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MANUFACTURING AND NON-MANUFACTURING EMPLOYMENT, EXCHANGE RATE AND OIL PRICE: A U.S. STATE-LEVEL TIME SERIES ANALYSIS

Bradley T. Ewing
Rawls Professor of Operations Management
Area of Information Systems & Quantitative Sciences
Rawls College of Business
Texas Tech University
Lubbock, TX 79409-2101 Tel: (806) 742-3939
E-mail: bradley.ewing@ttu.edu

Benhua Yang
Assistant Professor
Department of Economics
Stetson University
421 N. Woodland Blvd., Unit 8301
Deland, FL 32723
Office: 386-822-7542
E-mail:byang@stetson.edu

Abstract

This paper investigates the time series properties of U.S. state-level manufacturing and non-manufacturing employment and two economy-wide variables: real effective exchange rate and real oil price. Examining the 1990 to 2005 period, cointegration tests and error-correction models reveal a long run relationship between manufacturing employment and the exchange rate in eleven states, while no evidence of this relationship between non-manufacturing employment and the exchange rate was detected. Additionally, in the vast majority of states, both manufacturing and non-manufacturing employment appear to have a long-run equilibrium relationship with the real price of oil.

Keywords: Manufacturing and Non-manufacturing; Employment; Economics

1. Introduction

The United States experienced considerable exchange rate fluctuations since the adoption of a flexible exchange rate regime in the early 1970s (see Figure 1). Increases in the exchange rate have been argued to be associated with employment reductions and thus have been followed by frequent calls for employment protection. Since the 1973-1974 oil price shocks, the U.S. also experienced substantial volatility in oil prices, drawing attention to oil's impact on the economy in general and jobs in particular. Much has been written on the employment effect of exchange rate movements and oil price changes throughout the whole economy and within industry sectors, particularly manufacturing. However, little attention has been given to (1) how individual state employment measures respond to changes in these two economy-wide variables and (2) the relationship between these macroeconomic factors and non-manufacturing employment. This research thus focuses on the time series dynamics of state-level employment, exchange rate, and oil prices. Moreover, given potentially vast differences in institutional and market structures between the traditional goods-producing and non-manufacturing sectors, we examine manufacturing and non-manufacturing employment separately. Previous studies have focused on the manufacturing employment effects of exchange rate movements; yet it is interesting to examine the non-manufacturing job effects in light of its increasingly large proportion in the U.S. economy and its increasing integration into the global economy. Such an analysis is also important from a policy perspective, for example, if the non-manufacturing sector is also responsive to exchange rate movements, then policy measures targeting exchange rate fluctuations may need to be reevaluated. Similarly, since prior research on job effects of oil price changes has frequently used aggregate employment data, this paper also investigates the long run relationship between employment and oil price changes distinguishing between the manufacturing and non-manufacturing sectors.

A number of researchers have examined the response of U.S. employment to exchange rate fluctuations.[1] Focusing on the first half of the 1980s, Branson and Love (1988) and Revenga (1992) suggest that the sharp rise in the exchange rate resulted in a decrease in manufacturing employment, while Glick and Hutchison (1990) contend that the exchange rate change had minimal influence. Many recent studies continue to present contradictory results. Burgess and Knetter (1998), and Goldberg and Tracy (1999), for example, find significant responsiveness of employment to exchange rate movements, whereas Campa and Goldberg (2001) find only a small effect, and Kandil and Mirzaie (2003)

[1] International studies of the employment-exchange rate relationship have also been conducted. For example, Branson and Marston (1989) and Dekle (1998) analyze the case for Japan, Gourinchas (1999) and Hatemi-J and Irandoust (2006) consider France, and Burgess and Knetter (1998) provided an international comparison of the G-7 countries.

contend that exchange rate fluctuations have no statistically significant effect on manufacturing employment growth. Thus, the employment effect of exchange rate movements is still unclear.

One problem with the aforementioned studies is that they have implicitly assumed the stationarity of the respective time series, although their results depend much on the use of non-stationary data (e.g., Branson and Love, 1988; Revenga, 1992; Burgess and Knetter, 1998; Campa and Goldberg, 2001). As a result, prior estimation may have led to spurious results and inconsistent parameter estimates. Another problem is that much of the existing literature does not take into account regional heterogeneity and therefore fails to incorporate into the analysis the differential impact of the exchange rate on state-level employment. Explicitly examining the time series properties of state-level employment and the exchange rate appears crucial for understanding this relationship.

