**DISSERTATION**

REGIONAL ANALYSIS OF AN URBAN AND RURAL ECONOMY IN THE STATE OF OREGON: A COINTEGRATION APPROACH

Submitted by

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In partial fulfillment of the requirements

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**WE HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER OUR SUPERVISON BY SCOTT ENGLAND ENTITLED "REGIONAL ANALYSIS OF AN URBAN AND RURAL ECONOMY IN THE STATE OF OREGON: A COINTEGRATION APPROACH" BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.**

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ABSTRACT

REGIONAL ANLAYSIS OF AN URBAN AND RURAL ECONOMY IN THE STATE OF OREGON: A COINTEGRATION APPROACH

Throughout regional literature the debate of the relationship of diversity and stability is abundant. Various indices have been devised to measure these two economic phenomena and are analyzed with regression techniques or input-output models. This dissertation will present another method to test their relationship using Johansen's (1988) multivariate cointegration technique. This procedure is conducted on two regional economies, the Portland Metropolitan Area (PMA) and Southwest (SW) Region, within the state of Oregon. These two economies were chosen because of the urban and rural nature of the PMA and SW respectively. This defining difference will indicate each economies differing levels of diversity and resulting stability.

Within each regional system a new and statistically valid aggregation scheme based upon pairwise cointegration is used. This scheme enables unique characteristics of each economy to be illustrated and analyzed, which enables the study to be more accurate. Pairwise cointegrated aggregation reveals that previous techniques have considerable biases as the aggregates fail to maintain the properties of their individual components. The combination of this technique with the analysis of the Vector Error Correction Mechanism of each cointegrated system provides a test to verify whether correct aggregation and specification have taken place.

Each economy's relative diversity and stability is revealed within their respective cointegrated systems and persistent profiles. The cointegrated system illustrates diversity through the number of common trends. Persistent profiles enable an analysis of stability to be conducted by analyzing how quickly an economy returns to long run equilibrium after the introduction of a system wide shock. These results combined with impulse response functions lead to policy recommendation for both economies to improve upon their diversity and stabililty.

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# CHAPTER I

## Introduction

The relationship between economic diversity and stability has been a heavily debated topic over the last 70 years. This dissertation extends the study on this issue by analyzing regional economies using cointegration to test the relationship. Cointegration has been adopted from macroeconomic theory recently and has the potential to improve regional analysis. Most empirical studies aggregate data using the easily obtained one digit Standard Industrial Classification code. I propose a new aggregation technique based on pairwise cointegration that creates aggregates free of statistical biases. This combination of statistically valid aggregation and cointegration analysis to test the diversity/stability relationship is invaluable.

McLaughlin (1930) and Tress (1938) originated the debate of diversity and stability. McLaughlin analyzed manufacturing industries in large metropolitan areas to determine the level of concentration and therefore the level of diversity. Tress used a refined, or ogive, index to measure diversity in large metropolitan areas. Since these studies many improvements have been made enabling regression analyses and input-output studies to be conducted.

The two economies analyzed within this dissertation are the urban area of the Portland Metropolitan Area (PMA) and the rural area of the Southwest (SW) Region in the state of Oregon. The findings show that the PMA is more diversified and stable relative to the SW Region.

Chapter II summarizes two areas of regional literature. First is the area of diversity and stability. The second is the progression of cointegration analysis within regional economics. Studies analyzed within the first area include those of McLaughlin (1930), Tress (1938), and others containing cross sectional, time series, and input-output techniques. Various different diversity and stability indices are also explored.

The development of cointegration within the regional literature is reviewed by showing the progression of this technique. Early studies used Vector Autoregressive (VARs) models that had to be first differenced to appropriately analyze nonstationary variables. VARs can be transformed into Vector Error Correction Models (VECMs) if cointegration exists, which implies that a linear combination of the nonstationary forms a stationary relationship revealed through the residuals. This progression illustrates the potential cointegration possesses to more accurately model regional economies.

Chapter III presents the difference between stationary and nonstationary data and the transformation from a VAR to VECM is illustrated. From the VECM the Maximum Likelihood (ML) procedure of the Johansen multivariate cointegration technique is discussed. The ML technique enables estimates of the cointegrated relationships to be uncovered, as well as, the number of cointegrated relationships that exist. Persistent profiles conclude the chapter, which represent a statistical technique that can be applied to cointegrated systems to analyze movements within the cointegrated vectors (CIVs).

Chapter IV introduces the unique features of the two regional economies, followed by an introduction of possible aggregation techniques. These methods are shown to contain biases as they fail to maintain the characteristics of the individual sectors within the aggregate. The statistically valid method of aggregation, pairwise cointegration, is shown to overcome this failing. Pairwise cointegration implies that each sector within an aggregate is cointegrated with every other sector, thereby guaranteeing the aggregate maintains the features of each individual sector.

Chapter V presents the diversity and stability relationships for both the PMA and SW Region. Indices from regional literature are used to establish each economy's diversity and stability followed by the cointegration and persistent profiles explanation of the two phenomena. Policy recommendations to increase the SW Region's ability to absorb economic shocks are made from this analysis combined with generalized impulse response functions.

Chapter VI concludes the discussion of diversity and stability emphasizing the value of using cointegration for regional analyses. Recommendations for future research are also made.

# CHAPTER II

## Literature Review

### 2.1. Introduction

This chapter presents a survey of the literature on two components within regional economics. The first section deals with diversity and stability, and the second reviews regional cointegration.

The debated relationship between diversity and stability is presented through a variety of works within the regional literature. Support for the hypothesized relationship that an economy with greater diversity has greater stability dominates the literature. A variety of indices for both diversity and stability have been used and placed into either simple regression models or input-output models to verify their relationship. The initial works of McLaughlin (1930) and Tress (1938) are presented first followed by the various diversity and stability indices and modeling techniques.

Cointegration has become more prevalent within the regional literature over the past decade. This technique has been used to improve forecasts, test the theory of basic and non-basic sectors, and to verify structural relationships between industries. This increased forecasting efficiency is shown in the literature through comparison of Vector Autoregressive (VAR) models and Vector Error Correction Models (VECMs). These two methods of analyzing nonstationary data are presented followed by the benefits cointegration provides to regional economics.

## 2.2. Economic Diversity and Stability

Economic diversity and stability has been a heavily debated topic within regional economics for the last 70 years. A diversified economy is one characterized by a variety of economic activities and is dependant upon "(1) the number of different economic activities and (2) the evenness of distribution across these activities" (Malizia and Ke, 1993). Greater economic activity enables an economy to absorb layoffs from one sector lessening the tendency of wide fluctuations in unemployment within the region. This is in essence stability, or the "absence of variation in economic activity over time" (Malizia and Ke, 1993). The greater the number of industries that exist within an economic area, the less dependency there is on any one industry, which can potentially enable an economy to experience overall growth even when some industries perform poorly.[1] For this reason the theory of greater diversification leading to greater stability exists. The encouragement of growth in many different sectors decreases an economy's dependency upon a limited number and promotes diversity.

