	Nominal	Real	Nominal	Real	Nominal	Real
1969	4.60	4.60	4.40	4.40	4.47	4.47	3.77	3.77	3.07	3.07	4.46	4.46
1970	5.10	4.81	5.20	4.91	5.27	4.98	3.98	3.76	3.24	3.06	4.65	4.39
1971	5.60	5.07	5.60	5.07	5.68	5.14	4.24	3.84	3.44	3.11	4.90	4.44
1972	6.20	5.43	5.95	5.21	5.98	5.24	4.56	4.00	3.65	3.20	5.38	4.71
1973	6.40	5.28	6.60	5.44	6.45	5.32	4.84	3.99	3.90	3.22	5.78	4.77
1974	6.85	5.09	7.10	5.28	6.85	5.09	5.22	3.88	4.23	3.14	6.16	4.58
1975	7.50	5.10	7.70	5.24	7.70	5.24	5.97	4.07	4.65	3.17	7.03	4.79
1976	8.10	5.22	8.45	5.44	7.90	5.09	6.54	4.22	5.00	3.22	7.53	4.85

Notes: Real wage rates represent nominal rates divided by the CPI, all items, 1969 = 100.

a/ Average base rate in effect for mechanics in collective agreement between American Airlines and Transport Workers Union.

b/ Average base rate in effect for mechanics in collective agreement between United Airlines and Machinists Union. Wages for mechanics at Braniff, Continental, Eastern, TWA and United are similar.

c/ Average base rate in effect for mechanics in collective agreement between Western Airlines and Teamsters Union.

d/ Average hourly earnings of maintenance mechanics in manufacturing, from the BLS Area Wage Survey.

e/ Average straight-time hourly earnings of production workers in manufacturing, from Citibase.

f/ Average base rate in effect for licensed aircraft mechanics in collective agreement between Boeing and Machinists Union from the BLS Wage Chronology.

Table 2

Autoregressive Representations of Real Wage Rates

(standard errors in parentheses)

	Contract Real Wage: 1969III-1976IV					Contract Real Wage: 1964III-1978IV			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1. Contract Wage (t-1)	.71 (.08)	.61 (.07)	.63 (.08)	.60 (.07)	.61 (.07)	.69 (.05)	.66 (.05)	.66 (.05)	.66 (.05)
2. Contract Wage (t-2)	-.04 (.07)	-.04 (.07)	-.12 (.07)	-.09 (.07)	-.12 (.07)	-.02 (.05)	-.01 (.05)	-.03 (.05)	-.01 (.05)
3. Manufacturing Wage (t-1)	-- --	2.04 (.39)	.47 --	.74 (.57)	.86 (.52)	-- --	1.48 (.36)	-- --	.70 (.47)
4. Manufacturing Wage (t-2)	-- --	-1.37 (.40)	-- --	-1.08 (.52)	-1.19 (.47)	-- --	-.95 (.36)	-- --	-.62 (.44)
5. Price Index (t-1)	-- --	-- --	-1.86 (.42)	-1.72 (.64)	-1.56 (.59)	-- --	-- --	-1.62 (.40)	-1.14 (.54)
6. Price Index (t-2)	-- --	-- --	1.45 (.49)	1.13 (.53)	.94 (.50)	-- --	-- --	1.40 (.39)	.96 (.51)
7. Employment (t-1)	-- --	-- --	-- --	-- --	-.07 (.06)	-- --	-- --	-- --	-- --
8. Employment (t-2)	-- --	-- --	-- --	-- --	.12 (.06)	-- --	-- --	-- --	-- --
9. Probability Value for Exclusion of Manufacturing Wage	--	.00	--	.15	.06	--	.00	--	.15
10. Probability Value for Exclusion of Consumer Prices	--	--	.00	.04	.03	--	--	.00	.05

Note: Regressions include constants, linear trends, and quarterly dummy variables. Coefficients (except constants, trends, and seasonals) are restricted to be equal across airlines. Contract wages and manufacturing wages are deflated by the Consumer Price Index. Regressions contain airline-specific dummy variables for strike and immediate post-strike observations.