In addition to the exchange rate, this research investigates the effect of oil price on state-level employment. Oil price shocks have been argued to affect a number of macroeconomic variables (for a general survey, see Brown and Yucel, 2002), including the natural rate of unemployment (e.g., Caruth, Hooker and Oswald, 1998; Davis and Haltiwanger, 2001). Keane and Prasad (1996) find that oil price increases reduce aggregate employment in the short run but increase aggregate employment in the long run, suggesting possible substitution between energy and labor in the aggregate production function. Kandil and Mirzaie (2003), on the other hand, find that energy price changes do not affect aggregate employment growth, but unanticipated energy price movements may increase manufacturing employment. One common feature of these studies is the assumption of exogeneity of the oil price movement with respect to U.S. macroeconomy. This latter point has recently been criticized by Barsky and Kilian (2004), who suggest reverse causality may exist going from macroeconomic variables to oil prices.

In this paper we explore the time series properties of state-level employment for both manufacturing and non-manufacturing sectors and the two macroeconomic variables mentioned above. We employ the Engle-Granger (1987) cointegration procedure in conjunction with error correction models. The advantage to this approach is that the results are straightforward to interpret and robust. Both manufacturing and non-manufacturing industry employment data for each state are utilized as well as the corresponding aggregate U.S. employment measure. The employment data correspond to the recently constructed North American Industry Classification System (NAICS) and therefore serve to update the previous studies which utilized the older Standard Industrial Classification (SIC) definition of employment. In what follows, Section 2 describes the methodology and data, Section 3 presents the empirical results, and concluding remarks are provided in the final section.

2. Methodology and Data

This study employs the Engle-Granger (1987) bivariate cointegration procedure to test for a long-run equilibrium relationship between a state's employment in terms of both manufacturing and non-manufacturing and the two macroeconomic variables, i.e., exchange rate and oil price. However, before performing the cointegration tests, it is necessary to examine the univariate time-series properties of each variable. In order to determine whether a series is stationary or nonstationary we perform the augmented Dickey-Fuller (ADF) test.[2] The ADF test is based on the following regression:

$$\Delta Z_t = \alpha_0 + \alpha_1 t + (\alpha_2 - 1) Z_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Z_{t-i} + \eta_t \qquad (1)$$

where Z_t is the individual time series under investigation, Δ is the first -difference operator, t is a linear time trend and η_t is a stationary random error. The lags used in the test are determined by Schwarz Information Criterion (SIC) to ensure serially uncorrelated error terms. The null hypothesis is that Z_t is a nonstatinary time series and is rejected if $(\alpha_2\text{-}1)$ is negative and statistically significant.

Two time series are said to be cointegrated if they are each nonstationary but some linear combination of them is stationary. When the two time series are integrated of the same order, we estimate the following cointegrating regression in levels of the two variables (e.g., manufacturing employment and exchange rate):

$$Y_t = \alpha + \beta X_t + \varepsilon_t \qquad (2)$$

where Y_t is the respective state (or U.S.) employment measure and X_t is the macroeconomic variable of interest. Following Engle and Granger (1987), the residuals from the above regression are tested for stationarity

[2] The ADF test is known to have low power in small samples (Shiller and Perron, 1985). Thus, we also use the Phillips-Perron test whenever the ADF fails to reject the null hypothesis of non-stationarity.

to determine whether or not a cointegrating relationship exists between Y_t and X_t as follows:

$$\Delta\varepsilon_t = \gamma_1\varepsilon_{t-1} + \sum_{i=1}^{m}\gamma_i\Delta\varepsilon_{t-i} + \mu_t \tag{3}$$

where ε_t is the residual from equation (2), and μ_t is stationary random error. The null hypothesis of nonstationarity and thus noncointegration is rejected when γ_1 is significantly negative. In the context of this study, the finding of cointegration implies a stable long-run relationship exists between the employment measure and the macroeconomic variable.

When nonstationary series are found to be cointegrated, an Error Correction Model (ECM) may be estimated to examine short-run and long-run dynamics. In addition, the ECM allows for tests of Granger causality. The ECM takes the following form:

$$\Delta Y_t = \varphi_0 + \sum_{i=1}^{m}\varphi_{1i}\Delta Y_{t-i} + \sum_{j=1}^{n}\varphi_{2j}\Delta X_{t-j} + \rho\varepsilon_{t-1} + \nu_t \tag{4}$$

Where Y_t is state (or U.S.) employment, X_t is the macroeconomic variable of interest, Δ is the first-difference operator, ε_{t-1} is the error correction term, i.e., the lagged residual series from equation (2), and ν_t is the random error. The error correction term measures the deviation from long-run equilibrium. The lagged changes in X_t can be interpreted as the short-run causal impact of the macroeconomic variable on the employment measure. The null hypothesis that ΔX_t does not Granger cause ΔY_t is rejected not only if the coefficients on ΔX_{t-j} are jointly significant but if the coefficient on ε_{t-1} is statistically significant.

Quarterly data from 1990 to 2005 are used for this study.[3] The dependent variable in the regression is the natural logarithm of a particular state's (or the overall U.S.) employment measure, that is, either manufacturing or non-manufacturing. Employment data are obtained from U.S. Bureau of Labor Statistics Current Employment Statistics. The real effective exchange rate is represented by the natural logarithm of the trade weighted exchange index (1973=100) available from the Federal Reserve Bank of St. Louis Economic Database (FRED). The real oil price level is proxied by the world crude oil price (obtained from U.S.