The original works on diversity and stability were conducted by McLaughlin (1930) and Tress (1938). Since these initial works additions and improvements have been made, but there is still an inability to test the causal relationship. Improvements have come in the form of increased modeling capabilities with regression analysis and input-output models. McLaughlin's and Tress' works are presented first with the later works concluding this section of the literature review. The categories of the later works are based on their tool of analysis: simple regression and cross sectional analyses (pooled regression analysis), and input-output models.

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[1] This concept is similar to the idea of portfolio diversification within the financial world.

***Original Works of McLaughlin and Tress***

McLaughlin (1930) analyzed industrial concentration of manufacturing in large metropolitan areas. Two measures for concentration are used: the first is the percent of total manufacturing employment represented by the five largest industries in the area; and second by the 20 largest industries. The scale of these industries was determined by a multitude of factors that ranged from the value of their products to the number of wage earners in the industry. The determination of the degree of concentration was used as a proxy for diversity by determining the portion of employment controlled by the largest industries. To make the connection between diversity and stability McLaughlin analyzed how the industries responded to cyclical as well as seasonal fluctuations. He concluded that there is evidence of a relationship between the "degree of concentration and the severity of cyclical, as well as seasonal, fluctuations," in employment stability (McLaughlin, 1930, p. 148).

Tress (1938) calculated diversity using his refined or ogive index. This index looked at the percentages of employment controlled by industries within an economic region adding them together at each stage of production where lower values indicate greater diversity. Along with this calculation he made the observations that an optimal economy is one that is diversified. These observations run similarly to those of McLaughlin in that an area dependant upon too few industries runs the risk of high unemployment. Tress concludes by stating that economies need to diversify, but further research needs to be conducted before any sound policy recommendations can be made.

*Instability and Diversity Indices*

Several different indices have been used to measure diversity and stability. To illustrate these a sample are described: two that measure instability, and five for diversity. Each of these seeks to find the most logical method to quantitatively analyze its respective economic phenomenon.

Conroy (1972) introduced a coefficient of variation to measure instability:

$$Z = (1/N\text{-}1)\sum_{t}^{T}(Y_t - \hat{Y}_t)/(\bar{Y}^2), \qquad (2.1)$$

where $Y_t$ is the actual level of employment, $\hat{Y}_t$ the predicted level of employment, $\bar{Y}$ represents the average level of employment over the studied time period, and N equals the number of industrial sectors. The number of observations is denoted, T. The predicted level of employment, $\hat{Y}_t$, was derived with a quadratic time trend equation,

$$Y = b_0 + b_1 t + b_2 t^2, \quad t = 1 \ldots T. \qquad (2.2)$$

Conroy's formula stresses the importance of growth in employment, emphasized in the quadratic growth as $\hat{Y}_t$ is preferred over $\bar{Y}$, "to reflect the variance around a growth trend rather than absolute variance over the time period" (Jackson, 1984, p. 106).

Kort (1981) uses a similar instability index to test the hypothesis that as an economy increases in size (ie. employment growth), it becomes more stable. This relationship is verified through use of his Regional Economic Instability (REI) index.

$$REI_i = [\Sigma\,((E_{it} - \hat{E}_{it})/\hat{E}_{it})^2/(T\text{ -}2)]^{1/2}, \qquad (2.3)$$

where $E_{it}$ is total quarterly employment adjusted for seasonality for region *i* at time *t*, $\hat{E}_{it}$ is an approximation of the long-run growth trend in employment in region *i* at time *t*, and T is the frequency of the data used. The predicted values of employment in Kort's index were derived from a linear approximation of the long run growth rate.

Both of these indices take on greater values as instability increases, which occurs when predicted levels of employment deviate from actual levels of employment. Values of predicted and actual employment levels that are closer together give the perception of a more stable economy. The predicted values of employment, for both indices, are created from rigid models that do not allow changes in functional form over time which restricts them to predetermined paths, however. These two methods therefore do not have the capabilities to fully capture changes in the growth rates of employment.

The diversity indices have been more abundant than those for instability. Five diversity indices are presented here: ogive, entropy, portfolio, national average, and percent durable. Each of these indices attempt to more fully capture the true level of diversity of the economy analyzed.

Tress (1938) introduced the ogive index:

$$\text{Ogive Index} = \sum_{i}^{N} (X_i - 1/N)/(1/N). \qquad (2.4)$$

N represents the number of sectors in the economy, and $X_i$ is the portion of economic activity for the ith sector. This index for diversity is a goodness of fit measurement and can be used in comparison to the benchmark, 1/N (Siegel, et al., 1995). A completely diversified economy takes on the benchmark value, which represents an equal percentage of employment in each sector, and yields an ogive value of zero (Siegel, et al., 1995).

The entropy index is an index borrowed from the natural sciences and is "based on the second law of thermodynamics - the entropy law," (Siegel, et al., 1995, p. 265).[2] Theil (1972) adopted this measurement into the economic world and, like the ogive index, this measurement identifies an ideal economy as one that has equiproportional employment in all sectors of employment. The entropy formula is:

$$\text{Entropy}_i = \sum_{1}^{k} (E_{ij}/ E_i) \ln (E_i/ E_{ij}) \qquad (2.5)$$

where $i$ is the $i$th region, $j$ the $j$th industry, $k$ the total number of industries in the $i$th region, $E_{ij}$ is employment in the $j$th industry in region $i$, and $E_i$ is the total employment in region $i$ (Malizia and Ke, 1993). This index ranges from zero to the natural log of k when specialized and completely diversified, respectively. As the values of the entropy increase the economy is identified as more diversified.

The portfolio measurement of diversity is an idea adopted from the financial literature. Introduced by Markowitz (1952), portfolio diversification is the notion of hedging risk. Risk can be hedged when investments are undertaken in a wide arrangement of assets. This is in an attempt to maximize the expected return on investments and minimize the variance of the return (Attaran and Zwick, 1987). This is the same idea behind portfolio measurement of diversification. Risk with an economy would be periods of high unemployment, which can be hedged against with less reliance upon any specific industry.

[2] "According to the entropy law, every time energy is transformed from one state to another there is a loss in the amount of available energy. The equilibrium state occurs when entropy reaches a maximum, and there is no longer free energy available to perform additional work. This occurs when energy is distributed as uniformly as possible, subject to whatever constraints exist," (Mohan, 1979, p. 87-93).

