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A Multi-Sector Export Base Model of Long-Run Regional Economic Growth

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The relationships between intersectoral export and local employment and regional economic growth are analyzed in a long-run equilibrium framework. Dynamic location quotients decompose regional employment into export and local components for multiple sectors. Johansen's Full-Information Maximum Likelihood (FIML) approach is used to identify the existence and resultant rank of the co-integrating relationship between sectoral export and local employment in West Virginia's four metropolitan areas. Empirical results indicate inter-sectoral basic and non-basic employment form a co-integrating system of equations. Furthermore, this analysis shows that inter-sector shocks to local and export employment may cause multipliers to be positive or negative in magnitude.

The export-base model continues to be one of the more widely used in regional economic analyses. Although it has been widely criticized for its theoretical weaknesses (see for example, Krikelas 1992; and Isserman 1980), it remains one of the most widely accepted economic models utilized by economic development practitioners and regional economic policy analysts. The primary reasons for this acceptance are that it is easy to use and the costs associated with implementing alternative methodologies, such as I-O models or Computable General Equilibrium models (CGEs), are relatively high.

The traditional export-base model is comparatively static in nature. The multipliers derived from the model are used to 'forecast' changes in income or employment attributed to a change in regional exports. Some recent research, however, has applied structural econometric and time-series methodologies to the export-base model (Kraybill and Dorfman 1992; Lesage and Reed 1989; Lesage 1990). This paper departs from the traditional export-base study by applying time-series methodology and combining it with the concept of cointegration introduced by Granger (1983, 1986). The model presented in this paper allows sectoral interactions. In addition, the time-series model fully estimates the long-run equilibrium relationships among a region's economic sectors, thereby increasing the efficiency of estimation with nonstationary time-series data.

First, the temporal regional multiplier literature is briefly reviewed and a multi-sector economic growth model is developed, in addition to a discussion of the underlying properties of co-integration. This is followed by the construction of dynamic location quotients used in the separation of total employment into export and local employment, the empirical results, and a discussion on the implications of the empirical results in the regional economic analysis.

Temporal Multiplier Analysis

The vast majority of studies incorporating time-dependent multipliers utilize the export-base model. In its most basic form, the export-base model is defined in terms of income or employment. When the model is expressed using income, it is given as:

$$Y = Y_b + Y_n \tag{1}$$

$$Y_n = a + cY \tag{2}$$

where Y is total income and Y_b and Y_n represent base (export) and nonbase (local) income, respec-

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tively; a is an intercept term and c is MPC (marginal propensity to consume locally). With a little algebra, the export-base relationship is redefined as:

$$Y = \frac{a}{1-c} + \frac{Y_b}{1-c} \tag{3}$$

The export-base model can be expressed econometrically by simply adding an error term to (3), giving

$$Y = \beta_1 + \beta_2 Y_h + \varepsilon \tag{4}$$

where β_1 represents $a/(1-c)$ and β_2 is the equivalent of $1/(1-c)$.

Richardson (1985) notes that prior regional multiplier analyses identified the multiplier's time component by including lagged values of Y_b as explanatory variables. The results of these studies were mixed, however, with some finding little or no support for the short-run export-base hypothesis (Giarratani and McNelis 1980; Lutrell and Gray 1970; McNelis 1980; McNulty 1977; Moody and Puffer 1970) and others supporting the short-run hypothesis (Henry and Nyankori 1981; Lesage and Reed 1989; Moriarty 1976).

Dynamic export-base models explicitly identify the time component of regional growth and, thus, represent an important advance in regional economic analysis. In terms of sectoral dimensions, however, most models maintain the simple bifurcation implicit in the export-base model, between an exogenous basic sector and an endogenous nonbasic sector (Kraybill and Dorfman 1992). Exceptions do exist, however. Lesage (1990) uses the standard basic-nonbasic categorization, but he develops an error-correction mechanism that enhances the potential for interindustry interaction and base-nonbase interaction. Kraybill and Dorfman (1992) utilize a multi-sector state-space representation of the export-base model that fully estimates dynamic intersectoral and intrasectoral multipliers.

Conceptual Framework

We now develop a dynamic econometric model that explicitly recognizes the temporal and sectoral distributions of regional economic growth. First, however, the concept of cointegration as developed by Engle and Granger (1987) as well as the testing procedure developed by Johansen (1989, 1991, and 1995) will be presented. Ultimately, the econometric model operates under the assumption that the properties of the sectoral variables presented in this study form a long-run equilibrium.