[3] The NAICS based state employment series are available starting in 1990 from the U.S. Bureau of Labor Statistics due to the recent switch from SIC to NAICS.

Department of Energy Monthly Energy Review) divided by the Production Price Index (PPI).

3. Empirical Results

Prior to performing the cointegration and ECM estimations, we test for the stationarity of each time series under consideration using the ADF test. The results of the unit root tests are presented in Table 1 (Hawaii is not included in the test due to lack of data.). The two macroeconomic variables and all of the state manufacturing employment series are found to contain a unit root and thus considered to be nonstationary; however, each variable is rendered stationary by taking its first difference. With the exception of Louisiana, each of the non-manufacturing state employment series is determined to be non-stationary in levels but stationary in first differences. In addition, the US manufacturing employment series is found to be non-stationary in levels but stationary in first differences, whereas the US non-manufacturing employment series is non-stationary in both level and first difference forms. For those series that contain a unit root but which are stationary when first differenced, we perform cointegration tests as specified in equation (2) and (3). Further, we proceed to estimate the ECM as defined in equation (4) whenever a cointegration relationship is detected.

Table 2 reports the bivariate test results (i.e., both cointegration and ECM results, where applicable) for state manufacturing employment and real effective exchange rate. The states are classified into eight regions (New England, Mideast, Great Lakes, Plains, Southeast, Southwest, and Far West) as defined by Bureau of Economic Analysis (BEA) for the purpose of presentation. As can be seen, U.S. manufacturing employment at the national level is not cointegrated with the exchange rate. At the state level, however, cointegration between employment in the manufacturing industry and effective exchange rate is found in eleven states (Vermont, Iowa, Kansas, Minnesota, North Dakota, South Dakota, Kentucky, Arizona, Idaho, Wyoming, and Oregon), indicative of a long-run equilibrium relationship. Note that none of the states in either the Mideast or Great Lakes regions has a cointegrating relation with the exchange rate, while five out of the seven state manufacturing employment series in the Plains region are found to be cointegrated with the real effective exchange rate series. Granger causality, however, is evident only in two states, Vermont where it is suggested by the significance of the lagged change in the exchange rate, and South Dakota where it is detected by the negative and significant error correction term. The error correction term in the latter case also reflects the adjustment of the exchange rate to state manufacturing employment. In particular, while the two series return to a long run stable relationship following a disturbance, the adjustment process is rather slow with only two percent of the process being completed within one quarter.

The bivariate cointegration test results for state-level non-manufacturing employment are presented in Table 3. The test results fail to indicate any evidence of a cointegration with the real effective exchange rate.[4] Compared to the manufacturing employment case where cointegration is found for eleven states, this result is more supportive of the previous focus on manufacturing job effects of exchange rate movements. A cointegration test between the national employment level and the exchange rate is not performed because neither the level nor first-difference of the U.S. non-manufacturing employment series was found to be stationary.

In contrast with the results associated with the exchange rate variable, evidence provided in Table 4 shows that the oil price series is cointegrated with manufacturing employment at the national level as well as with most states. In fact, the only states in which no evidence of cointegration was found are Kansas, Arizona, Utah, and Oregon. Although the joint significance of the lagged changes in oil price indicates Granger causality in just four cases (Connecticut, Indiana, Arkansas, and Mississippi), the statistically significant error correction terms provide another channel of causality in 22 additional states. In all, 26 states were found to have some form of statistical causality running from oil price to manufacturing employment. The error correction terms also provide insight into the adjustment speed of oil prices to manufacturing employment when there is a disturbance in the long run relationship. In particular, the amount of adjustment that is completed within one quarter is approximately 2 percent in four states (Pennsylvania, Nebraska, South Dakota, and South Carolina), 3 percent in seven states (Ohio, Wisconsin, Iowa, Minnesota, Arkansas, Tennessee, and Texas), 4 percent in eight states (Missouri, Florida, Georgia, Kentucky, Oklahoma, Colorado, Idaho, and California), 5 percent in four

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[4] Accordingly, subsequent ECM estimations and Granger causality tests are not performed.

states (New Hampshire, Vermont, Indiana, and Michigan), and 8 percent in one state (Wyoming).

Table 5 provides results of the state-level non-manufacturing employment and oil price cointegration tests. Evidence of cointegration between non-manufacturing employment and oil price is found in 31 states, among which 11 show evidence of Granger causality. This is in clear contrast with the case of manufacturing employment where cointegration is found in 45 states and Granger causality in 26 of these states. The error correction terms suggest that when non-manufacturing employment and the oil price revert to their long run relationship, the adjustment speed is quite slow. In fact, it is about 2 percent within one quarter in North Dakota and West Virginia, and about 1 percent in South Dakota and Montana. Note also that in the case of non-manufacturing employment, no state in the regions of New England and Mideast is found to be cointegrated with oil price, while all states in these two areas exhibit cointegration between manufacturing employment and oil price.