Conroy (1974) took this idea from the financial world and applied it to regional economics where each sector of employment is a separate investment and all sectors the portfolio (Siegel, et. al., 1995). The variance of the portfolio is calculated from:

$$\text{Var} = \sum_{i=1}^{N} W_i^2 \ \text{VAR}(X_i) + \sum_{i=1}^{N} \sum_{j=1, j\neq i}^{N} W_i W_j \ \text{COV}(X_i, X_j). \qquad (2.6)$$

$W_i$ and $W_j$ represent employment in the ith and jth sectors, $VAR(X_i)$ is the variance of the ith sector, and $COV(X_i, X_j)$ the covariance of the ith and jth sectors (Siegel, et al, 1995). As the portfolio value increases diversity decreases implying a low value is desired.

The national average index for diversification is based completely on mimicking the national economy. The optimal industry mix is achieved when a regional economy has the same percentage of employment in all industries as the national economy. This index therefore represents a goodness of fit measure with the national average as its benchmark (Siegel, et al, 1995).

Data for the region and nation are required to calculate this index.

$$\text{National Average Index} = \sum_{i=1}^{N} (X_i - \bar{X}_i)^2 / \bar{X}_i \, , \qquad (2.7)$$

where $X_i$ is the ith sector's share of employment within the region and $\bar{X}_i$ is the ith sector's share at the national level. From this equation it is obvious that the more closely the region reflects the nation the lower the value obtained, therefore the greater the diversification.

The percent durable diversity index is "assumed to be an indication of that region's reliance on export income," (Jackson, 1984, p. 104). To quantify this index simply divide employment in the durable goods industries, $E_D$, by total employment in the region, $E_T$.

$$\text{Percent Durable} = E_D/E_T. \quad (2.8)$$

As this value increases diversity decreases, which implies greater regional dependency upon the export sector(s). Export sectors are influenced by exogenous factors such as national economic changes, so reliance upon these sectors more easily introduces national shocks into the regional economy. Fluctuations in the national economy cause fluctuations in employment for these sectors as they produce products with a high income elasticity of demand. A recession can therefore lead to a large change in employment levels if an area is highly dependant upon these sectors (Jackson, 1984).

These indices have their positive and negative aspects. The ogive and entropy indices provide an easy computational approach to diversity, as they provide an easily identifiable range focused on the variety of industries rather than the type of industries. Attaran and Zwick (1987) claim the entropy index is more flexible and analytical, because of its scientific applications, than the other indices presented. The entropy index can also be decomposed to reveal interindustry diversification (Attaran and Zwick, 1989).

In contrast to the above indices the portfolio measurement seems to reveal greater explanatory power when used in regression analysis (Siegel, et al. 1995). This measurement of diversity can also reflect structural composition, through intra and intersectoral employment (Jackson, 1984). Portfolio analysis is also able to break away from the belief that equal employment in all industries is ideal, as shown in the ogive and entropy indices. This measure, however, does not measure diversity independent of stability and therefore cannot be used to test their causal relationship (Siegel, et al, 1995).

The national average index defines an economy that replicates the national economy as ideal. This is the best definition that can be provided because there is no true economy that has an ideal level of diversification. A regional economy cannot model their economy around the national economy, because regions are more limited in their production capabilities. Regions develop around their unique characteristics that enable them to create comparative advantages. The national average index can therefore be seen to ignore region specific characteristics (Siegel, et al, 1995). Another limiting factor this index has is that it cannot incorporate changes that occur to the national economy (Attaran and Zwick, 1987). This reveals the inability of this measurement to determine whether the regional economy is becoming more or less diversified (Attaran and Zwick, 1989).

Lastly, the percent durable index provides an excellent way to visualize where downturns in the national economy can most damage any regional economy. This measurement, however, provides a narrow analysis of the economy focused only on employment in the durable sectors. This combined with the actualization that the measure implies an optimal mix of durable and nondurable employment for every regional economy exists makes this index's importance small (Jackson, 1984).

***Later Research on Diversity and Stability***

McLaughlin (1930) and Tress (1938), take the approach of first analyzing industries that are by nature more unstable and second how these industries are affected by cyclical fluctuations within the economy. Their approach leads to biased results because of the narrowly defined focus sectors, and therefore do not encompass the interrelatedness of the industries which may actually promote increased stability. Including all employment avenues would more fully validate the theory in regards to a specified economy. This is what is primarily done with later research, as all employment except that in agricultural is usually included. Agriculture is oftentimes discarded because of its natural volatility.

Later research considers a greater array of employment opportunities in the defined economic regions to conduct a more complete analysis. These studies use a variety of models from simple regression and cross sectional analysis, and input-output models. Oftentimes simple regression and cross sectional are pooled together enabling a dynamic analysis across regions to be conducted.

### *Pooled Analyses*

Regression analysis has been used to determine the sign, magnitude, and significance of the relationship between diversification and instability. These analyses differ as to what is included in the regression as some include additional explanatory variables, or other measurements of instability, such as employment or income growth. The results of these have varied in the strength of the relationship as seen in the significance levels and $R^2$s (Siegel, et al., 1995). These results can validate the hypothesized relationship, but still leave room for further improvements.

To highlight the pooled analysis the following five articles are briefly summarized: Jackson (1984), Wundt (1992), Smith and Gibson (1988), Kort (1981), and Malizia and Ke (1993)[3].

Jackson analyzed employment data for the state of Illinois excluding the sectors of agriculture and government. He concluded, through use of various diversification measures, that the theory fails to hold for the state of Illinois. This is based on the results

[3] See also Gratton (1979), Brewer (1984), and Attaran and Zwick (1989).

of his regression analysis in which the relationship of diversification and instability were positively related in most cases, which is the opposite of what theory predicts.

Basically, Jackson regressed average growth rates, or a time trend growth of employment, against the different diversification measurements: portfolio, ogive, percent durable goods, and national average indices. These contradictory results, although discouraging, highlight the importance of the level of aggregation placed on the data, as well as its quality. The data sensitivity illustrated with the conflicting results indicates the importance of data limitation issues. Jackson's study may have been victimized by small sample bias, as well as, seasonal bias due to use of 18 annual observations measured in the month of March.

Wundt (1992) conducted a similar study on the state of Connecticut. Wundt used employment figures for manufacturing employment at the two and three digit Standard Industrial Classification (SIC), and conducted a series of regressions on various diversity indices. Within this study the theory of increased diversity was found to increase stability for each of the indices. The t-statistics on the regression results were almost all significant and the $R^2$s were much stronger than in previous studies, with a high of 0.829 and 0.922 for analysis using the three and two digit SIC, respectively. The stronger results seen in the more highly aggregated data (going from the 3 to 2 digit) is foreseeable as conceptual problems can be masked with greater aggregation (Wundt, 1992). It is important to note, however, that analysis done on the most disaggregate level is the most beneficial for policy implications.