Table 3

Means and Standard Deviations: Domestic Airline Data 1969-I - 1976-IV

		Airline:						
		American	Braniff	Continental	Eastern	TWA	United	Western
1.	Average Quarterly Departures	92980	41230	35250	119570	70210	140000	37380
2.	Standard Deviation of Departures	9740	2870	2370	820	4420	14720	1860
3.	Average Quarterly Maintenance Employment	6255	1072	1109	6209	6358	9170	1336
4.	Standard Deviation of Employment	440	57	95	189	223	1002	47
5.	Average Number of Seats per Flight	132	116	129	107	126	134	121
6.	Average Flight Length	713	446	552	476	786	681	549
7.	Coefficient of Variation of Departures	.105	.070	.067	.049	.063	.105	.050
8.	Coefficient of Variation of Employment	.070	.053	.086	.030	.035	.109	.035
9.	Ratio of Coefficients of Variation-Employment/Departures	.67	.76	1.28	.62	.56	1.04	.70
10.	Standard Error of Detrended-Deseasonalized Log Departures	.052	.065	.066	.052	.042	.058	.040
11.	Standard Error of Detrended-Deseasonalized Log Employment	.035	.036	.041	.031	.036	.081	.031
12.	Ratio of Standard Errors-Employment/Departures	.67	.55	.62	.60	.86	1.40	.78

Note: Data pertain to domestic operations. Data from quarters with strike activity are removed. The following airlines had strikes during the sample period: American (1969-I), Continental (1976-IV), TWA (1973-IV), United (1975-IV) and Western (1969-III). All data are from Civil Aeronautics Board published and unpublished sources.

Table 4

Autoregressive Representations of Employment

(standard errors in parentheses)

	Dependent Variable: Logarithm of Maintenance Employment				
	(1)	(2)	(3)	(4)	(5)
1. Employment (t-1)	1.16 (.06)	1.09 (.06)	1.09 (.06)	1.09 (.06)	1.08 (.06)
2. Employment (t-2)	-.42 (.07)	-.34 (.07)	-.34 (.06)	-.36 (.06)	-.36 (.06)
3. Departures (t-1)	--	.12 (.04)	.13 (.04)	.14 (.04)	.13 (.04)
4. Departures (t-2)	--	-.10 (.04)	-.09 (.04)	-.11 (.04)	-.09 (.04)
5. Contract Wages (t-1)	--	--	.02 (.04)	--	-.01 (.04)
6. Contract Wages (t-2)	--	--	-.06 (.04)	--	-.10 (.04)
7. Manufacturing Wage (t-1)	--	--	--	-.28 (.16)	-.24 (.16)
8. Manufacturing Wage (t-2)	--	--	--	.46 (.16)	.53 (.16)
9. Probability Value of Exclusion Test for:					
(a) Departures	--	.05	.04	.04	.04
(b) Contract Wages	--	--	.27	--	.01
(c) Manufacturing Wages	--	--	--	.03	.02

Note: All regressions include constants, trends, and quarterly dummy variables. Coefficients (except constants, trends, and seasonals) are restricted to be equal across airlines. Wage rates are deflated by the CPI. The probability values in rows (9a)-(9c) refer to an F-test for the joint significance of two lagged values of the indicated variable.

Table 5

Additional Autoregressive Models of Employment

(standard errors in parenthesis)