4. Concluding Remarks

This paper investigated the time series properties of state-level manufacturing and non-manufacturing employment and two key macroeconomic variables: real effective exchange rate and real oil price. Exchange rate and oil price are found to be non-stationary in levels but stationary in first differences. Each manufacturing and non-manufacturing employment series is determined to be first-difference stationary with the exception of the non-manufacturing employment series for the (total) U.S. and Louisiana. The results based on cointegration tests over the 1990 to 2005 period show that state-level manufacturing employment bears a long-run relationship with the exchange rate in eleven states, while no such relationship was found with respect to non-manufacturing employment. Estimation of error correction models indicated Granger causality in only two of these eleven states. By contrast, cointegration between state manufacturing employment and oil price is found in 45 states. Such a relationship is also present in 31 states for the case of non-manufacturing employment. Granger causality tests indicated that causality runs from oil price to employment in 26 states in manufacturing and eleven in non-manufacturing industries.

These results highlight the importance of distinguishing between manufacturing and non-manufacturing when examining the long run relationship between employment and the exchange rate or oil price. The results are consistent with Ewing and Thompson (2007) who documented the differential responses of service- and goods-producing worker compensation to unexpected changes in macroeconomic variables. They argue that differences in the supply chain characteristics[5] of firms operating in these two broadly defined industrial sectors may account for the differential responses. While non-manufacturing industries (e.g., construction, mining, services, transportation) produce goods and services that are typically non-tradable, the manufacturing sector delivers tradable goods and therefore may be more responsive to international relative price changes. On the other hand, both manufacturing and non-manufacturing employment are found to be responsive to oil price changes in a large number of states, with more states having experienced co-movements between manufacturing employment and oil prices. This latter effect may result from either direct or indirect dependencies on energy for use in manufacturing processes, transportation and logistics.

Failure to account for regional heterogeneity and/or manufacturing/non-manufacturing differences may result in overstating or understating the impact of relevant macroeconomic variables on employment. Our results also concur with the well known proposition that proper identification of the time series properties of state-level employment and macroeconomic variables helps to ensure against the spurious regression problem (Payne, Ewing and George, 1999). Finally, we note that policy designed to accomplish a particular goal may actually have no effect or, possibly, even the opposite effect, if the empirical time series properties of oil prices, exchange rates and employment, across states and by manufacturing/non-manufacturing classification, are not properly taken into account.

[5] For example, the degree to which inventories and other demand management techniques may be used to mitigate uncertainty from upstream and downstream sources.

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Fig. 1. U.S. exchange rate and crude oil price (1973-2005)

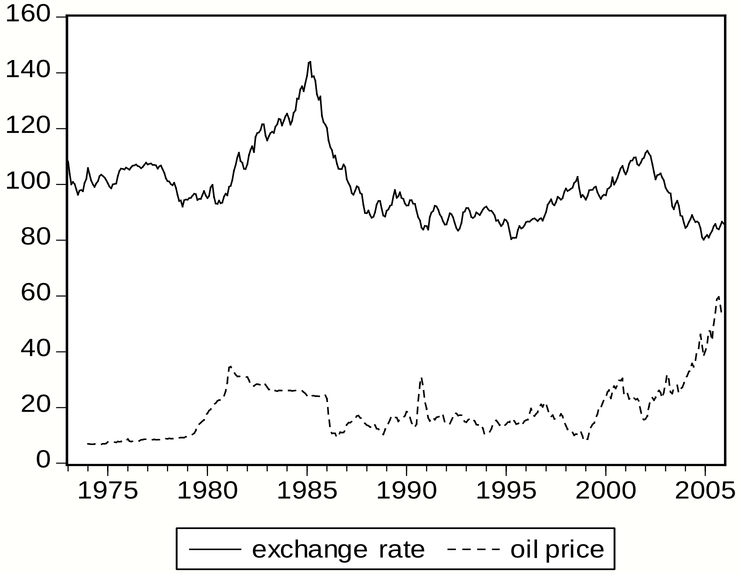

Table 1. Unit root test (ADF)

