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Inter-regional Employment Equilibrium and Dynamics

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1. Introduction

During the past few years, residents of Southern California have lived a biblical existence. They have experienced fires, a drought, floods, earthquakes, a civil disturbance, defense base closures, county bankruptcies and a national and regional recession. In addition, the Southern California economy was slow to emerge from the past recession and, while the rest of the nation basks in the warm glow of economic growth, Southern California remains a cool place. This has led some to question whether the Southern California economy will ever return to its former health, let alone become the "go-go" place it was during the 1980s.

Many economists are quick to dismiss this line of reasoning. Theory predicts that factor migration (particularly labor) and factor price adjustment will operate to push the growth rate of the Southern California economy toward the national growth rate. The problems are just transitory. Theory is less obliging when it comes to stating how long these transitory adjustments might take. The study by Barro and Sala-i-Martin (1992) on the convergence of per capita income and product across US states partially fills this gap. They demonstrate that economies which are above steady-state equilibrium grow more slowly in per capita terms than those below steady-state equilibrium, provided that sectoral composition of these economies are held constant. Since Southern California is one of the most highly developed regions in the US, it should be one of the most slowly adjusting regions. However, slow and fast are relative terms. In their empirical work, Barro and Sala-i-Martin estimate that rate of convergence of per capita income to be in the neighborhood of 2% per year. Their estimate implies that the half-life of an economic shock to interregional equilibrium is 34 years. Thus, while there is comfort in the idea that Southern California will re-emerge, the sluggishness of convergence makes it cold comfort indeed.

The work of Brown, Coulson and Engle (1990) goes further; they cast doubt on whether the equilibrium growth paradigm has a basis in fact as tell as theory. In a study encompassing nine industries and twenty states for the period 1969 : 3 to 1981 : 4, they categorically reject the presence of an interregional equilibrium. The implication of this study is that "... the effects of shocks seem to be permanent." (1990:14) This result is supported by Coulson (1993). This is not good news for Southern Californians since it means that the recent spate of disasters may have permanently and negatively altered the economic prospects of the region. In addition, it suggests that there is a critical role for a Keynesian-like interventionist industrial policy in California. Programs which attract industry and jobs will have permanent effects on the competitiveness of the region and, because the effects are permanent, they are likely to pay for themselves (Brown et. al. 1990:14).

Given the implications of the Barro and Sala-i-Martin, Brown et. al. and Coulson studies for Southern California, further attention needs to be given to several questions: (i) Does some form of interregional growth equilibrium bind Southern California to the rest of the nation? (ii) How long does it take to re-establish interregional equilibrium following a shock? (iii) Which employment shocks have a statistically significant impact on Southern California? and (iv) Which employment shocks have a temporary effect and which have a permanent effect?

I argue that the answer to the question of whether an interregional equilibrium exists depends critically on specification of the equilibrium. Brown et al. test for factor price equalization and find that wages and prices do not appear to equalize across regions. This may be the result of the short data set (12 years) used by these authors, in conjunction with a slow speed of adjustment, rather than a failure of factor price equalization. I show that when one shortens the time horizon to the medium run, an interregional equilibrium does exist, albeit a temporary equilibrium. Thus, in principle, shocks may be permanent or temporary and it is an empirical question as to which shocks are which.

The existence of an interregional equilibrium is one part of the equation, getting to it is the other. Factor prices and factor migration must mitigate interregional employment differences to establish an equilibrium following a shock. My estimates imply that it takes between eight to ten years for these adjustments to take place. While faster than the estimated by Barro and Sala-i-Martin, these are still slow processes.

The paper consists of six sections. In section 2, I presents a simple regional employment model. I use this model to provide guidelines for empirical specification. Section 3 gives a brief description of the data. In section 4, I test for the existence of a long run interregional employment equilibrium by testing for cointegration among employment series. In section 5, I estimate the impulse response functions for five industries. Through the impulse response functions I determine which shocks are temporary and which are permanent. I conclude in section 6.

2. A Simple Regional Employment Model

I use the simple interregional employment model. In the model, the same technology is available to all regions but regions differ in terms of their installed human and nonhuman capital bases and in terms of location specific factors of production. Labor is the sole variable factor of production and firms maximize profit with respect to the amount of labor they use. I consider the labor market equilibrium in region i, industry j, at time t. However, to economize on notation, I suppress the regional index i in the following equations. I assume production function as $Q_{jt}=F_j L_{jt}^{\beta_j} e^{\rho t}$, where Q_{jt} is production, F_j a composite fixed factor, L_{jt} employment, ρ_t a national productivity shift and β_j the elasticity of labor demand in industry j. As firms maximize their profit, $\pi_{jt}=P_{jt}Q_{jt}-W_{jt}L_{jt}$, the labor demand function for industry j is expressed as

$$l_{jt}=\alpha_j w_{jt}-f_j-\rho_t, \quad \alpha_j \leq 0 \ \forall j \quad (1)$$

where l_{jt} is the log of employment, w_{jt} the log of the real wage rate, f_j the log of a composite fixed factor.

