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Welcome to the Transportation Research Forum's 1998 Annual Meeting

These proceedings contain those papers presented at the 40th Annual Meeting of the Transportation Research Forum, held in Philadelphia from October 29-31, 1998, that were received by the deadline publishing date. All papers were reviewed by the Program Vice President to assess their suitability for inclusion in these volumes. Additional papers may be made available by some of the presenters at the time of the Conference.

The Transportation Research Forum (TRF) is an independent organization of transportation professionals providing pertinent and timely information to those who conduct research and those who use and benefit from research. It functions as an impartial meeting ground for carriers, shippers, government officials, consultants, university researchers, suppliers, and others seeking an exchange of information and ideas related to both passenger and freight transportation. The Transportation Research Forum started with a small group of transportation researchers in New York in 1958 and the first national meeting was held in St. Louis in 1960. National meetings have been held annually since 1960 at various cities throughout the U.S. and Canada.

Numerous TRF members and supporters aided in the development of this year's Forum, but it is authors of the papers, the organizers and contributors to the various panels, and the session chairs who make TRF annual meetings so worthwhile and enjoyable. The conference program simply reflects the interests, enthusiasm and commitment of those members of the transportation community. Special thanks go to Patrick and Judy Little who graciously agreed to assemble this year's proceedings for me. Without their help, the job of Program Chair would have been much more of a burden.

A number of other TRF members also assisted in the development of this meeting. Randy Resor and Jim Blaze were constant sources of ideas and encouragement. When help was asked for, they came through repeatedly. Other TRF members provided help with the program in their areas of interest. I want to thank Alan Bender, Michael Belzer, Ken Ericksen, Paul Gessner, Harold Kurzman, Scott Ornstein, Clint Oster, and Peter Smith for their help. Claire LaVaye at the University of Texas assisted with promoting the meeting on TRF's website. Finally, Rick Guggolz provided valuable assistance on the businees arrangements for the conference.

We are also grateful to those companies and organizations who have sponsored awards or made other contributions to the success of the Forum. These include: LTK Engineering, The Metropolitan Transit Association, and RailTex. Among our own members, we are especially indebted to the TRF Foundation, the Cost Analysis Chapter and the Aviation Chapter for their assistance and support.

These proceedings are prepared and distributed at the TRF Annual Forum as a means of disseminating information and stimulating an exchange of ideas during the meeting. Every effort has been made to reproduce these papers accurately. TRF, however, assumes no responsibility for the content of the papers contained in these volumes.

Richard Golaszewski
Program Vice President
October, 1998

Deregulation and Trucking Wages: A Time Series Approach

The effect of deregulation is re-examined using a time series approach. Unlike previous studies which rely upon cross-sectional techniques to analyze deregulation's effect on the wages of truck drivers, the authors use Unit Root and Cointegration techniques to analyze what is, in fact, a time series phenomenon. Relating the trucking wage to alternative economy-wide wage measures, the changing wage differentials between trucking and other industries can not be attributed to the structural change of deregulation. Wage declines in trucking post-deregulation mirror those found economy-wide and provide support for the hypothesis that previous studies overstate deregulation's effect by ignoring time processes in the data.

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I. Issues of Nonstationarity in Micro Analysis

Although much attention has been paid to nonstationarity in modeling macroeconomic phenomena, this has not carried over to microeconomic literature, with the exception of recent developments in panel data estimation. This is especially surprising in the deregulation literature in industrial organization. Studies on the effects of government intervention, especially those focusing on the effects of deregulation typically use repeated cross sections (often from the Current Population Survey).[1] Since these studies are ostensibly measuring some phenomenon which is a function of time (such as deregulation), it seems that particular attention should be paid to stochastic time processes in the data, however, using repeated cross sectional data, little attention has been paid to time components. Further, the data typically used is cross-sections over a relatively small number of years (usually less than twenty). Using this data structure, little can be done to analyze the data generating processes over time.