	level	first difference
ln(exchange rate)	-2.095	-3.555***
oil price/PPI	-0.184	-7.761***
Manufacturing Employment		
Alabama	-0.526	-3.687***
Alaska	-0.769	-8.489***
Arizona	-1.600	-2.945**
Arkansas	-0.484	-2.813*
California	-2.301	-2.081**
Colorado	-0.739	-3.384**
Connecticut	-2.513	-2.689*
Delaware	-1.539	-3.387**
Florida	-0.786	-3.482**
Georgia	-0.607	-3.449**
Idaho	-2.334	-4.392***
Illinois	-0.013	-3.870***
Indiana	-0.962	-4.289***
Iowa	-1.820	-3.405**
Kansas	-1.745	-2.636*
Kentucky	-1.610	-2.530**
Louisiana	2.051	-2.176**
Maine	-1.350	-2.655*
Maryland	-1.212	-4.132***
Massachusetts	-2.256	-2.655*
Michigan	-0.088	-3.929***
Minnesota	-2.011	-2.650*
Mississippi	0.158	-3.408**
Missouri	-0.888	-3.311**
Montana	-0.654	-6.053***
Nebraska	-1.272	-3.513**
Nevada	-0.971	-4.319***
New Hampshire	-1.450	-2.979**
New Jersey	-1.372	-4.019***
New Mexico	-1.475	-3.186**
New York	-1.665	-3.241**
North Carolina	-1.516	-2.687*
North Dakota	-1.305	-6.491***
Ohio	-0.890	-2.746*

Table 1 (Continued)

	level	first difference
Oklahoma	-1.815	-2.250**
Oregon	-1.497	-3.730***
Pennsylvania	-1.447	-2.786*
Rhode Island	-1.200	-6.369***
South Carolina	-0.371	-2.286**
South Dakota	-2.021	-3.037**
Tennessee	-0.397	-3.189**
Texas	-2.573	-1.954**
Utah	-1.408	-3.321**
Vermont	-1.878	-2.463**
Virginia	-1.241	-3.668***
Washington	-1.063	-3.390**
West Virginia	-0.388	-5.519***
Wisconsin	-1.522	-2.813*
Wyoming	-1.968	-4.101***
U.S.	-0.534	-2.655*
Non-manufacturing Employment		
Alabama	-0.236	-4.600***(PP)
Alaska	-2.737	-8.097***
Arizona	-3.058	-4.833***(PP)
Arkansas	-0.366	-5.144***(PP)
California	-0.410	-2.804*(PP)
Colorado	-0.847	-2.574*
Connecticut	0.599	-2.641*
Delaware	0.370	-5.687***
Florida	-0.019	-3.245**
Georgia	-1.128	-3.643***(PP)
Idaho	-1.361	-5.049***
Illinois	-1.343	-2.959**
Indiana	-0.846	-2.898*
Iowa	-1.046	-2.754*
Kansas	-1.957	-7.903***(PP)
Kentucky	-2.489	-5.939***
Louisiana	-0.558	-0.292
Maine	-0.088	-3.868***
Maryland	1.743	-2.803*

Table 1 (Continued)

	level	first difference
Massachusetts	-1.513	-2.290**
Michigan	-1.443	-2.237**
Minnesota	0.686	-4.910***
Mississippi	-2.020	-2.906**
Missouri	-1.699	-4.269***
Montana	-1.656	-8.672***
Nebraska	-0.080	-8.139***
Nevada	-1.810	-4.101***
New Hampshire	0.781	-4.078***
New Jersey	1.312	-3.889***
New Mexico	-1.667	-2.826*
New York	-0.631	-2.794*
North Carolina	-1.261	-4.263***(PP)
North Dakota	-1.041	-8.152***
Ohio	-0.890	-2.746*
Oklahoma	-0.626	-4.321***
Oregon	-1.054	-2.630*
Pennsylvania	1.074	-5.403***
Rhode Island	1.296	-4.164***
South Carolina	-0.767	-3.291**
South Dakota	-0.886	-5.351***
Tennessee	0.448	-2.721*
Texas	-0.926	-2.964**
Utah	-2.446	-3.348**(PP)
Vermont	1.100	-4.712***
Virginia	-0.182	-3.316**
Washington	-1.629	-2.948**
West Virginia	-0.385	-3.655***
Wisconsin	-0.776	-3.176**
Wyoming	-2.538	-6.634***
U.S.	-2.825	-1.783

Notes: ***, **, * denotes significance at 1, 5, 10% respectively based on critical values in MacKinnon (1996). PP denotes Philips-Perron test result.