On the supply side, I assume that consumers maximize a log linear utility function with respect to a composite good and labor supply subject to the usual full income budget constraint. That is, max $\{\gamma \log Z_{jt}+\delta \log R_{jt}\}$ subject to $Z_{jt}+W_{jt}R_{jt}=W_{jt}H_{jt}$, where Z_{jt} is commodity consumption, R_{jt} the amount of leisure time, and H_{jt} the total number of hours available to workers in industry j. This gives the labor supply function

$$l_{jt}=\ln(1-\theta)+T_{jt}, \quad 0<\theta<1 \quad (2)$$

where θ is share of leisure in the consumer's budget, $\frac{\delta}{\gamma+\delta}$ and T_{jt} the log of H_{jt}. This is a special case of the linear expenditure system often used in empirical work. For details, refer to Park(1996).

To close the labor market in region i, I assume that the aggregate labor supply to each industry responds to current industrial wage structure in the region. As the wage in an industry rises relative to the other sectors, labor migrates toward that the high wage sector. The magnitude of this response depends on costs of transition and the elasticity of substitution between labor in sending and receiving sectors. I approximate the mobility response by aggregate labor share equation

$$T_{jt} = T_t + s_j + \sum_{k \neq j} \beta_{kj} (w_{jt} - w_{kt}), \quad 0 \leq \beta_{kj} \tag{3}$$

where $T_t = \sum_j T_{jt}$ is the total labor supply in the region, β_{kj} the elasticity of labor mobility from industry k to industry j with respect to the real wage rate and s_j is the share of labor in industry j in a neutral wage structure (i.e., $w_{jt} = w_{kt}$). The latter term measures the natural attractiveness of industry j to residents of the region.

The reduced form market labor demand/supply equations for the industries in region i are obtained by using equation (2) and (3) to solve for the equilibrium wage in each industry

$$w_{jt} = \frac{1}{\alpha_j} (\ln(1-\theta) + T_{jt} + f_j + \rho_t), \quad \forall j \tag{4}$$

and using these wages in equation (3) to obtain the regional equilibrium labor demands

$$l_{jt} = \delta_{j0} + \delta_{j1} T_t + \delta_{j2} \rho_t + \sum_k \phi_{jk} f_k. \tag{5}$$

This function depends on the size of the labor market, labor productivity and fixed factor endowments in the different sectors of the regional economy. Note that T_t represents both the aggregate labor supply and, via equation (1), the aggregate real income in the region. Since the size of the labor market and labor productivity are probably integrated of order one, the labor demands in (5) will also be integrated of order one.

The short run difference between the employment for sector j in region i and k is

$$l_{ij} - l_{kj} = (\delta_{ij0} - \delta_{kj0}) + (\delta_{ij1} T_{it} - \delta_{kj1} T_{kt}) + (\delta_{ij2} - \delta_{kj2}) \rho_t + \sum_S (\phi_{ijs} f_{is} - \phi_{kjs} f_{ks}) \tag{6}$$

The difference depends their relative labor supplies in the two regions, how well the each region responds to flucturations in national productivity, and the relative availability and efficiency of use of the fixed factors of production. Over the long run, all of these reasons for a difference in the regional labor demands should disappear. Labor migration should equalize the real wages in the two regions and, when this occurs, the right hand side of (6) vanishes. Thus, in the long run, the stochastic process $l_{ij} - l_{kj}$ is stationary with a zero mean; that is, l_{ij} and l_{kj} are cointegrated with the cointegration vector (1,-1).

3. Data

I use monthly data from the "Employment and Earnings: States and Areas" (U.S. Department of Labor, Bureau of Labor Statistics) for labor demand variables l_{ij}. Data span the time period 1972.1 to 1993.12. I take the employment data for the Los Angeles Primary Metropolitan Statistical Area (PMSA) to represent employment in Southern California. I use the nation as a whole as a second region. The same assumption is made in Brown et. al. (1990), which is common in traditional empirical regional economic models (Brown et. al. 1990:6). For industries, I use the five one-digit SIC industrial sectors: construction, manufacturing, wholesale and retail trade, finance, insurance and real estate (FIRE), and service.

In addition to the time series on industrial employment I add two aggregate employment series, one for Southern California and the other for the United States. These data also come from the BLS tables. I use these aggregate series for total labor supplies T_t. I add a further labor supply variable which is not in the model. "'Defense related employment" series which is obtained from CITIBASE is included to capture the effect of shifts in defense related jobs in Los Angeles instituted at the national level. I use it to test whether defense base closures have a permanent effect on the industrial employment in Los Angeles. All variables are taken in natural logarithms.

4. Long Run Relations

The focus of this section is on determining whether there exist one or more long run equilibrium relationships linking employment in Los Angeles to employment in the rest of the nation. Accordingly, I devote considerable attention to stationarity properties of the employment series. The series must be nonstationary for a long run relationship to exist, although short run relationships may exist if the series are stationary.

To examine the stationarity of each employment series, I test for unit roots using the augmented Dickey-Fuller (ADF) test (Fuller 1976; Dickey and Fuller 1979) and Phillips and Perron (PP) test (Perron and Phillips 1988). From Table 1, the results are clear. All series are characterized by a random walk component.