Smith and Gibson (1988) conducted their study on nonmetropolitan counties in the state of Idaho using annual data over 11 years. They used the same indices for instability and diversity as Kort (illustrated in the next section): the Regional Economic Instability and entropy indices. These values were regressed in five different regressions, each with different independent variables, and were all found to support the theory. The inclusion of the agricultural and mining industries as additional independent variables, in some of the regressions, added to instability. This indicates that extractive industries should not be industries that an economy chooses to develop around.

Kort emphasizes that the size of the economic region analyzed is important to know so that heteroskedasticity can be avoided. This issue was previously indicated in terms of how city size influences the degree of diversification, but not the problems of heteroskedasticity.[4] Kort follows the study of Thompson (1965) and attempts to explain why smaller statistical areas have a wider range of instability than larger areas. The explanation for this observation is that greater levels of diversification increase the similarities of regional economies to the national economy and therefore reduces their susceptibility to local shocks.

Kort used four diversity indices (entropy, ogive, national average, and percent durable) and an instability index based on a time trend, and analyzed 106 standard metropolitan statistical areas (SMSAs). The data was quarterly from 1967 to 1976 on all nonagricultural employment. After calculation of the indices for each of these areas regressions were run to quantify the relationship across the SMSAs. All regressions, except the one with the percent durables index, yielded the hypothesized relationship. The $R^2$s improved dramatically after correcting for heteroskedasticity, and the regression with the entropy index performed the best. Kort's success indicates that with appropriate econometric techniques some data problems can be alleviated.

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[4] See Rodgers (1957), Thompson (1965), Clemente and Sturgis (1971), and Marshall (1975)

Malizia and Ke (1993) found more conclusive evidence for the theory than Kort. The need for greater evidence can be easily seen from the previous works above as contradictions have occurred. Malizia and Ke emphasize not only the need for diversity within an economic region but also competitiveness. Competitiveness, as mentioned previously by Isard (1956), Vining (1946), and Thompson (1965), and diversity are both needed to create a stable economy as these two elements act as the main stabilizers. With competitiveness comes specialization, however, which is the opposite recommendation of previous works. Specialization leads to agglomeration as spillover effects and supply and demand linkages are felt and established from the competitive industry, such as the computer industry in the Silicon Valley. A major point to mention is that an economy can still be diverse if sufficiently large enough to have numerous industries in which it specializes. This aspect of course necessitates a major metropolitan area.

Malizia and Ke used quarterly data from 1972 to 1988 at the two digit SIC for 255 metropolitan statistical areas (MSAs) and county metropolitan statistical areas (CMSAs). They use the same index as Kort for instability and use the entropy index for diversity. Along with this model they also include the use of an unemployment model to provide a comparison to instability. Further explanations were gained by the inclusion of demographic statistics and dummy variables as additional independent variables in the regressions. The dummy variables were used to represent the regions analyzed. Also included with the entropy measurement for industrial diversification was another entropy measurement for occupational diversification. Both models, instability and unemployment, yielded the correct signs on the industrial diversification variable.

The conclusions drawn from this study are that increased diversity does indeed lead to greater stability, but so too does having multiple specializations. The later aspect enables a more homogenous labor force to develop, which enables the unemployed to more easily become reemployed.

### *Input-Output Studies*

To further capture interindustry linkages other studies have used input-output (IO) analyses.[5] Within these studies portfolio theory is sometimes incorporated in attempts to analyze growth and stability impacts of diversification (Siegel, et. al. 1995). Wagner and Deller (1998) built further upon the idea of interindustry linkages through a scalar measurement of economic structure. This enabled them to create a new diversity index incorporating both interindustry linkages and size of the regional economy.

Siegel et. al. (1995), compare the variety of diversity indices that exist and then make the argument that IO models are the best method to represent the relationship between diversity and stability. Their study highlights the work of Cho and Schuermann (1980), Gilchrist and St. Louis (1991), Berck et. al. (1992) and Wundt and Martin (1993). They emphasize the need to break the economy into export and local, or basic and nonbasic, industries. The rationale is that the growth stems from the export sectors as they act as injectors. The authors, therefore, push that the demand for these export goods and services be the predictor of growth and stability. The value of modeling an economy with an IO model is that the performance of the region can be modeled as a function of its industrial structure (Siegel, et al. 1995).

[5] Cho and Schuerman (1980), Wundt and Martin (1993), Siegel, Alwang, and Johnson (1994, 1995), and Wagner and Deller (1998).

Wagner and Deller (1998) construct three scalar measurements to more adequately model various regions. The regions in which they study are at the state level due to greater data availability and that policies predominately get implemented at this level. The scalar measurements capture the economies' structure in terms of their production, consumption, and trade relationships, which requires an IO model. The first scalar measures the size of the economy through comparison of the endogenous industries within the studied economy to a hypothetical base economy. The second scalar measures the level of imports to quantify the degree of importation and resulting leakage. The third scalar measures the interindustry linkages that exist. These three scalars, when analyzed together, create a new measurement for diversity which incorporates the size and degree of interindustry linkages.

The conclusion of their study is to have multiple specializations within an economy, which is the same result of Malizia and Ke (1993). This element of their study has implications with policy recommendations, and that is the necessity for both horizontal and vertical integration. This type of development strategy encourages the creation of value added production and establishment of agglomerations.

Within the literature the disagreement has not been about the relationship that exists between diversification and instability, but the empirical results. These discrepancies are primarily caused due to four areas of data sensitivity identified by Wagner and Deller (1998): (1) sample sizes are small; (2) over aggregation of data sets; (3) measurements of diversity and stability; and (4) overly simplified statistical methods. Heteroskedasticity also has to be recognized as a potential reason for these anomalies as recognized by Wasylenko and Erickson (1978), where highly specialized cities appear stable and diverse cities unstable.

A time series model seems most appropriate to fully displays the time dynamics between the calculated indices. The initerindustry linkages of the IO model, however, provide a powerful linkage in understanding the intimacies of an economy. A combination of these two aspects would create a much improved method of modeling an economy, as well as, being able to test the diversity/stability link. Cointegration is an econometric technique that would enable both of these aspects to be implemented within one model, as cointegration enables long run equilibriums to be derived. These equilibriums represent the time dynamics between sectors, and an economy in equilibrium is one that is in a stable state. The act of maintaining that equilibrium would be the characteristic of stability, which as diversity increases should become easier.

**2.3. Regional Cointegration**

The studies outlined in this section demonstrate the use of Vector Autoregressive (VAR) models and Vector Error Correction Models (VECMs) at the regional level. These modeling techniques enable the analysis of nonstationary data to be conducted. If the nonstationary data are cointegrated then a VECM is used instead of a VAR leading to improved forecasts.