Given any $(n \times 1)$ vector time series, $\mathbf{y}_t$, it is said to be cointegrated if each series taken individually is $I(1)$, or nonstationary with a unit root, while a linear combination of the series $\alpha' y_t$ is stationary, or $I(0)$, for some nonzero $(n \times 1)$ vector α. The α vector is also known as the cointegrating vector. If additional variables are present in the y_t vector, there may be two nonzero $(n \times 1)$ vectors, α_I and α_2, such that the linear combinations $\alpha_I'\mathbf{y}_t$ and $\alpha_2'\mathbf{y}_t$ are both $I(0)$ (Hamilton 1994).

The most common representation of a cointegrated system is obtained by the notion that any Vector Autoregression of the form:

$$\mathbf{y}_t = \alpha + \Phi_1 \mathbf{y}_{t-1} + \Phi_2 \mathbf{y}_{t-2} + \cdots + \Phi_p \mathbf{y}_{t-p} + \varepsilon_t \tag{5}$$

can also be written as

$$\mathbf{y}_t = \zeta_1 \Delta\mathbf{y}_{t-1} + \zeta_2 \Delta\mathbf{y}_{t-2} + \cdots + \zeta_{p-1}\Delta\mathbf{y}_{t-p+1} + \alpha + \rho\mathbf{y}_{t-1} + \varepsilon_t \tag{6}$$

where $\rho \equiv \Phi_2 + \Phi_2 + \cdots + \Phi_p$ and $\zeta \equiv -[\Phi_{s+1} + \Phi_{s+2} + \cdots + \Phi_p]$ for $s = 1, 2, \ldots, p-1$. Subtracting $\mathbf{y}_{t-1}$ from both sides of (6) produces

$$\Delta\mathbf{y}_t = \zeta_1 \Delta\mathbf{y}_{t-1} + \zeta_2 \Delta\mathbf{y}_{t-2} + \cdots + \zeta_{p-1}\Delta\mathbf{y}_{t-p+1} + \alpha + \zeta_0 \mathbf{y}_{t-1} + \varepsilon_t \tag{7}$$

where: $\zeta_0 = \rho - \mathbf{I}_n = -(\mathbf{I}_n - \Phi_1 - \Phi_2 - \cdots - \Phi_p) = -\Phi(1)$. If $\mathbf{y}_t$ is assumed to have h cointegrating relations, substitution of the term $\Phi(1) = \mathbf{BA}'$ and the previous expression into (6) results in

$$\Delta\mathbf{y}_t = \zeta_1 \Delta\mathbf{y}_{t-1} + \zeta_2 \Delta\mathbf{y}_{t-2} + \cdots + \zeta_{p-1}\Delta\mathbf{y}_{t-p+1} + \alpha + \zeta_0 \mathbf{y}_{t-1} + \alpha - \mathbf{BA}'\mathbf{y}_{t-1} + \boldsymbol{\varepsilon}_t \tag{8}$$

Defining $\mathbf{z}_t \equiv \mathbf{A}'\mathbf{y}_t$, and noticing that $\mathbf{z}_t$ is a stationary $(h \times 1)$ vector, equation 8 can be written as:

$$\Delta\mathbf{y}_t = \zeta_1 \Delta\mathbf{y}_{t-1} + \zeta_2 \Delta\mathbf{y}_{t-2} + \cdots + \zeta_{p-1}\Delta\mathbf{y}_{t-p+1} + \alpha + \zeta_0 \mathbf{y}_{t-1} + \alpha - \mathbf{B}\mathbf{z}_{t-1} + \boldsymbol{\varepsilon}_t \tag{9}$$

This last expression is known as the error-correction representation of a cointegrated system. In error-correction form, changes in each variable are regressed on a constant, $(p-1)$ lags of changes in each of the other variables, and the levels of each of the h elements of $\mathbf{z}_{t-1}$. The above sets of expressions are referred to as the Granger Representation Theorem.

A profound implication of the Granger Representation Theorem is that when one moves beyond the bivariate VAR, the possibility immediately arises of the existence of more than one cointegrating relation. Thus, choosing which variable to call

y_l and which to call y_2 might make a material difference for the estimate of the **a** vector as well as for the evidence one finds for cointegration among series. The Johansen's Full-Information Maximum Likelihood (FIML) estimate proposed by Johansen (1988, 1991) is one of several approaches that avoids this normalization problem (Hamilton, 1994).