Table 2. Empirical results: state manufacturing employment and exchange rate

	cointegration estimation		ECM estimation			
	equation (2)	equation (3)	equation (4)			
	β	ADF	∑φ2	F/T	ρ	T
US	0.117	-0.611				
New England						
Connecticut	-0.205	-0.979				
Maine	-0.081	-0.501				
Massachusetts	0.001	-0.711				
New Hampshire	0.322	-1.059				
Rhode Island	-0.315	-0.280				
Vermont	0.533	-1.947**	0.071	(1.767)*	-0.008	(-0.355)
Mideast						
Delaware	-0.017	-0.107				
Maryland	0.059	-0.412				
New Jersey	-0.170	0.063				
New York	-0.201	-0.343				
Pennsylvania	0.051	-0.066				
Great Lakes						
Illinois	0.068	-0.993				
Indiana	0.152	-1.213				
Michigan	0.301	0.321				
Ohio	0.064	-1.027				
Wisconsin	0.322	-1.338				
Plains						
Iowa	0.308	-1.907*	0.042	(1.426)	-0.025	(-1.310)
Kansas	0.461	-1.851*	0.040	(1.137)	-0.027	(-1.094)
Minnesota	0.328	-1.804*	0.001	(0.043)	-0.022	(-1.600)
Missouri	-0.029	-0.936				
Nebraska	0.361	-1.426				
North Dakota	0.682	-1.658*	0.036	(0.569)	-0.021	(-1.451)
South Dakota	0.236	-2.106**	0.013	(0.354)	-0.021	(-1.684)*
Southeast						
Alabama	-0.070	-0.542				
Arkansas	0.119	-0.536				
Florida	0.021	-0.786				
Georgia	0.137	-0.506				
Kentucky	0.270	-1.733*	0.045	(1.388)	-0.031	(-1.611)
Louisiana	0.089	1.334				
Mississippi	-0.176	-0.458				

Table 2. (Continued)

	cointegration equation (2)	estimation equation (3)	ECM	estimation equation		(4)
	β	ADF	∑φ2	F/T	ρ	T
North Carolina	-0.046	-0.172				
South Carolina	0.037	-0.466				
Tennessee	-0.085	-0.486				
Virginia	-0.003	-0.122				
West Virginia	0.013	0.118				
Southwest						
Arizona	0.519	-1.956**	0.037	(1.039)	-0.017	(-1.023)
New Mexico	0.229	-0.850				
Oklahoma	0.459	-1.530				
Texas	0.404	-1.338				
Rocky Mountain						
Colorado	0.434	-1.147				
Idaho	0.527	-3.151***	0.007	(0.151)	-0.019	(-0.907)
Montana	0.298	-1.208				
Utah	0.362	-1.465				
Wyoming	0.161	-2.185**	-0.024	(-0.448)	-0.042	(-1.029)
Far West						
Alaska	-0.826	-0.632				
California	0.244	-1.429				
Nevada	0.896	-0.815				
Oregon	0.308	-2.280**	0.054	(1.385)	-0.020	(-0.902)
Washington	0.294	-0.464				

Note: F/T denotes F-statistics when two or more lags are used and T-statistics when one lag is used; T denotes T-statistics; lags in the ECM model are chosen based on Schwarz criterion; ***, **, * is significance level at 1, 5,10% respectively.

Table 3. Empirical results: state non-manufacturing employment and exchange rate

	cointegration equation (2)	estimation equation (3)		cointegration equation (2)	estimation equation (3)
	β	ADF		β	ADF
US					
New England			Southeast		
Connecticut	0.333	0.232	Alabama	0.376	-0.761
Maine	0.446	0.413	Arkansas	0.445	-0.640
Massachusetts	0.499	-0.307	Florida	0.593	-0.142
New Hampshire	0.574	-0.580	Georgia	0.691	-0.789
Rhode Island	0.353	-0.238	Kentucky	0.443	-1.011
Vermont	0.341	-0.480	Louisiana		
Mideast			Mississippi	0.508	-1.289
Delaware	0.501	-0.464	North Carolina	0.686	-0.696
Maryland	0.380	0.660	South Carolina	0.518	-0.409
New Jersey	0.392	0.558	Tennessee	0.493	-0.923
New York	0.304	0.286	Virginia	0.496	-0.324
Pennsylvania	0.309	0.245	West Virginia	0.331	-1.097
Great Lakes			Southwest		
Illinois	0.381	-0.992	Arizona	0.829	-0.317
Indiana	0.340	-1.167	New Mexico	0.408	-0.391
Michigan	0.416	-1.102	Oklahoma	0.510	-0.999
Ohio	0.389	-0.911	Texas	0.642	-0.891
Wisconsin	0.424	-1.031	Rocky Mountain		
Plains			Colorado	0.789	-1.265
Iowa	0.359	-0.589	Idaho	0.622	-0.168
Kansas	0.475	-1.064	Montana	0.393	-0.872
Minnesota	0.479	-0.882	Utah	0.735	-0.447
Missouri	0.428	-1.042	Wyoming	0.302	-0.088
Nebraska	0.446	-0.923	Far West		
North Dakota	0.308	-1.257	Alaska	0.334	-0.608
South Dakota	0.443	-1.541	California	0.483	0.230
			Nevada	0.888	-0.132
			Oregon	0.507	-0.534
			Washington	0.496	-0.763

Note: In no case is the ADF test statistic significant at the conventional level.