LeSage and Reed (1989) devised a dynamic location quotient to better represent industries that are considered as basic (export) and nonbasic (local). Industries identified as basic have a large percentage of their output exported out of the local economy, whereas non-basic industries produce primarily for the local economy. These non-basic sectors can respond to changes in the basic sectors, however. Location quotients are used to identify which classification each industry belongs by comparing the percentage of employment in the regional industry to the national economy.[6] Since the national economy is considered self-sufficient any local economy that has a greater percentage of their labor force employed in a specific industry must produce at least partially for export (LeSage and Reed, 1989).

Their location quotient was used to analyze eight metropolitan areas within the state of Ohio. After placement of the sectors into basic and nonbasic sectors they were decomposed into three variables: non-durable manufacturing, durable manufacturing, and non-manufacturing. These variables were modeled using a VAR process to enable impulse response functions to be conducted, which enabled predictions of future movements within these industries to be made. These predictions represented an improvement over previous studies that failed to incorporate the dynamic approach to the determination of basic and nonbasic industries (LeSage and Reed, 1989). This paper presented the methodology for the establishment of dynamic relations, which provided the groundwork used in LeSage's later studies that incorporate cointegration.

Two later works by LeSage (1990a, 1990b) implemented the use of the dynamic calculation of the location quotient plus cointegration. The main objective of both of these studies was to compare the forecasts from traditional VARs to VECMs.

The first study concluded that with the existence of cointegration VECMs out perform VAR models by 20 percent. When cointegration does not exist these results are reversed. This study used monthly labor market data at the two and three digit Standard

[6] Other derivations of the location quotient exist, such as, using the state as the benchmark or use of income instead of employment.

Industrial Classification (SIC) level for 50 Ohio industries. From these industries five were found to be nonstationary by both the Dickey-Fuller and Augmented Dickey-Fuller tests for unit roots, but were not found to be cointegrated (LeSage, 1990a).

The second study built a stronger case for the value of cointegrated models at the regional level. The objective was to establish that a long run relationship between basic and nonbasic sectors in order to validate the use of cointegration. LeSage continued the study he began with Reed (1989) and used the same data on the eight metropolitan areas within the state of Ohio. Three variables durable manufacturing, non-durable manufacturing, and non-manufacturing were once again used and one cointegrated relationship was found. This relationship enabled the use of a VECM to make forecasts. The value of the increased accuracy of predictions from a VECM representation over a VAR becomes greater as number of forecast periods increase. The main contribution of this study is that the

> error-correction mechanism methodology employed here allows traditional static export-base theory to be extended to a time-series framework that incorporates both long-run equilibrium relations and short-run dynamic interactions between local and export employment (LeSage, 1990b, p. 321),

which provides the justification to use cointegration to analyze regional economies and issues.

Shoesmith (1992) attempted to prove through cointegration that state, regional, and national employment follow similar patterns. The existence of cointegration would provide another method that could be used to analyze aggregate economic data besides gross domestic product. These relationships were tested through analysis of each state's employment to verify if cointegration exists with any other state. The results indicated of the 3422 possible pairs only 69 revealed any evidence of cointegration. There was evidence, however, that national employment does granger cause employment at the state and regional levels (Shoesmith, 1992).

The lack of cointegration found between these three employment distinctions is discouraging, especially given their causal relationship. The study does, however, provide further evidence that VECM models out perform VAR models in terms of forecast accuracy when cointegration exists. When cointegration does not exist a VAR model in first differences is best (Shoesmith, 1992).

Brown, Coulson, and Engle (1992) examined monthly employment data from Philadelphia from 1975-87 using cointegration. Through location quotients they aggregated the data into basic and nonbasic sectors, and created a simple two variable cointegrated system. This system provided a unique method to test whether the series is indeed aggregated into their correct classifications accomplished through the normalization requirement of the Johansen technique and analysis of the speeds of adjustment (Brown, et al, 1992).

The normalization requires that a unique variable exist in each cointegrated vector, in this case there was only one so it was easily accomplished. But the choice of which series to normalize around presents an interesting analysis. The VECM representation of a cointegrated system can be used to examine the speeds of adjustment.[7] These speeds of adjustment, when combined with the cointegrated coefficients, determine the speed in which the cointegrated vectors return to equilibrium. Along with the speed, the series responsible for reequilibrating the vector can also be determined. This

[7] Modeling short run dynamics should in fact be modeled using the VECM with its ability to represent partial adjustments (Engle and Granger, 1987 and Sasaki, 1963).

combined with basic and nonbasic theory suggests that the non-basic sectors respond to local disequilibrium and force a return to equilibrium while basic sectors should be unresponsive. The regional literature supports this theory, which indicates that the non-basic sector should be the one that is normalized to determine its structural relationship to the basic sector (Brown, et al, 1992). This analysis becomes more complicated as the number of variables increase, but with just two the distinction of which variable to normalize around does not matter. This idea of basic and non-basic theory combined with cointegration is the main contribution of this work.

Shoesmith (1995) used Johansen's multivariate test for cointegration to expand the number of variables analyzed. This study verified increased proficiency in a cointegrated model's VECM representation over that of a VAR when cointegration exists (Shoesmith, 1995).

Shoesmith analyzed data from the United States and the four states of New York, North Carolina, Texas, and Vermont in separate models. The state models were comprised of five variables: real gross national product (GNP), implicit price deflator for GNP, three-month Treasury bill, state employment (without agriculture), and state real personal income. This system represented a major leap from the simple two variable system analyzed by Brown, Coulson, and Engle (1992). Johansen and Juselius (1992) also estimated a five variable system, but it was conducted at the national level. There was very little evidence of cointegration among these variables in each of the four states (Shoesmith, 1995). This result may discourage the use of cointegration at the regional level, but it should not as the multivariate process attempted here represented a significant increase in difficulty.

Phillips and Chang (1995) used Shoesmith's (1995) approach of Johansen's multivariate cointegration techniques to study the Texas economy. They used four variables in their study: relative wages, Texas employment, United States employment, and a lead indicator variable from the state itself. Among these variables it was found that one cointegrated vector existed, which justified use of a VECM model to predict Texas employment (Crane and Nourzad, 1998).

Crane and Nourzad (1998) followed up on the studies of Shoesmith (1995) and Phillips and Chang (1995). Their study used the multivariate cointegration technique to analyze manufacturing employment in Milwaukee, Wisconsin. Data used in this study consisted of: local manufacturing employment, nominal local manufacturing wage, United States manufacturing wage, the Consumer Price Index, a dummy variable, and a lead indicator variable. Like Phillips and Chang only one cointegrated vector was found, but it provided insight into the structural relationship between those variables as the "link between the local and national labor markets," (Crane and Nourzad, 1998, p. 192). The long run implications of the model indicated by its forecast capabilities are seen with the knowledge of the structural relationships.