	Additional Explanatory Variable Included in Employment Regression								
	Consumer Prices (1)	Real GNP (2)	Output Price Index[a] (3)	Fuel Price Index[b] (4)	Parts Price Index[c] (5)	Available Seat Miles[d] (6)	Revenue Passenger Miles[e] (7)	Domestic Flight Hours[f] (8)	Total Flight Hours[g] (9)
1. Employment (t-1)	1.03 (.06)	1.06 (.06)	1.09 (.06)	1.07 (.06)	1.09 (.07)	1.00 (.07)	1.07 (.06)	1.04 (.06)	1.08 (.06)
2. Employment (t-2)	-.31 (.06)	-.33 (.06)	-.36 (.06)	-.35 (.06)	-.34 (.07)	-.31 (.06)	-.34 (.06)	-.31 (.07)	-.35 (.06)
3. Departures (t-1)	.15 (.04)	.13 (.04)	.13 (.03)	.11 (.04)	.09 (.04)	.25 (.06)	.14 (.04)	.21 (.08)	.18 (.06)
4. Departures (t-2)	-.11 (.04)	-.09 (.04)	-.07 (.03)	-.08 (.04)	-.07 (.04)	-.05 (.06)	-.11 (.04)	-.11 (.07)	-.09 (.06)
5. Contract Wages (t-1)	.02 (.04)	-.01 (.04)	.01 (.03)	-.03 (.04)	.01 (.04)	.03 (.04)	-.02 (.04)	.01 (.04)	.00 (.03)
6. Contract Wages (t-2)	-.10 (.03)	-.10 (.04)	-.11 (.03)	-.07 (.04)	-.11 (.04)	-.10 (.04)	-.08 (.04)	-.10 (.04)	-.08 (.04)
7. Manufacturing Wage (t-1)	-.53 (.23)	-.26 (.17)	-.34 (.15)	-.14 (.20)	-.39 (.18)	-.41 (.18)	-.26 (.16)	-.22 (.19)	-.24 (.17)
8. Manufacturing Wage (t-2)	.74 (.21)	.76 (.20)	.48 (.14)	.64 (.20)	.73 (.20)	.58 (.18)	.59 (.17)	.58 (.19)	.53 (.17)
9. Added Variable (t-1)	-.33 (.26)	-.08 (.11)	.07 (.07)	.01 (.03)	.15 (.08)	-.12 (.04)	-.03 (.02)	-.10 (.07)	-.06 (.06)
10. Added Variable (t-2)	.27 (.21)	-.04 (.10)	.01 (.07)	.02 (.03)	-.10 (.08)	-.04 (.04)	.02 (.02)	.00 (.07)	-.01 (.06)
11. Probability Value for Exclusion of Added Variable	.55	.34	.50	.34	.17	.01	.57	.22	.46

Notes: See notes to Table 4.

[a] Price index of domestic passenger fare rates set by the Civil Aeronautics Board (constructed by the author).

[b] Price index for jet fuel (constructed by the author).

[c] Price index for commodity group 14: miscellaneous parts and machinery.

[d] Available seat miles on scheduled domestic passenger routes.

[e] Revenue passenger miles on scheduled domestic passenger routes.

[f] Aircraft revenue hours in domestic service, including non-scheduled, freight, and scheduled passenger service.

[g] Aircraft revenue hours in domestic and international service.

and (4) of Table 8. The estimates in column (7) correspond to the structural estimates in column (5) of

Table 6

Autoregressive Representations of Departures

(standard errors in parentheses)

	Additional Explanatory Variable Included in Departures Regression:				
	None (1)	Employment (2)	Real GNP (3)	Manufacturing Wage (4)	Consumer Prices (5)
1. Departures (t-1)	1.07 (.07)	1.03 (.06)	.91 (.06)	1.00 (.07)	1.00 (.07)
2. Departures (t-1)	-.24 (.07)	-.26 (.06)	-.22 (.06)	-.23 (.07)	-.24 (.06)
3. Added Variable (t-1)	--	.00 (.06)	.24 (.16)	.20 (.32)	-.49 (.33)
4. Added Variable (t-2)	--	-.05 (.06)	-.22 (.17)	-.08 (.32)	.49 (.33)
5. Probability Value for Exclusion of Added Variable	--	.35	.38	.69	.38

Notes: See notes to Table 4.

Table 7

Reduced Form Parameter Estimates for Departures, Wages, Employment: Seven Domestic Airlines 1969III – 1976IV[1]

(standard errors in parentheses)