Johansen's (1988, 1991, and 1995) FIML procedure is designed to estimate a system characterized by exactly h cointegrating relations. We denote $\mathbf{y}_t$ a $(n \times 1)$ vector. The maintained hypothesis is that $\mathbf{y}_t$ follows the general $VAR(p)$ in levels. Above, we showed that any pth-order VAR can be written in the form

$$\text{(10)}\quad \Delta\mathbf{y}_t = \zeta_1\Delta\mathbf{y}_{t-1} + \zeta_2\Delta\mathbf{y}_{t-2} + \cdots + \zeta_{p-1}\Delta\mathbf{y}_{t-p+1} + \alpha + \zeta_0\mathbf{y}_{t-1} + \varepsilon_t$$

with

$$E(\varepsilon_t) = \mathbf{0}$$

$$E(\varepsilon_t\varepsilon_\tau) = \begin{cases} \Omega \text{ for } t = \tau \\ \mathbf{0} \text{ otherwise.} \end{cases}$$

Assuming that each variable in $\mathbf{y}_t$ is $I(1)$, although h linear combinations of $\mathbf{y}_t$ are stationary, ζ_0 is denoted by $\zeta_0 = -\mathbf{BA}'$, where $\mathbf{B}$ is an $(n \times h)$ matrix and $\mathbf{A}'$ is an $(h \times n)$ matrix. Thus, under the null hypothesis of h cointegrating relations, only h separate linear combinations of the levels of $\mathbf{y}_{t-1}$ (the h elements of $\mathbf{z}_{t-1} = \mathbf{A}'\mathbf{y}_{t-1}$) appear in equation (8). One's main goal is to choose the maximized form of the log-likelihood function $\mathcal{L}(\Omega, \zeta_1, \zeta_2, \ldots, \zeta_{p-1}, \alpha, \zeta_0)$ subject to the constraint that ζ_0 can be written in the form $\zeta_0 = -\mathbf{BA}'$.

Given our original VAR presented in equation (5), we can rewrite the cointegration model in compact mathematical notation:

$$\text{(11)}\quad \Delta\mathbf{y}_t = \Pi\mathbf{y}_{t-1} + \sum_{i=1}^{p-1}\Gamma_i\Delta\mathbf{y}_{t-i} + \mathbf{Bx}_t + \varepsilon_t$$

where

$$\Pi = \sum_{i=1}^{p}\mathbf{A}_i - \mathbf{I}_n\,\Gamma_i = -\sum_{j=i+1}^{p}\mathbf{A}_j$$

Based on Granger's Representation Theorem, if the coefficient matrix Π has a reduced rank such that $h < k$, then there exist two $(k \times h)$ matrices, α and β, each with rank h such that $\Pi = \alpha\,\beta'$ and $\beta'\mathbf{y}_t$ is stationary. Once these error-correction terms are included in the cointegrating equations (assuming the $\mathbf{y}_t$ vector has no deterministic trends and the resultant equations have intercepts), we obtain the basic form of the long-run export-base model

$$\text{(12)}\quad \Delta\mathbf{y}_t = \Pi\mathbf{y}_{t-1} + \sum_{i=1}^{p-1}\Gamma_i\Delta\mathbf{y}_{t-1} + \mathbf{Bx}_t + \varepsilon_t = \alpha\,(\beta\mathbf{y}_{t-i} + \rho_0)$$

where the $\mathbf{y}_t$ vector is composed of sectoral employment (local or export) in period t up to a defined number of lags and ρ_0 represents the intercepts for each cointegrating equation. On a conceptual basis, regional export activity and local intersectoral linkages motivate the model. Equation (12) decomposes changes in regional employment into a long-run equilibrium component associated with variations in regional export activity and a short-run component associated with intersectoral linkages.

A desirable property of cointegration is that first differencing the data is not needed to achieve stationarity. Differencing individual series separately results in a loss of information if the series are CI(d, b). Ultimately, cointegration, in a regional economic context, would imply a long-run equilibrium between local employment growth (or decline) and regional export growth (or decline). A conceptual justification for this relationship is posited by export base theory, which outlines export demand as the driving force behind regional economic growth (Kraybill and Dorfman 1992; North 1955; Richardson 1985). The deviations from equilibrium captured by the error-correction term in equation (12) are associated with dynamic relationships among a region's industries. These deviations from equilibrium may be linked to such factors as regional capacity constraints, shifts in regional labor supply or skill levels, or shifts in regional prices relative to national (or international) prices.