The success of cointegration within the last two works provides justification for this technique for regional analysis. The final models derived are often more complex than the initial works and yield even greater forecasts. The main contributions of these cointegrated models are the potential of establishing links between industries within the economy, and ability to capture time dynamics through long run equilibriums. These two contributions from the use of cointegration make it a valuable tool to use at all levels.

## CHAPTER III

## Mathematical Approach to Cointegration and Persistent Profiles

### 3.1. Introduction

This chapter presents the mathematical representation of cointegration and persistent profiles. Transformation of a vector autoregressive (VAR) model into vector error correction model (VECM) must be conducted first, however. This transformation enables Johansen's multivariate technique for deriving maximum likelihood estimators (MLEs) of cointegrating vectors (CIVs) to be performed. The VECM provides the speeds of adjustment matrix, $\alpha$. When $\alpha$ is combined with the cointegrated coefficients, the $\beta$ matrix, a stationary outcome results and cointegration exists. After the equations for the MLEs have been illustrated, the math of persistent profiles is illustrated.

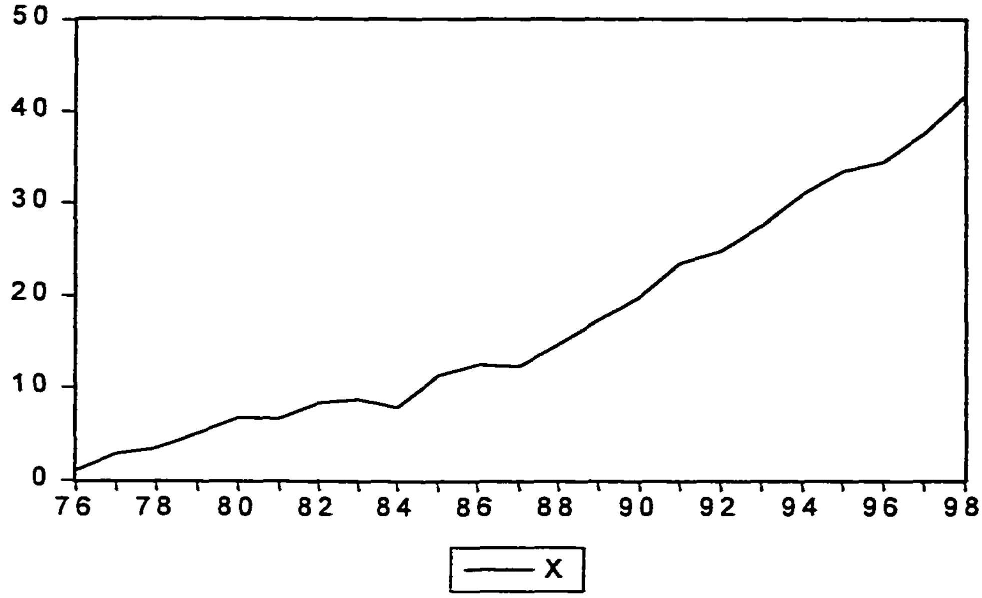
### 3.2. Cointegration

Cointegration is a statistical method used to determine long run relationships between two or more nonstationary series, which have infinite means and variances shown in equations (3.1) and (3.2):

$$E(X_t) = n\mu \quad \text{and} \quad E(X_{t+1}) = (n+1)\mu \tag{3.1}$$

$$Var(X_t) = n\sigma^2 \quad \text{and} \quad Var(X_{t+1}) = (n+1)\sigma^2. \tag{3.2}$$

These characteristics reveal the series as non-mean reverting and they tend to drift upward (or downward) over time. Figure 3.1 illustrates a randomly generated nonstationary series, $X_t$, and a stationary series, $DX_t$. $X_t$ is integrated to the first degree, I(1), or must be first differenced to be made stationary, while $\Delta X$ is stationary.



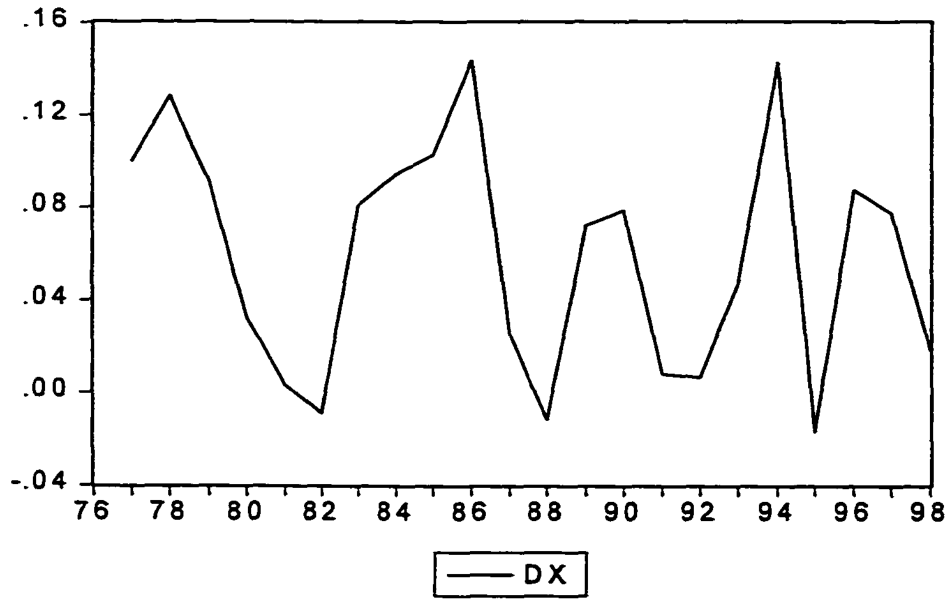




**Figure 3.1. Nonstationary ($X_t$) and Stationary ($DX_t$)**

Cointegration identifies stationary relationships between nonstationary series through cointegrating vectors (CIVs). These stationary combinations identify long run equilibriums, which are formalized through this definition,

> "The components of the vector $x_t$ are said to be [co-integrated] of order d, b, denoted $x_t \sim CI(d,b)$, if (i) all components of $x_t$ are I(d); (ii) there exists a vector $\alpha$ ($\neq 0$) so that $z_t = \alpha' x_t \sim I(d-b)$, $b > 0$. The vector $\alpha$ is called the [co-integrating] vector," (Engle and Granger, 1987).