Given the strong random walk behavior of all employment time series, the next step is to test for cointegration among employment variables. I begin by testing for long run factor price

Table 1. Unit Root Tests

Industries	Augmented Dickey-Fuller (ADF) tests[1),2)]		Phillips-Perron (PP) tests[1),3)]	
	Untrended	Trended	Untrended	Trended
Los Angeles Employment (LAIND)				
Construction	-1.83	-2.74	-2.11	-2.67
Manufacturing	-2.44	-3.38	-2.09	-2.88
Trade	-1.71	-1.65	-1.76	-3.13
F.I.R.E.	-1.98	0.22	2.19	0.03
Services	-0.84	-1.65	-1.45	-2.34
United States Employment (USIND)				
Construction	-1.59	-1.38	-1.87	-1.59
Manufacturing	-0.31	-0.47	0.46	0.10
Trade	-2.31	0.10	-2.23	-0.56
F.I.R.E.	-1.97	0.91	-2.28	0.35
Services	-1.96	-0.31	-2.43	-0.55
Employment Aggregates				
US Total (USTOTAL)	-0.01	-2.94	-1.44	-2.94
Southern California (SOCAL)	-1.88	-0.91	-2.43	-0.65

Note : 1) The 5% critical values for the untrended and trended Augmented Dickey-Fuller tests and the Phillips-Perron tests are -2.89 and -3.43, respectively.
2) The ADF tests use six lags to account for serial correlation in the error term. In practice, the appropriate order, k, of the ADF regression in Table 1 is rarely known. Said and Dickey (1984) showed that the ADF test is valid asymptotically if k is increased with sample size, T, at a controlled rate, $T^{1/3}$. For the sample size T=264, this translates into k=6.
3) Tests are calculated with twelve lags in the Newey-West covariance estimator to span all seasonal frequencies.

equalization. When the real wages in two regions are equalized, the logs of the labor demands in these regions, l_{ij} and l_{kj}, are cointegrated with coefficients 1 and -1, respectively. To test this proposition, I test for the nonstationarity of the variable $l_{ij} - l_{kj}$ using a Phillips-Perron (PP) test. When the PP test statistic is less than the critical value I can reject the null hypothesis of nonstationarity in log of the relative employment levels and support the alternate hypothesis of stationarity.

In column 1 of Table 2 the tests clearly indicate that the log of the relative employment levels, $l_{ij} - l_{kj}$, is nonstationary for all the sectors, since Phillips-Perron Z_t statistic lies above the critical value -1.95. Thus, no sector has long run equilibrium where real wage rates are equalized across region.

Column 2 presents the results from a less restrictive test of factor price

Table 2. Cointegration Tests

One Digit Sectors	[1] PP Test on Constrained Regression	[2] PO Test on Unconstrained Regression	[3] PO Test on Full Regression
Construction	0.32	-2.25	-3.02
Manufacturing	0.97	1.80	-4.61
Trade	2.42	-0.15	-4.22
FIRE	2.02	-1.33	-4.23
Service	1.56	-2.09	-6.33
Critical Values	-1.95	-3.42	-4.49 (5%) -4.20 (10%)

equalization. In the test, the cointegration vector for the logs of the labor demands in Los Angeles and the United States sets in $1-\gamma$ rather than in (1, -1), as in the preceding test. The parameter γ is estimated. The Phillips-Ouliaris (PO) test is the appropriate test for cointegration when the cointegration vectors must be estimated. The null hypothesis of the test is that the time series are not cointegrated. The null is rejected when the PO test statistic is less than the critical value. Again, it clear from the table that the null

for any sector cannot be rejected. Consequently, even this looser version of long run factor price equalization is rejected.

The preceding tests are analogous to the tests for cointegration conducted by Brown et. al. (1990) and, on the basis of these tests, I would come to the same conclusion - that cointegration does not exist. However, this conclusion may be premature. When I expand the empirical definition of a long run equilibrium, I am able to show that cointegration does exist. The variables in an expanded cointegration equation are: aggregate employment in the United States (USTOTAL), aggregate employment in national defense (USNDEF), national employment for the industry (USIND), aggregate employment in Southern California (SOCAL) and Los Angeles employment for the industry (LAIND). With the exception of national defence employment, these are the employment variables in equation (6). The variables LAIND and USIND are the industry employment variables l_{ij} and l_{kj} and SOCAL and USTOTAL are the corresponding market labor supply variables T_{it} and T_{kt}. USNDEF is a policy variable included to capture the effect of shifts in defense related jobs in Los Angeles instituted at the national level. The PO test statistics for the test for cointegration based on these variables are given in column 3. These statistics show that the manufacturing and service sectors of Los Angeles are cointegrated at the 5% level of significance, while the trade and FIRE sectors are cointegrated at the 10% level of significance. The construction sector is the only sector for which I can not reject the null hypothesis of no cointegration.

I also test for cointegration using Johansen's (1988, 1991) full information maximum likelihood (FIML) method. Johansen's test uses a complete vector autoregressive model to purge the transitory dynamics from the long run relationships. It also enables to test for the number of cointegrating relations, not just the existence of cointegration.