Data

Despite pleas from regional economic modelers and policy planners, there remains no comprehensive source of regional income and product accounts for the United States. For this reason, export base studies generally utilize nonsurvey-based methods to estimate regional export activity (Isserman 1980). Lesage and Reed (1989) developed a time-varying location-quotient to estimate regional export data for Ohio's eight metropolitan areas and their technique is used in this paper to develop the analysis of the relationship between changes in local and export employment in four metropolitan areas in West Virginia.

Prior to the empirical analysis, data were obtained from the United States Bureau of Labor Statistics FTP archive of the monthly *Employment and Earnings* publication. This site contains seasonally adjusted data for major industries (with manufacturing separated into durable and nondurable goods) for the United States and all U.S. metropolitan statistical areas (MSAs). This analysis focuses on West Virginia's four primary MSAs: Charleston, Huntington, Parkersburg and Wheeling. The time period covered by the sample is January 1975 to December 1998.

The sectoral export and local employment variables are estimated using the following equation and assumptions (1) and (2):

$$y_{irt}^{L} = y_{rt}\left(\frac{y_{it}^{US}}{y_{t}^{US}}\right)$$

where: y_{irt}^{L} = local employment requirement in region r for industry i at time t

y_{rt} = total regional employment in region r at time t

y_{it}^{US} = total national employment in industry i at time t

y_{t}^{US} = total national employment at time t

To separate employment into export or local, we adopt the following set of assumptions:

$$\text{Assumption (1)} \begin{Bmatrix} y_{irt}^{n} = y_{irt} \\ y_{irt}^{b} = 0 \end{Bmatrix} \text{(if } y_{irt}^{L} \geq y_{irt}\text{)}$$

$$\text{Assumption (2)} \begin{Bmatrix} y_{irt}^{n} = y_{irt}^{L} \\ y_{irt}^{b} = y_{irt} - y_{irt}^{L} \end{Bmatrix} \text{(if } y_{irt}^{L} < y_{irt}\text{)}$$

where y_{irt}^{b} = export employment in region r by industry i at time period t

y_{irt}^{n} = local employment in region r by industry i at time period t

These assumptions indicate that if local employment requirements of industry i in region r at time t are less than the actual employment in that region's industry, the difference is classified as that portion of goods and services production for export (y_{irt}^{b}) at time t. Alternatively, if the local requirement is greater than or equal to employment in a region's industry at time t, then employment in that region's industry i at time t is classified as local employment (y_{irt}^{n}).

Local and export employment for the major SIC industries in West Virginia's MSAs were aggregated into three industries for the analysis. The first industry, mining, merely includes the local and export employment estimates for the mining sector (LEMIN and XEMIN). The second industry, manufacturing, includes durable and nondurable local (LEMFG) and export (XEMFG) employment. The third industry, services (LESERV and XESERV), includes the private services sector, retail trade and government services.

Empirical Results

Prior to model estimation, the assumption that local and export employment are $I(1)$ is tested. The Augmented Dickey Fuller (ADF) test was used. The six employment variables tested as $I(1)$ for all metropolitan areas. Readers should not be surprised by these results since most economic time series data have been found to be $I(1)$.

When variables in a VAR are integrated of order one or more, unrestricted estimation may result in a 'spurious regression' (Granger and Newbold 1974). A more complete estimation procedure involves estimating the matrix of cointegrating vectors, β, and the associated weighting matrix, α, then proceeding to estimate the VAR, incorporating the cointegrating relations from the factorization of the coefficient matrix, II. Several methods have been proposed to address this problem, but the powerful FIML approach by Johansen (1988, 1990, 1991) has attracted the most attention from applied researchers and software developers (Johnston and DiNardo 1997).

The availability of Johansen's algorithm in powerful computer software, such as EViews, makes it appealing for estimating a multi-sector export base model. The Johansen Test was performed under the assumption that the data have no deterministic time trends but the cointegrating equations have intercepts. The choice of lag pair intervals was based on sequential lag length tests using the Akaike AIC information criterion. The specification criterion indicated identical lag pairs (1–12) for each MSA.

According to the results of each MSA's model, the reduced rank test (Osterwald-Lenum 1992) reveals that there are at most three cointegrating equations. Based on the authors' arbitary choice of normalization, the results indicate that local employment is cointegrated with regional export employment within and across sectors. The local service sector displays the highest levels of responsiveness—in terms of statistical significance[1]—in the long run to changes in export employment.