	Unrestricted Reduced Forms		Restricted Reduced Forms[2]				
			Labor Demand Model		Strong Form Efficient Contract Model		General Model
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Departures Equation:							
1. Departures (t-1)	1.08	1.06	1.09	1.10	1.09	1.10	1.13
	(.16)	(.16)	(.15)	(.14)	(.15)	(.13)	.12
2. Departures (t-2)	-.27	-.26	-.30	-.28	-.30	-.29	-.33
	(.13)	(.13)	(.11)	(.14)	(.11)	(.09)	(.09)
Wages Equation:							
3. Contract Wages (t-1)	.62	.62	.62	.64	.62	.64	.68
	(.17)	(.16)	(.17)	(.13)	(.17)	(.12)	(.15)
4. Contract Wages (t-2)	-.08	-.12	-.07	-.14	-.08	-.14	-.19
	(.16)	(.15)	(.16)	(.11)	(.16)	(.10)	(.12)
5. Manufacturing Wages (t-1)	1.43	.70	1.39	.59	1.37	.58	.65
	(.77)	(.99)	(.76)	(.63)	(.73)	(.59)	(.71)
6. Manufacturing Wages (t-2)	-.59	-.85	-.62	-.80	-.57	-.85	-.50
	(.77)	(.96)	(.70)	(.61)	(.66)	(.55)	(.69)
7. Consumer Prices (t-1)	---	-1.21	---	-1.22	---	-1.25	-1.01
		(1.12)		(.68)		(.82)	(.90)
8. Consumer Prices (t-2)	---	.62	---	.63	---	.63	.56
		(.96)		(.60)		(.71)	(.78)
Employment Equation:							
9. Employment (t-1)	1.01	1.01	1.04	1.05	1.03	1.05	1.07
	(.13)	(.14)					
10. Employment (t-2)	-.29	-.30	-.26	-.27	-.26	-.27	-.28
	(.11)	(.12)					
11. Departures (t-1)	.15	.14	.15	.13	.14	.13	.15
	(.07)	(.07)					
12. Departures (t-2)	-.10	-.10	-.09	-.08	-.09	-.08	-.09
	(.06)	(.07)					
13. Contract Wages (t-1)	.05	.05	-.01	0.0	0.0	0.0	0.0
	(.07)	(.08)					
14. Contract Wages (t-2)	-.15	-.14	0.0	-.01	0.0	0.0	-.02
	(.07)	(.07)					
15. Manufacturing Wages (t-1)	-.35	-.30	.02	0.0	.06	0.0	.01
	(.27)	(.40)					
16. Manufacturing Wages (t-2)	.67	.70	-.01	-.01	-.02	0.0	-.06
	(.29)	(.36)					
17. Consumer Prices (t-1)	---	.07	---	-.02	---	.01	.01
		(.50)					
18. Consumer Prices (t-2)	---	-.03	---	.01	---	.01	-.07
		(.37)					
Log Likelihood	-209.85	-194.03	-225.09	-208.08	-225.32	-206.09	-204.26

Notes: [1] Estimated on detrended and deseasonalized data. Observations from strike and immediate post strike periods are deleted. Estimates are from the second stage of a two-step generalized least squares procedure.

[2] Restricted reduced forms are conditional on parameter estimates for consumer price and manufacturing wage equations. The estimates in columns (3) and (4) correspond to the structural estimates in columns (1) and (2) of Table 8. The estimates in columns (5) and (6) correspond to the structural estimates in columns (3) and (4) of Table 8. The estimates in column (7) correspond to the structural estimates in column (5) of Table 8.

Table 8

Parameter Estimates for Partial Adjustment

Employment Equation: Seven Domestic Airlines

1969III - 1976IV[1/]

(standard errors in parentheses)

	Labor Demand Model		Strong Form Efficient Contract Model		General Model
	Prices Excluded (1)	Prices Included (2)	Prices Excluded (3)	Prices Included (4)	Prices Included (5)
1. Partial Adjustment Parameter (λ)	.44 (.22)	.44 (.21)	.44 (.22)	.44 (.21)	.49 (.24)
2. Serial Correlation Parameter (ρ)	.60 (.23)	.61 (.22)	.60 (.23)	.60 (.22)	.57 (.26)
3. Output Elasticity (b_1)	.77 (.41)	.66 (.30)	.70 (.37)	.67 (.29)	.76 (.30)
4. Contract Wage Elasticity (b_2)	.03 (.05)	.03 (.03)	0.0 ---	0.0 ---	.38 (.91)
5. Alternative Wage Elasticity (b_3)	0.0 ---	0.0 ---	.29 (1.34)	-.05 (.95)	-1.02 (2.44)
6. Log Likelihood	-225.09	-208.08	-225.32	-206.09	-204.26
7. Goodness-of-fit against Unrestricted Model[2/]	30.48 (.000)	28.10 (.000)	30.94 (.000)	24.12 (.000)	20.46 (.001)

Notes: [1/] See notes to Table 7. Estimates in columns (1) and (3) are based on a forecasting equation for contract wages that excludes consumer prices. Estimates in columns (2), (4), and (5) are based on a forecasting equation for contract wages that includes manufacturing wages and consumer prices. Estimates are conditional on parameter estimates for consumer price and manufacturing wage equations.

[2/] Probability value in parentheses. The models in columns (1) and (3) have 4 degrees of freedom. The models in columns (2) and (4) have 6 degrees of freedom. The model in column (5) has 5 degrees of freedom.