Table 4. Empirical results: state manufacturing employment and oil price

	cointegration estimation equation (2)		ECM estimation equation (4)			
	β	ADF	∑φ2	F/T	ρ	T
US	-0.927	-2.331**	-0.009	(-0.497)	-0.019	(-1.937)*
New England						
Connecticut	-1.282	-2.038**	0.091	(3.722)*	-0.007	(-0.863)
Maine	-1.411	-2.247**	0.024	(0.488)	-0.016	(-1.134)
Massachusetts	-1.463	-2.248**	0.013	(0.398)	-0.014	(-1.592)
New Hampshire	-0.895	-2.071**	-0.029	(-0.543)	-0.047	(-2.592)**
Rhode Island	-1.785	-2.534**	-0.035	(-0.567)	-0.008	(-0.678)
Vermont	-0.548	-2.913***	-0.016	(-0.318)	-0.047	(-2.574)**
Mideast						
Delaware	-1.266	-2.550**	-0.079	(-0.626)	-0.001	(-0.004)
Maryland	-1.125	-2.607***	0.056	(1.542)	-0.019	(-1.461)
New Jersey	-1.491	-2.713***	0.003	(0.102)	-0.003	(-0.419)
New York	-1.671	-2.681***	-0.029	(-1.021)	-0.007	(-1.175)
Pennsylvania	-1.215	-2.280**	0.006	(0.218)	-0.019	(-1.821)*
Great Lakes						
Illinois	-1.217	-2.334**	-0.012	(-0.282)	-0.019	(-1.144)
Indiana	-0.517	-2.097**	-0.111	(-2.365)**	-0.048	(-2.009)**
Michigan	-1.089	-2.360**	-0.060	(-0.742)	-0.051	(-1.703)*
Ohio	-1.041	-2.375**	-0.013	(-0.365)	-0.032	(-2.146)**
Wisconsin	-0.516	-1.840*	-0.001	(-0.051)	-0.030	(_2.273)**
Plains						
Iowa	-0.200	-1.673*	0.029	(0.184)	-0.033	(-2.014)**
Kansas	-0.234	-1.433				
Minnesota	-0.354	-1.922*	0.039	(1.451)	-0.026	(-2.323)**
Missouri	-0.881	-2.251**	0.018	(0.049)	-0.036	(-1.705)*
Nebraska	-0.327	-1.832*	-0.001	(-0.029)	-0.023	(-1.719)*
North Dakota	1.125	-2.468**	0.031	(0.377)	-0.024	(-1.651)
South Dakota	-0.242	-2.193**	-0.043	(-0.934)	-0.024	(-1.998)*
Southeast						
Alabama	-1.070	-2.301**	-0.028	(-0.731)	-0.026	(-1.664)
Arkansas	-0.789	-2.495**	-0.059	(-2.052)**	-0.034	(-2.374)**
Florida	-0.793	-2.398**	-0.028	(-0.810)	-0.035	(-2.225)**
Georgia	-0.898	-2.238**	-0.025	(-0.621)	-0.037	(-2.065)**
Kentucky	-0.496	-1.907*	-0.050	(-1.282)	-0.042	(-2.381)**
Louisiana	-0.993	-2.437**	-0.047	(-0.974)	-0.022	(-0.770)
Mississippi	-1.482	-2.199**	-0.168	(7.379)***	-0.016	(-1.123)

Table 4. (Continued)

	cointegration estimation equation (2)	estimation equation (3)	ECM estimation equation (4)			
	β	ADF	∑φ2	F/T	ρ	T
North Carolina	-1.693	-2.392**	-0.064	(1.709)	-0.010	(-0.986)
South Carolina	-1.252	-2.453**	0.007	(0.246)	-0.024	(-1.934)*
Tennessee	-1.030	-2.356**	-0.078	(2.787)	-0.030	(-1.923)*
Virginia	-1.114	-2.315**	0.003	(0.095)	-0.016	(-1.137)
West Virginia	-1.086	-2.420**	0.023	(0.508)	-0.012	(-0.621)
Southwest						
Arizona	-0.350	-1.557				
New Mexico	-0.665	-2.185**	0.090	(1.377)	-0.045	(-1.502)
Oklahoma	-0.707	-1.745*	0.038	(0.778)	-0.042	(-2.200)**
Texas	-0.565	-1.803*	0.019	(0.897)	-0.027	(-2.948)***
Rocky Mountain						
Colorado	-0.671	-1.774*	0.023	(0.507)	-0.039	(-2.399)**
Idaho	-0.149	-2.452**	0.029	(0.521)	-0.043	(-2.462)**
Montana	-0.484	-2.101**	-0.171	(2.669)	-0.045	(-1.485)
Utah	0.013	-1.394				
Wyoming	-0.210	-2.178**	0.048	(0.718)	-0.075	(-2.014)**
Far West						
Alaska	-0.824	-2.043**	0.210	(0.849)	0.001	(0.016)
California	-0.679	-2.162**	0.032	(1.133)	-0.035	(-3.254)***
Nevada	1.590	-1.921*	-0.022	(-0.378)	-0.010	(-1.431)
Oregon	-0.138	-1.539				
Washington	-1.108	-1.902*	0.082	(0.844)	-0.035	(-1.026)

Note: F/T denotes F-statistics when two or more lags are used and T-statistics when one lag is used; T denotes T-statistics; lags in the ECM model are chosen based on Schwarz criterion; ***, **, * is significance level at 1, 5,10% respectively.