Alternately, we would propose that the same type of industry analysis could be done from a pure time series perspective. Rather than using cross-sectional observations on particular individuals over time, monthly time series data can be used to analyze industry changes. An industry, which seems to lend itself particularly well to this type of analysis is trucking. Typical analysis of the effect of trucking deregulation finds significant wage decreases from deregulation. These wage effects are significantly different than those found in other industries such as telecommunications, airlines and railroads, where deregulation's effect was felt on employment and not wages (Hendricks

[1] Examples are numerous. Cites for the trucking industry alone include Rose (1987), Hirsch (1988 and 1993), Hirsch and Macpherson (1997), Heywood and Peoples (1994) and Peoples and Saunders (1993).

1994). Notable is the fact that previous studies on trends in trucking wages over the past 20 years have few, if any, time controls. However, trucking deregulation began administratively in the mid to late 1970's and was enacted as law in 1980. Concurrently, there were also strong downward trends in blue collar wages economy-wide.

Though the wages of drivers are falling following deregulation (using 1979 as a benchmark as is common to trucking studies), the downward trends in driver wages preceded this and are mirrored in movements of manufacturing and construction wages. The question, then, becomes whether deregulation in the trucking industry actually caused substantial declines in driver wages, or if the wage declines found in previous studies result from the failure to account properly for the time aspects of the data. If the latter were true, then the wage declines attributed to deregulation could be largely due to economy-wide wage trends not specific to the trucking industry.

If we believe that labor is fairly mobile between industries then real wage differentials between trucking and other industries need to briefly be addressed. The obvious explanations are skill differentials and compensating differentials. Both of these arguments could be used to explain the higher wages in trucking than either construction or manufacturing. A major source of the trucking wage premium prior to 1980 was regulation. Rent sharing was prevalent in trucking pre-deregulation, especially for unionized drivers. (Hirsch 1988 and Rose 1987).

Using time series econometric techniques, we can identify periods where the real wage differential between trucking and either manufacturing or construction is constant, and the points in time where there is a structural break in the differential. A structural break could be caused by many factors. For example, a technology shock in one particular industry requiring higher skilled labor which much be compensated at a higher level, or aggregate demand shocks exclusive to one industry. The structural break of particular interest to this study is deregulation. The goal is to determine whether deregulation, a structural break, explains the change in the trucking wage vis-à-vis two other non-regulated industries. This analysis relies upon exploiting time series estimation techniques and applying them to industry analysis - a method overlooked in labor and industrial organization literature.

II. Nonstationarity and Estimation of Wage Trends in Trucking

The difference between "macro" and "micro" analysis is often easy to demarcate by examination of the data and estimation procedures used. Whereas "micro" analysis relies upon large cross-sectional data sets, using oftentimes sophisticated cross-sectional estimation techniques, "macro" analysis is characterized by time series data sets with many fewer observations, relying on equally sophisticated time series estimation techniques. Typically there is little crossover between the two, the notable exception being panel data analysis that is becoming more widespread in all fields.

In time series analysis, much attention has been paid to stochastic time processes in the data and the consequences of OLS estimation under these data structures since the pioneering work of Granger and Newbold (1974). Granger and Newbold demonstrate the problem of "spurious regression" by regressing two independently generated random walks against each other. They find a significant relationship a majority of the time. They posit that attention paid to autoregressive processes in macroeconomic data overlooks the fact that the data is nonstationary (and often integrated of some order). Using OLS and relying on t tests to determine if a series is AR(1) versus difference stationary, i.e. modeling $Yt = \delta + \varphi Yt-1 + \varepsilon t$ and testing $\varphi = 1$, is invalid since the t statistic does not have a t distribution in the presence of a unit root. OLS distribution theory is invalid in the presence of unit roots according to Phillips (1986) and inference needs to be based on a corrected distribution.

Arising from this issue of nonstationarity or "unit roots" in a data generating process can give rise to the "Spurious Regression" problem where a relationship may appear to exist between two variables (using OLS) merely because they follow a similar time trend. This stems from the fact that if two variables are I(1) then the residuals from the OLS regression are also I(1), violating a classic assumption of OLS. Engle and Granger (1987) present a comprehensive treatment for modeling nonstationary series. If there is a relationship between two I(1) variables that is stationary such that the residuals from an OLS regression are I(0) then the variables are said to be cointegrated. This represents a stable long run relationship between the variables.