For each of the one digit sectors in the study, I construct a five dimensional system of equations employing the same variables used in PO tests. I selected the lag length for the vector autoregressive model by minimizing the Schwarz criteria (Lutkepohl, 1991). The sectors are consistent in their lag orders; a lag order of 7 minimizes the Schwartz for all sectors. The results of the tests are reported in Table 3. Panel (A) reports the results of the trace test

Table 3. Testing for the Dimension of the Cointegrating Space

(A) H_0: rank $(\Pi) \leq r$ against H_1: rank $(\Pi) = 6$
Test statistic
(Critical Values in Parentheses)*

Sector	$r \leq 4$ (3.96)	$r \leq 3$ (15.20)	$r \leq 2$ (29.51)	$r \leq 1$ (47.18)	$r = 0$ (68.91)
Construction	0.90	9.85	26.90	45.52	88.99
Manufacturing	0.39	6.03	19.62	41.98	107.89
Trade	1.08	5.68	23.78	60.94	114.24
FIRE	0.19	3.90	18.21	45.17	83.10
Service	0.02	6.34	24.50	59.37	138.92

(B) H_0: rank $(\Pi) = r$ against H_1: rank $(\Pi) = r+1$
Test statistic
(Critical Values in Parentheses)*

Sector	r=4|r=5 (3.96)	r=3|r=4 (14.04)	r=2|r=3 (20.78)	r=1|r=2 (27.17)	r=0|r=1 (33.18)
Construction	0.90	8.95	17.05	18.62	43.46
Manufacturing	0.39	5.63	13.60	22.36	65.91
Trade	1.08	4.60	18.10	37.16	53.30
FIRE	0.19	3.70	14.31	26.97	37.93
Service	0.02	6.32	18.16	34.88	79.55

* Critical values are taken from Hamilton (1994).

in which the null hypothesis that there are at most r cointegrating vectors (where $r=0,\ldots,4$) is tested against a general alternative (in this case r=5). Using this test, I can reject the null hypothesis that there is no cointegration (i.e., r=0) at the 5 percent level for all sectors. The null hypothesis that there is at most one cointegrating relation ($r\leq 1$) is rejected at the 5 percent significant level for the wholesale and retail trade sector and service sectors. From these tests, I conclude that wholesale and retail trade and service sectors have two cointegrating relations, while the other sectors have one cointegrating relation. Panel (B) reports the maximum eigenvalue tests which are based on the null hypothesis of r cointegrating relations against the alternative of $r+1$ cointegrating relations. The test results are quite similar to Panel (A) and confirm the conclusion about the number of cointegration equations needed for each sector.

The PO and Johansen tests leave little doubt that the variables in the expanded system are cointegrated. What is not clear is the theoretical interpretation of the cointegration relationships. However, I believe that the failure of Brown et al. (1990) and this paper to confirm factor price equalization gives a clue. Factor price equalization is a very slow process. The persistent North-South wage differential in the United States over much of this century is a prime example of the slowness of equilibration. Yet, I am trying to capture this phenomena with only two decades of data. I suggest that the span of data may not be up to the task of isolating such a long run phenomenon. In turn, this indicates that cointegration equations may be catching a sequence of medium term temporary equilibria. In my opinion, the most likely set of equilibria are those underlying equation (6). This equation requires the labor markets in regions i and k be jointly in equilibrium. Net labor migration between the regions would disturb this temporary equilibrium, and therefore, it must be ruled out for equation (6) to hold. Hence, equation (6) traces out the set of temporary labor market equilibria consistent with no net migration from the rest of the United States to the Los Angeles region. In the long run, this leads to factor price equalization.

The next step is to estimate the cointegration equations. I use the Stock and Watson's (1993) dynamic OLS procedure. The standard error of estimate is calculated using the Newey-West (1987) estimator of the spectral density at frequency zero. Estimates are presented in Table 4, with the t statistics for each coefficient in parentheses. The estimates of equation (6) are presented in columns 1, 2, 3, 5, and 6. The signs of variables USTOTAL, USIND and SOCAL have the correct signs and are strongly statistically significant. The only disappointing result is that, with the exception of the construction sector, the coefficients on the variable USIND are not close to unity, the value postulated in equation (6). A t test of this hypothesis is given in the first row of Table 5. I reject the null hypothesis that the coefficient is equal to unity for all sectors, save construction.