Equation (3.3) illustrates a simple two variable cointegrated relationship,

$$\beta_1 X - \beta_2 Y = \varepsilon, \tag{3.3}$$

where $\beta_1$ and $\beta_2$ are the cointegrated coefficients and $\varepsilon$ the stationary series representing departures from long run equilibrium.

### *Johansen Method*

To illustrate Johansen's multivariate cointegration technique a nonstationary VAR process, $X_t$, must be defined and transformed into a vector error correction (VEC) representation. This transformation separates the stationary and nonstationary components. $X_t$ is illustrated in equation (3.4) as an AR(2) process;

$$X_t = \Gamma_1 X_{t-1} + \Gamma_2 X_{t-2} + \varepsilon_t; \text{ where } \varepsilon_t \sim (0, \sigma_\varepsilon^2). \tag{3.4}$$

Subtracting $X_{t-1}$ from both sides leaves;

$$X_t - X_{t-1} = \Gamma_1 X_{t-1} - X_{t-1} + \Gamma_2 + \varepsilon_t,$$

which can be rearranged into

$$\Delta X_t = (\Gamma_1 - I)X_{t-1} + \Gamma_2 X_{t-2} + \varepsilon_t, \tag{3.5}$$

where I = an identity matrix. Next add and subtract $(\Gamma_1 - I)X_{t-2}$ from the right hand side;

$$\Delta X_t = (\Gamma_1 - I)X_{t-1} + (\Gamma_1 - I)X_{t-2} - (\Gamma_1 - I)X_{t-2} + \Gamma_2 X_{t-2} + \varepsilon_t,$$

placing like terms together yields;

$$\Delta X_t = (\Gamma_1 - I)\Delta X_{t-1} + (\Gamma_2 + \Gamma_1 - I)X_{t-2} + \varepsilon_t. \qquad (3.6)$$

Respecifying $(\Gamma_1 - I)$ as $\Pi_1$ and $(\Gamma_2 + \Gamma_1 - I)$ as $\Pi_0$ (3.6) can be rewritten as;

$$\Delta X_t = \Pi_1 \Delta X_{t-1} + \Pi_0 X_{t-2} + \varepsilon_t. \qquad (3.7)$$

Equation (3.7) reveals the stationary component, $\Delta X_{t-1}$, and the nonstationary component, $X_{t-2}$.

$\Pi_0 = \alpha\beta'$, contains the speeds of adjustment matrix, $\alpha$, and the matrix of the cointegrating coefficients, $\beta$. $\beta' X_{t-2}$ yields a stationary outcome and therefore it can be seen that together they form a CIV. This same process can be conducted for any order VAR, as illustrated with a VAR(k) in equation (3.8);

$$\Delta X_t = \Pi_1 \Delta X_{t-1} + \Pi_2 \Delta X_{t-2} + ... + \Pi_{k-1} \Delta X_{t-k+1} + \Pi_0 X_{t-k} + e_t, \qquad (3.8)$$

where

$$\Pi_i = \Sigma\Gamma_i - I, \text{ and } \Pi_0 = (\Gamma_1 + \Gamma_2 + ... + \Gamma_k - I). \qquad (3.9)$$

The Johansen procedure calculates equation (3.9) using maximum likelihood by means of a concentrated log likelihood function which maximizes the parameters $\Pi_1$, which will be illustrated following the presentation of Banerjee, et al. (1993). This is accomplished through a series of regressions which break down to ordinary least squares regressions of, "$\Delta X_t + \alpha\beta' X_{t-k}$ on the lagged differences" (Johansen, 1988, p. 134), illustrated below.

The process starts with the log likelihood function, L, which is maximized through the parameters $\Pi_i$. With $\Pi = \alpha\beta'$ it can be seen that the attained estimates are in terms of $\alpha$ and $\beta$, along with the variance/covariance matrix, $\Omega$. The log likelihood function

$$L = (Tn/2)\log 2\Pi - (T/2)\log|\Omega| - (1/2)\sum_{1}^{T} e_t'\Omega^{-1}e_t, \quad (3.10)$$

which is concentrated to yield the maximum likelihood estimates.

First concentrate L with respect to $\Omega$,

$$\partial L/\partial\Omega = T^{-1}\sum_{1}^{T} e_t e_t', \quad (3.11)$$

which reduces to the sum of squared residuals (SSR)

$$\hat{\Omega} = (\sum_{1}^{T} e_t' e_t)/T. \quad (3.12)$$

The I(0), or stationary variables from (3.8) must now be removed to focus on the $\Pi_0$ matrix. This requires further concentration of L with respect to $\Pi_1 ... \Pi_{k-1}$ accomplished through the ordinary least squares mentioned. These regressions give the residuals, $R_{0t}$ and $R_{kt}$. To illustrate let

$$q_t = (\Delta X'_{t-1}, ... \Delta X'_{t-k+1}), \quad (3.13)$$

and

$$R_{0t} = \Delta X_t - \sum_{i=1}^{k-1} \hat{\prod} \Delta X_{t-i}. \quad (3.14)$$

Identifying $q_t$ and $R_{0t}$ allows the concentration procedure to proceed by identifying $\Pi_i$ ... $\Pi_{k-1}$;

$$(\hat{\Pi}_1 ... \hat{\Pi}_{k-1}) = (\sum_{t=1}^{T} X_{t-k} q_t')(\sum_{t=1}^{T} q_t q_t')^{-1}. \quad (3.15)$$

$R_{kt}$ can be seen to equal;

$$R_{kt} = X_{t-k} - \sum_{i=1}^{k-1} \bar{D}_i \Delta X_{t-i}, \quad (3.16)$$

enabling

$$(\tilde{D}_1 \cdots \tilde{D}_{k-1}) = (\sum_{t=1}^{T} X_{t-k} q_t')(\sum_{t=1}^{T} q_t q_t')^{-1} . \tag{3.17}$$

The log likelihood function, $L(\Pi)$,now reveals dependency only upon $R_{0t}$ and $R_{kt}$,

$$L(\Pi) = k_0 - (T/2)\log\left|\sum_{t=1}^{T}(R_{0t} - \Pi R_{kt})(R_{0t} - \Pi R_{kt})'\right| \tag{3.18}$$

$$S_{ij} = T^{-1}\sum_{t=1}^{T} R_{it} R_{jt}' \text{, where i, j = 0, k.} \tag{3.19}$$

Combining equation (3.18) with (3.19) enables $L(\Pi)$ to be rewritten as

$$L(\Pi) = k_0 - (T/2)\log|S_{00} - \Pi S_{k0} - S_{0k}\Pi' + \Pi S_{kk}\Pi'|. \tag{3.20}$$