Given our development of the long-run multi-

[1] The estimated cointegrating coefficients may not be meaningful estimates of the 'true' long-run multipliers. It is important to note, however, that the relative signs of the coefficients are more indicative of the cointegrating relation.

sector cointegrating equation in Section 3, we now present the cointegrating representation of the Charleston MSA's three-sector model.[2] For the Charleston MSA, the long-run equilibrium relation is written

$$LEMIN = -3.782 + \underset{(0.675)}{0.063\,XEMIN} + \underset{(1.302)}{0.068\,XEMFG} + \underset{(0.547)}{0.025\,XESERV}$$

$$LEMFG = 5.240 + \underset{(2.204^{**})}{0.508\,XEMIN} + \underset{(3.619^{***})}{0.466\,XEMFG} - \underset{(1.223)}{0.138\,XESERV}$$

$$LESERV = 7.105 + \underset{(3.438^{***})}{1.275\,XEMIN} - \underset{(2.585^{***})}{0.336\,XEMFG} + \underset{(5.026^{***})}{1.125\,XESERV}$$

Note: t-statistics in parenthesis; *significant at 10% level, **significant at 5% level, ***significant at 1% level.

This cointegrating relation highlights several potentially significant results. The third equation in the system suggests that increases in manufacturing export employment (*XEMFG*) decrease local employment in the service sector (*LESERV*). This result is a possible indication of opportunity costs in employment associated with reallocating labor from manufacturing to the service sector (private, retail and govt. services). For example, if wages are higher in XEMFG than in LESERV, the labor supply will move from the local service sector to the manufacturing export sector when regional exports are growing. However, when manufacturing export employment declines, local service sector jobs may become more attractive, serving as temporary employment until regional manufacturing expands. This scenario appears quite reasonable for these sectors in West Virginia. The relative wages in West Virginia's primary manufacturing export sectors (i.e. SIC 28 Chemicals and SIC 33 Primary Metals) are substantially higher than the wages found in local service industries, which range from fast food to Health Services and Federal Government jobs.

Another result found in these models is that service sector export employment contributes to increases in local service employment. In general, a service is not considered an export. However, when a significant amount of nonresidents, i.e. tourists, enter a region to purchase lodging, gasoline, t-shirts, etc., the service sector immediately becomes an exporter. Expansion in service sector exports may eventually lead to further growth in local services. Ultimately, local service sector impacts will depend upon the region's interindustry linkages as well as the region's employment structure.

The results found in the second long-run equation provide some insight of how I-O inter-industry linkages look over time. First, mining and manufacturing export employment (XEMIN and XEMFG) 'cause' local, or I-O linked, manufacturing employment to grow. Increases in service sector export employment, however, have no effect on local manufacturing employment. This is a plausible result since local manufacturing industries have little or no linkages with the export service sector. Second, no export sectors affect local mining employment. This should not be particularly surprising given the relatively small amount of mining employment (notably sand and gravel) in West Virginia that is allocated to local activities.

Conclusions

The error-correction methodology developed by Engle and Granger (1987), employed in conjunction with the Johansen estimation procedure, allows the static export-base model to be extended to a time-series framework that includes long-run equilibrium relations and short-run dynamic interactions within and across multiple local and export sectors. Given our current levels of technology, the methodology presented in this paper preserves the low-cost, easy implementation that has helped maintain the popularity of the traditional export-base model.

A monthly location quotient proposed by Lesage and Reed (1989) is used to separate total employment for four metropolitan areas in West Virginia into basic and nonbasic employment in three major sectors. The results indicate that local employment in each major industry forms a long-run equilibrium with export employment within and across major industries. More importantly, however, the results suggest that increases in regional exports in one sector may decrease local employment in other sectors. Other techniques, such as input-output analysis, always produce positive multipliers due to the inherent linearity of the model and an absence of factor constraints. Since the intrasectoral and intersectoral interactions are calculated using a multi-equation statistical model of historical data, our results provide evidence that suggests long-run intersectoral multipliers can be either positive or negative. In addition, contrary to traditional interpretations of the export-base model, our results

[2] For brevity, we will provide the detailed results of the model presented here, as well as the three remaining models, upon request. The remaining models exhibit nearly identical results to the one presented here.

suggest that although impacts from the service sector's exports are limited to the local service sector, the service export sector plays a significant role than previously thought in determining regional growth patterns.

Knowledge of dynamic sectoral interactions may be important for those seeking a better understanding of the processes governing regional economic growth. As with any model, it is necessary to test the robustness of the empirical estimates. Thus, in the future it will be interesting to reformulate the long-run multipliers by constructing the basic and nonbasic employment variables using the "assumptions" method outlined by Isserman (1980), in addition to a higher level of disaggregated data. With the aid of modern time-series techniques, the export-base model should no longer be thought of as inferior to more sophisticated regional models in use today.

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