These techniques appear to lend themselves well to estimating the data generating processes underlying real wages. The objective of this study is to assess the effects of trucking deregulation from a perspective previously not examined; i.e. can we attribute the majority of the decline in trucking wages in the late 1970s and early 1980s to deregulation, or were there other economy-wide factors which played a significant role? Can we model trucking wages as mirroring economy-wide wage trends, thereby implying a smaller wage effect of deregulation than previously assumed? Econometrically, we are investigating whether the trucking wage is cointegrated with wages in other industries, and, if so, does deregulation represent a structural break in that relationship?

In order to test these issues, we model the real hourly trucking wage as a function of the real hourly manufacturing wage and the real hourly construction wage. These wages were chosen for two reasons. First, we have reason to expect that these wages can be considered "reservation wages" for truck drivers as these groups have similar demographic characteristics. Second, there is no reason to expect that trucking deregulation should have any significant effect on the wages in these two industries.

Figure 1 shows trends in wages for these two industries (deflated with the monthly CPI-U in 1982-1984 dollars). The data source used is "Employment, Hours, and Earnings United States, 1909-1994", published by the U.S. Department of Labor. As is evident, wages have declined in real terms over time, but these declines are particularly significant beginning in the late 1970s, which also corresponds to the beginning of deregulation. However it is interesting to note that both the construction and manufacturing wages also declined precipitously over the same period.

We thus model the trucking wage as a function of the manufacturing and construction wage. Care has to be taken in doing this as previously mentioned since if both series are nonstationary then using OLS to model the relationship is invalid. For example, if both series are trending downward over time, then OLS may find a relationship between the variables that actually is not present statistically due to "spurious regression". The first step, then, becomes to determine whether the two series are nonstationary. If the two series are nonstationary then the second step is to determine whether the two are cointegrated. The final step, if cointegration characterizes the relationship, is to quantify the relationship between the two variables.

The test for cointegration can also include a structural break for deregulation as the two series may be cointegrated before and after deregulation but may look as though they are not cointegrated over the entire period if the structural break is not included in the model. This follows from Perron (1989). If cointegration exists over the entire time period, without a structural break included, this implies a stronger relationship. It could almost be inferred that there was no wage effect of deregulation - that is, there was no wage shock felt by the trucking industry that was not also felt by the manufacturing or construction industries. This would, in turn, imply no effect of deregulation if we can reasonably assume that deregulation in trucking should have no significant effect on manufacturing or construction.

III. Estimation of the Relationship between Wages

Unit Root Tests

The first step in cointegration analysis is to test for the order of integration on the variables. A nonstationary series is integrated of order one if its first difference is stationary. However, it is not necessarily the case that a unit root characterizes all nonstationary series; nonstationary series could either be trend or difference stationary, the latter the only case that implies the presence of a unit root. To test for the type of nonstationarity present in the series on wages, we implement several unit root tests. These are the Augmented Dickey-Fuller (ADF) and the Weighted Symmetric (WS) tests. Table 1 presents the results of these tests. The optimal lag length is chosen using the

Akaike Information Criterion. We fail to reject the null hypothesis of a unit root in all cases.

We also employ unit root tests to examine the relationship between trucking and the two other sectors: manufacturing and construction. The wage differentials between sectors are obtained and this differential is tested for a unit root. If these series are stationary then it would seem there was no wage effect of deregulation, as the wage differentials remain constant over time. This is a strong condition and is rejected as presented in Table 2. Both the trucking-manufacturing differential and the construction-trucking differential are non-stationary. This does not necessarily imply that there was a wage effect due to deregulation. Changes in the wage differential could result from other factors external to deregulation, but a deregulatory wage effect can not be rejected.