The variable USNDEF is included because of the importance of defense related jobs in the Los Angeles. The

Table 4. Cointegrating Regressions

Independent Variables	Dependent variable						
	[1] LA Construction	[2] LA Manufacturing	[3] LA Trade	[4] U.S. Trade	[5] LA FIRE	[6] LA Services	[7] U.S. Services
Constant	7.774	9.517	6.074	-0.926	-1.204	-2.387	-12.717
	(2.324)	(11.583)	(10.628)	(-1.647)	(-2.135)	(-3.854)	(-9.830)
USTOTAL	-2.302	-2.492	-1.414	0.564	-0.383	-0.290	1.871
	(-3.699)	(-17.942)	(-11.715)	(5.520)	(-3.816)	(-2.748)	(7.957)
USNDEF	-0.085	0.118	0.002	-0.048	0.178	0.062	-0.044
	(-0.904)	(5.396)	(0.092)	(-3.011)	(11.368)	(4.366)	(-1.187)
USIND	0.999	0.676	0.511		0.444	0.513	
	(9.930)	(17.828)	(5.131)		(14.120)	(18.410)	
SOCAL	1.813	2.131	1.371	0.559	0.696	0.816	0.177
	(3.825)	(19.010)	(14.622)	(6.776)	(8.593)	(11.142)	(0.933)
R^2	0.868	0.994	0.995	0.996	0.996	0.999	0.996

* t-values are in parentheses

Table 5. Hypothesis Tests

Hypothesis	One Digit Sectors				
	Construction	Manufacturing	Trade	FIRE	Services
LA Industry Employment proportional to US Industry Employment:					
USIND=1	-0.013	-8.547	-4.909	-17.771	-17.445
	(0.990)	(0.000)	(0.000)	(0.000)	(0.000)
LA Industry Employment moves with ratio of Southern California to US aggregate employment:					
SOCAL+USTOTAL=0	-2.834	-12.743	0.361	-6.833	8.683
	(0.005)	(0.000)	(0.719)	(0.000)	(0.000)
LA Industry Employment moves with two ratios: Southern California to US aggregate employment and US Industrial Employment to US aggregate Employment:					
SOCAL+USIND+USTOTAL=0	4.306	20.628	15.323	8.463	8.915
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

* Probability values are in parentheses

close of the cold war has resulted in severe employment reductions by defense contractors in the Los Angeles region. Many argue that loss of these high wage, high skill jobs will have a permanent effect on employment prospects in Los Angeles. The direct effect of the employment reductions is captured by the variable SOCAL, while USNDEF measures the effect of changing the proportion of defense related jobs in the Los Angeles region (i.e., a mix effect). The USNDEF variable is statistically significant for the manufacturing, FIRE and service sectors. In each of these sectors the mix effect of defense employment is positive, but very small by comparison with the direct effect. Thus, the popular wisdom about defense cut-backs is partially correct - the loss will affect the long run attractiveness of the Los Angeles region. However, this does not imply that gains or losses in defense sector jobs will permanently affect the economic prospects of Los Angeles. Other sectors may compensate for changes in defense related jobs in ways which mitigate the partial effects highlighted in the cointegration equations. I examine the total effect of shock to USNDEF in the next section.

Two interesting hypotheses are suggested by the estimated coefficients. Both of these hypotheses suggest ratio approaches for estimating regional employment which are far simpler than equation (6). The first hypothesis is that employment in Los Angeles depends on the ratio of the total labor supply in Southern California to that in the nation (i.e., $\delta_{ij1} = \delta_{kj1}$). This appears to be approximately the case for the construction, manufacturing and trade sectors. However, they are not close enough. The t statistics for this hypothesis are presented in second row to Table5. These show that I can reject the hypothesis for all of the industrial sectors. The second hypothesis is that employment in Los Angeles depends on two ratios: the proportion of national employment in Southern California and the proportion of national employment in the designated industry. The hypothesis requires that the sum of the coefficients on SOCAL, USIND and USTOTAL equal zero. Again, this appears to be close to the case for several sectors. The F statistics for this hypothesis are in the third row of Table 5. I reject this hypothesis for all of the industrial sectors. In total, I conclude that simple ratio approaches to estimating regional employment are inappropriate.

The Johansen tests show that the trade and service sectors have two equilibrium relations. However, these two equations are not uniquely defined. For these sectors, I identify the first equation as equation (6) and the second equation as a reduced form labor demand equation. To achieve this identification, I normalize the coefficient on USIND to unity and coefficient on LAIND to zero. These normalizations make the labor demand equation and equation (6) as triangular system of equations. The estimates of the reduced form labor demands for the trade and service sectors are presented in columns 4 and 7 of Table 4.

The reduced form labor demand equations are functions of USTOTAL, SOCAL and USNDEF. The variable USTOTAL fills the role of the aggregate labor supply variable T_{jt} in equation (5). It fills this role well as it is positive and statistically significant for the both sectors. The SOCAL variables measures the long run effect of increasing total Southern California employment on national employment in the trade and service sectors, while holding the national labor supply fixed. A positive value implies that Southern California has a stronger effect on national employment in the sector than other regions in the nation. I find that this is the case for the trade sector, but not the service sector. The coefficient on SOCAL is statistically insignificant for the service sector. As in equation (6) the USNDEF variable catches the differential of increasing defense related employment while holding the national labor supply fixed. The coefficient for this variable is statistically significant for the trade sector only. The negative coefficient indicates that expanding defense employment hurts employment in the trade sector, although the effect is very small.

5. Short Run Employment Adjustments in Los Angeles

In this section, I examine how employment in Los Angeles responds to interregional disequilibrium in the short and long run. I estimate an error correction model (ECM) of the type popularized by Granger (1983) and Engle and Granger (1987) and calculate the impulse responses associated with the ECM. Although many questions can be examined

using this framework, I focus on three: (i) How long does it take to re-establish interregional equilibrium following a shock to national or Los Angeles employment? (ii) Which employment shocks have a statistically significant impact on employment in Los Angeles? and (iii) Which employment shocks have a permanent effect on employment in Los Angeles?