Table 5. Empirical results: state non-manufacturing employment and oil price

	cointegration estimation equation (2)	equation (3)	ECM estimation equation (4)			
	β	ADF	∑φ2	F/T	ρ	T
US						
New England						
Connecticut	0.537	-1.099				
Maine	0.989	-1.443				
Massachusetts	0.621	-0.960				
New Hampshire	1.148	-1.395				
Rhode Island	0.981	-1.469				
Vermont	0.852	-1.605				
Mideast						
Delaware	0.986	-1.552				
Maryland	0.902	-1.511				
New Jersey	0.797	-1.374				
New York	0.546	-1.163				
Pennsylvania	0.656	-1.599				
Great Lakes						
Illinois	0.479	-1.717*	-0.031	(-1.622)	-0.003	(-0.415)
Indiana	0.580	-2.038**	-0.085	(4.000)*	-0.005	(-0.608)
Michigan	0.461	-1.684*	-0.050	(3.667)*	-0.008	(-1.304)
Ohio	0.510	-2.787***	-0.034	(-2.118)**	-0.001	(-0.288)
Wisconsin	0.790	-2.156**	-0.030	(-1.863)*	-0.001	(-0.337)
Plains						
Iowa	0.539	-2.198**	-0.034	(-2.097)**	-0.004	(-0.659)
Kansas	0.654	-1.540				
Minnesota	0.820	-1.959**	-0.026	(-1.446)	-0.003	(-0.657)
Missouri	0.565	-1.439				
Nebraska	0.820	-2.060**	-0.001	(-0.079)	-0.006	(-0.903)
North Dakota	0.605	-2.321**	0.003	(0.154)	-0.018	(-2.324)**
South Dakota	0.801	-2.464**	-0.044	(-2.053)**	-0.013	(-2.092)**
Southeast						
Alabama	0.640	-2.211**	-0.020	(-1.398)	-0.005	(-1.143)
Arkansas	0.852	-2.277**	-0.034	(-1.792)*	-0.008	(-1.532)
Florida	1.369	-1.781*	-0.014	(-0.732)	0.002	(0.614)
Georgia	1.015	-1.694*	-0.031	(-1.216)	-0.003	(-0.703)
Kentucky	0.719	-1.983**	-0.030	(-1.411)	-0.007	(-1.098)
Louisiana						
Mississippi	0.695	-1.554				

Table 5. (Continued)

	cointegration equation (2)	estimation equation (3)	ECM	estimation equation		(4)
	β	ADF	∑φ2	F/T	ρ	T
North Carolina	1.100	-1.765*	-0.030	(-1.243)	-0.003	(-0.762)
South Carolina	0.916	-1.687*	-0.010	(-0.343)	0.005	(0.649)
Tennessee	0.822	-1.985**	0.003	(0.149)	-0.005	(-0.993)
Virginia	1.042	-1.601				
West Virginia	0.577	-2.079**	0.018	(0.774)	-0.017	(-1.918)*
Southwest						
Arizona	1.744	-1.883*	-0.017	(0.289)	-0.004	(-1.297)
New Mexico	0.991	-2.158**	-0.017	(0.323)	-0.007	(-1.658)
Oklahoma	0.755	-1.495				
Texas	1.052	-1.949**	0.001	(0.135)	-0.001	(-0.373)
Rocky Mountain						
Colorado	1.133	-2.110**	-0.015	(-0.859)	-0.003	(-0.916)
Idaho	1.401	-2.292**	-0.025	(-1.010)	-0.005	(-1.202)
Montana	1.002	-1.936*	-0.075	(3.661)*	-0.015	(-2.024)**
Utah	1.287	-2.267**	-0.012	(-0.695)	-0.004	(-1.352)
Wyoming	0.914	-2.298**	0.024	(0.876)	-0.004	(-0.729)
Far West						
Alaska	0.898	-2.259**	-0.028	(-1.380)	0.001	(0.034)
California	0.984	-1.566				
Nevada	2.175	-1.934*	-0.072	(-1.929)*	0.002	(0.543)
Oregon	0.847	-2.115**	-0.022	(-1.099)	-0.001	(-0.304)
Washington	0.950	-2.163**	0.007	(0.447)	-0.002	(-0.574)

Note: F/T denotes F-statistics when two or more lags are used and T-statistics when one lag is used; T denotes T-statistics; lags in the ECM model are chosen based on Schwarz criterion; ***, **, * is significance level at 1, 5,10% respectively.