The next step is to test the wage differentials for the presence of a structural break. A trend stationary process with a structural break is often indistinguishable from a difference stationary process (Perron 1989). If the wage differentials could actually be represented by a stationary process with a structural break corresponding to deregulation then the difference in means would capture the wage effect of deregulation.

A simple yet slightly inefficient test for this is to split the sample into periods pre and post deregulation. If the wage differentials are stationary within the sub-samples then it can be claimed that the proper representation is a trend stationary model with a structural break representing deregulation. Table 3 presents the results for this test. It is apparent that deregulation itself does not explain the non-stationarity in the wage differentials as they are non-stationary even within the sub-samples. There are two major limitations to this approach, however. The first is that it assumes that the labor markets respond homogeneously to aggregate shocks, in other words the cointegrating vector is (1, -1). The second is that it assumes that the only possible structural break occurs at the point of deregulation.

Cointegration

To test the relationship between the wages without imposing a (1, -1) cointegrating vector, we use Engle and Granger's residual based test for cointegration. Their test consists of estimating an OLS regression and testing the residuals for stationarity. If the variables in the regression are all I(1) and the residuals are I(0) then there exists a long run cointegrating relationship. We use the ADF test to test the residuals from the equation and we also use the critical values to reflect this. These results can be found in Tables 4 and 5.

From this we can see that there is no stable relationship between the trucking wage and the manufacturing wage or the construction wage pre or post deregulation. One possible explanation for this is that deregulation did indeed have an impact on the wage differential, but not unlike other structural changes that happened pre and post deregulation. The other difficulty with this or any approach is trying to identify the point in time when deregulation took place. In reality policies are implemented over time and not at a specific point in time.

IV. Summary and Conclusions

Though many studies of the effect of trucking deregulation on wages in the industry find substantial wage declines due to deregulation, none of these studies properly account for the time processes in the data. As deregulation is inherently a time effect, perhaps a better approach to modeling the impact of deregulation on wages is to approach the problem from a pure time series perspective.

Using time series techniques, trends in the real hourly trucking wage are examined over time and modeled as functions of economy-wide wage trends. Tests for unit roots find that the real trucking wage is non-stationary as are wages in the construction and manufacturing sectors. Though the differentials in wages are non-stationary as well, these can not be represented as trend stationary processes with structural breaks, suggesting that deregulation is not primarily responsible for this non-stationarity.

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Figure 1: Trends in Real Hourly Wages