For each industrial sector, the basic form of the ECM is

$$\Delta x_t = \Xi(L)\Delta x_{t-1} + \Lambda z_{t-1} + \mu_t + \varepsilon_t \qquad (7)$$

where x_t is the 5×1 vector of endogenous variables included in the cointegration equation: USTOTAL, USNDEF, USIND, SOCAL and LAIND.

$\Gamma(L)$ is a 5×5 matrix of lag polynomials. The variable z_{t-1} is the $r\times1$ vector of equilibrium disturbances calculated from the cointegration equations as $\Gamma' x_{t-1}$ where Γ is the $5\times r$ matrix of cointegration vectors. Correspondingly, Λ is a $5\times r$ matrix measuring the speed of adjustment to equilibrium. The elements of Γ are those in Table 4. For the construction, manufacturing and FIRE sectors, the variable μ_t is a 5×1 vector of deterministic components and ε_t is a 5×1 vector of innovations orthogonal to the employment variables.

I use OLS to estimate the system of equation (7). Because I place no restrictions on either $\Xi(L)$ or Λ, OLS yields efficient estimates of the parameters. I use the estimated coefficients and covariance matrix from equation (7) to derive the MA(∞) form of (7)

$$x_t = v_t + \varepsilon_t + \Psi_1 \varepsilon_{t-1} + \Psi_2 \varepsilon_{t-2} + \ldots. \quad (8)$$

The estimation is performed using the method developed by Lutkepohl (1990) and Lutkepohl and Reimers (1992). The matrix Ψ_s is the impulse response matrix for an innovation happening s periods earlier. Row i and column j of Ψ_s gives the consequence of a one unit increase in the innovation of the jth variable for the ith variable s periods later. When MA(∞) form is derived from a covariance stationary model, the impulse response matrices $\Psi_s \to 0$ as $s\to\infty$. However, when the MA(∞) form is based on a cointegrated model, such as the ECM (7), elements of $\Psi_s \to \infty$ as $s\to\infty$, where some or all of the elements of Ψ_∞ may be nonzero. When the (i,j)th element of Ψ_∞ is zero, the one-time shock to a variable j has a transitory effect on variable i, while when the (i,j)th element of Ψ_∞ is nonzero, the one-time shock to a variable j has a permanent effect on variable i (Lutkepohl and Reimers 1992, 70).

To ascertain how long it takes to re-establish interregional equilibrium following a shock in one of the variables, I find the time period when Ψ_s converges. Several definitions of convergence are possible. I say that the impulse responses have converged when $|\Psi_s - \Psi_{s-1}| < \tau$, where $\tau > 0$ is the convergence tolerance. This is the usual convergence criteria in computational models. The theoretical criteria, $|\Psi_s - \Psi_\infty| < \tau$, can not be used because Ψ_∞ unknown and uncertain. That is, Ψ_s converges when changes in the impulse responses are sufficiently small. I examine the speed of convergence by using three tolerances of increasing stringency: 10%, 5% and 1%. Results are presented in the first three columns of Table 6.

Table 6. Time to Long Run Employment Equilibrium (months)

	Full Dynamics			Long-run Dynamics
Tolerance	10%	5%	1%	1%
Construction	12	69	101	90
Manufacturing	56	72	110	41
Trade	18	69	134	120
FIRE	52	67	97	135
Service	15	26	47	85

* Convergence occurs when $|\Psi_s - \Psi_{s-1}| <$ tolerance.

The most striking result is that it takes a long time to re-establish an equilibrium. For the construction, manufacturing, trade and FIRE sectors, it takes 5-6 years (60-72 months) to re-establish equilibrium following a shock when I use a tolerance of 5% and 8-10 years (96-120 months) when I use a tolerance of 1%. This is much longer than the convergence of time for most macroeconomic dynamics, which generally take 2-3 years to converge. Yet, the long time to convergence was expected. Inter-sectoral and inter-regional labor migration is required to institute interregional equilibrium and migration is a notoriously slow processes. The service sector is an exception. It take only 2 years to converge within a 5% tolerance and 4 years to converge within a 1% tolerance. Impulse response estimates suggest that most of the adjustment to equilibrium in the service sector is done within the local labor market in Los Angeles. The time it takes to the sectors to converge within the 10% tolerance limit is a gauge of the duration of primary effects from a shock. The effects of the shock are quickly felt in the construction, trade and service sectors. Over 90% of the effects of the shock occur within the first 18 months. The manufacturing and FIRE sectors take longer. The primary effects of a shock are strung out over approximately 4.5 years.

In the last column of Table 6, I give the time to equilibrium when only the long run forces are operating. These times are determined by setting $\Xi(L)=0$, recalculating the impulse response matrices Ψ_s, and repeating the convergence experiments for the 1% tolerance criteria. The difference between the times in the third and fourth columns of the table shows the effect of the short run employment dynamics on the time required to re-establish an equilibrium. This comparison indicates that the short run employment dynamics hinder long run equilibrium for the construction, manufacturing and trade sectors, but assist long run equilibrium for the FIRE and service sectors.