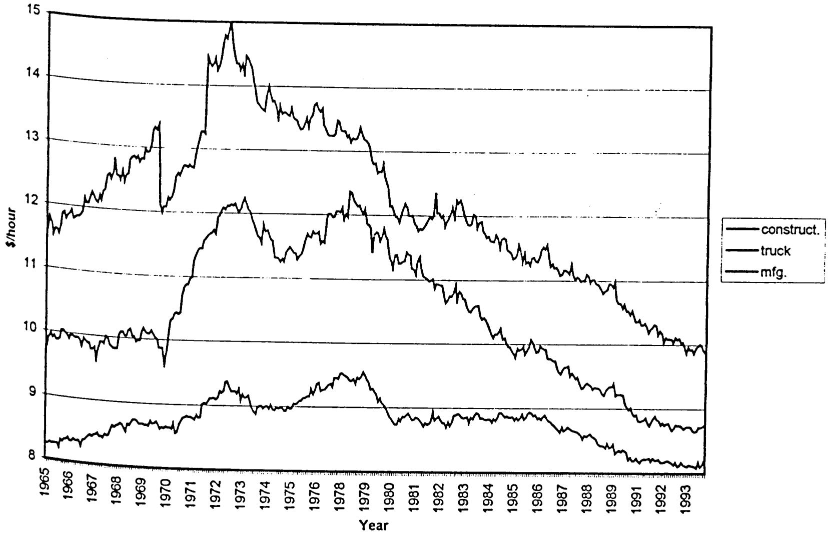

Table 1. Unit Root Tests on Wages

With Constant	alpha	t-stat	p-value
Weighted Symmetric			
Truck (14)	.9937	-1.466	.5357
Mfg (24)	.9911	-1.237	.6966
Construct (24)	.9970	-0.483	.9562
Augmented Dickey-Fuller			
Truck (14)	.9944	-1.258	.6470
Mfg (24)	.9890	-1.403	.5804
Construct (24)	1.001	0.210	.9728
With Constant and Trend	alpha	t-stat	p-value
Weighted Symmetric			
Truck (14)	.9925	-1.499	.8920
Mfg (24)	.9914	-1.128	.9616
Construct (24)	.9963	-0.379	.9958
Augmented Dickey-Fuller			
Truck(14)	.9896	-2.07	.563
Mfg (24)	.984	-1.99	.6061
Construct (24)	.9766	-2.298	.4353

Note : The maximum lag augmenting the AR regression appears in parentheses. It is based on the lowest, sample size corrected, Akaike Information Criterion plus two lags. The alpha column provides the estimate of the AR term, with the t-stat column its test statistic with the null hypothesis of unity. Finally the p-value is the asymptotic probability value based on the inclusion of the deterministic regressors.

Table 2. Unit Root Tests on Differentials

With Constant	alpha	t-stat	p-value
Weighted Symmetric			
Truck-mfg (15)	.9903	-1.484	.5231
Construct-truck (15)	.9712	-2.007	.1867
Augmented Dickey-Fuller			
Truck-mfg(15)	.9923	-1.142	.6982
Construct-truck (15)	.9738	-1.798	.3812
With Constant and Trend	alpha	t-stat	p-value
Weighted Symmetric			
Truck-mfg(15)	.9851	-1.853	.7409
Construct-truck (15)	.9616	-2.291	.4359
Augmented Dickey-Fuller			
Truck-mfg(15)	.9832	-2.054	.5718
Construct-truck (15)	.9639	-2.109	.5410

Note : The maximum lag augmenting the AR regression appears in parentheses. It is based on the lowest, sample size corrected, Akaike Information Criterion plus two lags. The alpha column provides the estimate of the AR term, with the t-stat column its test statistic with the null hypothesis of unity. Finally the p-value is the asymptotic probability value based on the inclusion of the deterministic regressors.

Table 3 Unit Root Tests on Sub-samples

With Constant	alpha	t-stat	p-value
Weighted Symmetric			
Truck-mfg-pre(15)	.9688	-1.950	.2138
Truck-mfg-post(14)	.9901	-1.240	.6946
Augmented Dickey-Fuller			
Truck-mfg-pre(15)	.9785	-3.609	.5836
Truck-mfg-post(24)	.9842	-2.148	.2256
With Constant and Trend	alpha	t-stat	p-value
Weighted Symmetric			
Truck-mfg-pre(15)	.9298	-2.775	.1541
Truck-mfg-post(14)	.9606	-1.664	.2436
Augmented Dickey-Fuller			
Truck-mfg-pre(15)	.9278	-2.723	.2265
Truck-mfg-post(24)	.9686	-1.495	.8310

Note: The maximum lag augmenting the AR regression appears in the parentheses. It is based on the lowest, sample size corrected, Akaike Information Criterion plus two lags. The alpha column provides the estimate of the AR term, with the t-stat column its test statistic with the null hypothesis of unity. Finally the p-value is the asymptotic probability value based on the inclusion of the deterministic regressors

Table 4. Cointegration Test Results - Trucking as a Function of Manufacturing

Full sample (7)	-2.0195	-3.3556
Pre-deregulation (7)	-1.3901	-3.3766
Post-deregulation (11)	-1.5028	-3.3738

Note: The ADF lag length appears in parenthesis, followed by the test statistic and the appropriate 95% critical value.

Table 5. Cointegration Test Results - Trucking as a Function of Construction

Full sample (3)	-1.6317	-3.3556
Pre-deregulation (1)	-1.4612	-3.3766
Post-deregulation (12)	-1.5476	-3.3738

Note: The ADF lag length appears in parenthesis, followed by the test statistic and the appropriate 95% critical value.