Table 7 shows estimates of the impulse responses for the five industrial sectors. Because I am interested only in the impacts on employment in Los Angeles, the table contains just the columns of the impulse response matrices pertaining to Los Angeles industrial employment. I calculate all the impulse responses up to convergence (1% level of tolerance) but, to save space, I present those at an annual frequency.

The estimates show that the long run impulse responses are specific to an industry. All the industries, except manufacturing, experience a statistically significant, permanent change with respect to a shock in one or more of the variables in the system. I estimate the standard errors of the impulse response coefficients in the manner analogous to the method derived by Lutkepohl and Reimers (1992). However, where Lutkepohl and Reimers use the cointegration vector estimated by Johansen's (1988, 1991) method, I use the cointegration vector estimated by Stock and Watson's dynamic OLS procedure and presented in Table 4. This does not cause any problems as Lutkepohl and Reimers' Theorem 1 treats the cointegration vector as essentially fixed.

For the manufacturing sector, shocks to USIND, SOCAL and LAIND produce significant transitory effects. The effects are restricted to the first three years after the shock, after which the effects become statistically insignificant.

There is only one general result with respect to the shocks to specific variables. Shocks to USNDEF have no significant permanent effect on employment for any industrial sector. This should be interpreted as showing that there is nothing inherently special about defense jobs. The effect of increasing or decreasing defense related jobs is captured by the USTOTAL and SOCAL variables.

A positive shock to aggregate employment in the United States (USTOTAL) has a statistically significant effect on employment for the Los Angeles construction (at the 10% level of significance) and trade sectors. In both sectors, these effects emerge in the long run, after approximately 4 years, and indicate that an expansion of national employment reduces the employment in Los Angeles in these sectors. Estimates show that a 1% increase in USTOTAL reduces Los Angels construction sector employment by 7.8% and Los Angeles trade sector employment by 2.8%. This effect is predicted by the cointegration equation (6) as a partial effect of expanding labor supply in a competing region.

Table 7. Impulse Responses on Los Angeles Employment

		Unit Shock to				
Effect on	Lag	USTOTAL	USNDEF	USIND	SOCAL	LAIND
Construction	1	0.500	-0.065	0.132	0.572	0.609**
	12	2.940	0.081	0.538	1.972*	0.496*
	24	-0.301	0.042	1.292**	3.430**	-0.161
	36	-3.298	0.000	1.858**	4.354**	-0.703
	48	-5.273*	-0.029	2.211**	4.902**	-1.049
	60	-6.442*	-0.046	2.414**	5.212**	-1.251
	72	-7.103*	-0.056	2.528**	5.384**	-1.365
	84	-7.469*	-0.061	2.591**	5.478**	-1.428
	96	-7.780*	-0.064	2.625**	5.529**	-1.462
	108	-7.839*	-0.066	2.644**	5.557**	-1.481
Manufacturing	1	-0.014	0.023	0.329**	0.503**	0.796**
	12	3.015	0.044	-0.723	2.522**	0.827
	24	6.096	-0.041	-1.491	2.733**	0.668
	36	7.961	-0.107	-1.861	2.718*	0.651
	48	9.058	-0.145	-2.088	2.720	0.643
	60	9.711	-0.167	-2.223	2.720	0.638
	72	10.101	-0.181	-2.304	2.721	0.635
	84	10.334	-0.189	-2.352	2.721	0.634
	96	10.473	-0.194	-2.381	2.721	0.633
	108	10.555	-0.196	-2.398	2.721	0.632
	120	10.605	-0.198	-2.408	2.721	0.632
Trade	1	0.415**	0.003	0.315**	0.119	0.885**
	12	0.268	0.119*	1.479**	0.340	0.971**
	24	-0.701	0.144	2.387**	-0.157	1.020
	36	-2.044	0.138	2.957**	-0.466	0.855
	48	-3.108*	0.118	3.145**	-0.535	0.621
	60	-3.627**	0.097	3.050**	-0.441	0.434
	72	-3.648**	0.084	2.829**	-0.290	0.341
	84	-3.379**	0.079	2.617**	-0.162	0.336
	96	-3.046**	0.082	2.488**	-0.093	0.382
	108	-2.796**	0.867	2.452**	-0.083	0.440
	120	-2.686**	0.092	2.482**	-0.110	0.484
	132	-2.694**	0.095	2.539**	-0.148	0.504
	144	-2.768**	0.096	2.590**	-0.178	0.503
FIRE	1	0.159	0.019	0.195	0.214	0.894**
	12	0.082	0.149**	3.927**	0.715**	0.719**
	24	-0.371	0.229*	6.954**	1.160	0.297
	36	-0.665	0.279*	8.670**	1.439	0.027
	48	-0.832	0.309	9.599**	1.601	-0.129
	60	-0.923	0.325	10.089**	1.691	-0.216
	72	-0.971	0.334	10.344	1.739	-0.263
	84	-0.996	0.338	10.475**	1.764	-0.287
	96	-1.010	0.341	10.541**	1.777	-0.300
	108	-1.016	0.342	10.574**	1.784	-0.306
Service	1	-0.409	-0.004	0.203	0.428**	0.807**
	12	-0.120	0.063	1.075	1.807**	0.218
	24	-0.444	0.069	1.213*	1.656**	0.239
	36	-0.619	0.064	1.059*	1.432**	0.260
	48	-0.668	0.058	0.934	1.331**	0.262

Note: Unnormalized Impulse responses.
* Significant at 10%,
** Significant at 5%.

In the model, expanding the labor supply in a competing region is equivalent to expanding aggregate real income. This makes employment in the competing region more attractive than employment in Los Angeles and results in a reduction in the labor supply in Los Angeles, as workers migrate to the region with a higher standard of living. Los Angeles had persistent in migration over the period spanned by my data. Hence, were my model predicts an out-migration, this should be interpreted as a slowing of the rate of in-migration. Equilibrium is re-reestablished when reductions in the labor supply to the industry force real industry wages up enough to halt further migration. For this partial effect to emerge as significant in the long run, it must dominate the induced responses in the other variables.

The SOCAL variable plays the same role for the Los Angeles region as the USTOTAL variable does for the United States. It measures aggregate real income. Consequently, the partial response of increasing SOCAL is to increase employment in any industry in Los Angeles. The migration response will be opposite that described for the USTOTAL variable. SOCAL exert a strong permanent effect on employment in the construction and service sectors. In the long run, a 1% increase in total employment in Southern California increases Los Angeles construction employment by 5.6% and Los Angeles service employment by 1.3%. A shock to SOCAL also induces transitory increases in employment in the manufacturing and FIRE sectors, but these cease to be significant after three years.

While USTOTAL and SOCAL measure the aggregate welfare in the United States and Southern California, respectively, the variables USIND and LAIND directly reflect the interregional competition for labor. The model predicts that a 1% increase in USIND must be accompanied by a 1% increase in LAIND for equilibrium to be maintained. This is also a requirement for full factor price equalization. Estimates show that a positive unit shock to USIND produces a significant long run increase in LAIND for the construction, trade and FIRE sectors. A 1% shock to USIND permanently increases Los Angeles construction employment by 2.6%, Los Angeles trade employment by 2.6% and Los Angeles FIRE employment by 10.6%. None of the impacts equal unity. The t statistics for null hypothesis that the long run impulse response equals unity are: construction, 1.88; manufacturing, -1.51; trade, 2.45; FIRE, 1.73; and service, -0.11. Thus, I can reject the null just for the trade sector. This result conflicts with the my result in the preceding section. There I rejected strict proportionality between USIND and LAIND in the cointegration equations for all the sectors except construction. It appears that proportionality (or factor price equalization) is a viable hypothesis for the complete, long run impact of a shock to USIND.

A unit shock to LAIND generates statistically significant transitory effects on itself, but no significant permanent effects arise. In all sectors, the transitory effects are confined to the first year after the shock. This suggests that the sectoral labor markets quickly adjust to maintain short run labor market equilibrium. It is the intersectoral and interregional equilibration that take time.

6. Conclusion

The most important for residents of Southern California is whether the region will return to its former health after the many shocks to the region in the past five years. The evidence shows that local employment fluctuations from such events as fires, floods and earthquakes are largely transitory and quickly over. They are not exerting any effect on employment in Los Angeles at this time. The defense base closures will have

permanent effects on employment in Los Angeles only to the extent that innovations in national defense related employment are positively correlated with innovations in total Southern California employment.

There is little cause for concern here. Innovations in national defense employment are negatively correlated with total Southern California employment and the correlation is small, approximately -0.05. Certainly, the workers in the defense industries will be affected, but there will cause no statistically identifiable shift of long run aggregate employment in Los Angeles. Greater attention should be given to innovations in aggregate US, and Southern California employments. Positive shocks to US total employment permanently reduce industrial employment in some industrial sectors of Los Angeles, while positive shocks to total Southern California employment permanently increase industrial employment in some sectors in Los Angeles. Moreover, these sources of shocks as substantial uncorrelated: the average correlation is 0.08, and therefore, they will not cancel each other out. There appears to be a role for an interventionist industrial policy in California which positively shocks Southern California employment. Policies which move jobs to California from the rest of the nation are particularly attractive.

The evidence in this paper supports the existence that an interregional labor force equilibrium binding Los Angeles to the rest of the nation. It shows that some employment shocks permanently effect employment prospects within the Los Angeles region but relevant shock varies by industry. Finally, it demonstrates that adjustment to equilibrium takes a long time, between eight and ten years.

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ABSTRACT

Inter-regional Employment Equilibrium and Dynamics

This paper applies dynamic versions of shift share models to a simple regional employment model. It tests for the existence of a long run interregional employment equilibrium and then estimates the impulse response functions for each employment series to determine which shocks are temporary and which are permanent.

Key Words : vector autoregressive, error correction, cointegration, impulse responses, convergence