Imposing the restriction $\Pi = \alpha\beta'$ transforms $L(\Pi)$ into $L(\alpha,\beta)$ in which $\hat{\alpha}$ and $\hat{\Omega}$ can be estimated using the SSR, equation (3.12). This is accomplished by taking the derivative of (3.12) with respect to $\alpha$. The SSR must first be redefined in terms of $S_{0t}$ and $S_{kt}$. Taking the square of the error term, $\varepsilon$, displays the SSR:

$$\varepsilon = S_{0t} - \alpha\beta S_{kt} \tag{3.21}$$

$$\varepsilon\varepsilon' = (S_{0t} - \alpha\beta S_{kt})(S_{0t} - \alpha\beta S_{kt})' \tag{3.22}$$

$$\varepsilon\varepsilon' = S_{0t}'S_{0t} - 2S_{0t}\alpha\beta' S_{kt} + \alpha\beta'\alpha\beta S_{kt}S_{kt}. \tag{3.23}$$

Taking the derivative as stated above gives $\hat{\alpha}$,

$$\partial\, \varepsilon\varepsilon'/\partial\, \alpha = -2S_{0t}\beta S_{kt} + 2\alpha\beta'\beta S_{kt}S_{kt} = 0 \tag{3.24}$$

$$\hat{\alpha}(\beta) = - S_{0k}\beta(\beta' S_{kk}\beta)\text{-}1. \tag{3.25}$$

Equation (3.25) can be plugged into (3.20) to gain $\hat{\Omega}$. To gain this estimate replace $\Pi$ with its equivalent $\alpha\beta'$ and plug into equation (20) wherever $\alpha$ appears to get,

$$L(\beta) = k_0 - (T/2)\log\left| S_{00} - (S_{0k}\beta)(\beta' S_{k0})/\beta' S_{kk}\beta - (S_{0k}\beta)(S_{0k}\beta)/\beta' S_{kk}\beta + [S_{0k}\beta/\beta S_{kk}\beta] (\beta' S_{kk}\beta) [S_{0k}\beta/\beta' S_{kk}\beta] \right|. \qquad (3.26)$$

Focusing on what is inside the absolute value symbol, reduces (3.26) to,

$$L(\beta) = S_{00} - [S_{0k}\beta\beta' S_{k0} + S_{0k}\beta S_{0k}\beta - S_{0k}\beta S_{0k}\beta]/\beta' S_{kk}\beta, \qquad (3.27)$$

which can be further reduced by factoring out $S_{0k}\beta\beta' S_{k0}$.

$$L(\beta) = S_{00} - [S_{0k}\beta\beta' S_{k0}(1 + 1 - 1)]/\beta' S_{kk}\beta, \qquad (3.28)$$

which is equal to,

$$\hat{\Omega}(\beta) = S_{00} - S_{0k}\beta(\beta' S_{kk}\beta)^{-1}\beta' S_{k0}. \qquad (3.29)$$

The estimates for $\alpha$ and $\Omega$ have been calculated holding the parameter $\beta$ constant. These estimates, along with $\Pi$, have now been transformed into their reduced form equations. This process requires further analysis of equation (3.29).

$$\hat{\Omega}(\beta) = | \beta' S_{kk}\beta |^{-1} | S_{00} || \beta' S_{kk}\beta - \beta' S_{k0} S_{00}^{-1} S_{0k}\beta |. \qquad (3.30)$$

$\hat{\Omega}(\beta)$ must be maximized with respect to $\beta$ to eliminate $S_{00}$, which is similar to minimizing the generalized variance ratio:

$$| \beta'(S_{kk} - S_{k0} S_{00}^{-1} S_{0k})\beta | / | \beta' S_{kk}\beta |. \qquad (3.31)$$

Limited information maximum likelihood implies $\beta' S_{kk}\beta = I$. This restriction enables the problem to be treated as a Lagrangian function, where $\beta'(S_{kk} - S_{k0} S_{00}^{-1} S_{0k})\beta$ is maximized subject to $\beta' S_{kk}\beta = I$. This step provides

$$| \beta'(S_{kk} - S_{k0} S_{00}^{-1} S_{0k})\beta | - \varphi[\mathrm{trace}(\beta' S_{kk}\beta - I)], \qquad (3.32)$$

where $\varphi$ is the Lagrangian associated with the constraint. Equation (3.32) is solvable by the generalized eigenvalue form,

$$(\lambda S_{kk} - S_{k0}S_{00}^{-1}S_{0k})\beta = 0. \qquad (3.33)$$

This result is derived from the theory of canonical correlations.[8] If equation (3.33) is rewritten to incorporate the eigenvalue matrix, β, accomplished by pre-multiplication by β, then $S_{kk}$ becomes diagnolized to an identity matrix. This procedure can therefore be seen to incorporate the identity restriction, $\beta' S_{kk}\beta = I$, and transform $S_{k0}S_{00}^{-1}S_{0k}$ to the matrix of eigenvalues, Λ. This can be seen to have introduced, $r^2$, restrictions into the system. If the individual eigenvalues, $\lambda_i$, within Λ take on the form, $\lambda_i = 1 + \mu_i$ and $\beta'(S_{kk} - S_{k0}S_{00}^{-1}S_{0k})\beta = \beta' S_{kk}^*\beta$, then (3.33) becomes,

$$(1 + \mu_i)[\beta'(S_{kk} - S_{k0}S_{00}^{-1}S_{0k})\beta]. \qquad (3.33')$$

Solving (3.33') gives,

$$\mu_i = \beta' S_{kk}^*\beta / \beta' S_{kk}\beta, \qquad (3.34)$$

which reveals that the smallest value of the ratio yields the largest $\mu_i$ and therefore the largest eigenvalue.

Returning to the eigenvalue matrix, Λ, and solving for the reduced form equations:

$$\Lambda_r = \hat{\beta} S_{k0} S_{00}^{-1} S_{0k} \hat{\beta}. \qquad (3.35)$$

$\Lambda_r$ represents the r largest elements of the eigenvalue matrix, or the significant eigenvalues. Using the maximum likelihood estimator $\hat{\alpha}(\beta) = - S_{0k}\beta(\beta' S_{kk}\beta)^{-1}$ and the restriction $\beta' S_{kk}\beta = I$, equation (3.35) can be reduced to,

$$\Lambda_r = \hat{\alpha}' S_{00}^{-1} \hat{\alpha}, \quad \text{and } \Lambda_{n-r} = \hat{\rho}' S_{00}^{-1} \hat{\rho}. \qquad (3.36)$$

[8] Details can be found in Anderson (1958).

These two equations define all the eigenvalues within the matrix, $\Lambda$. The $\Lambda_{n-r}$ equation (3.36) represents the eigenvalues that are not significant, and $\hat{\rho}$ represents $\hat{\alpha}$ for these omitted eigenvalues.

The significance of the eigenvalues can be tested through the Maximum Eigenvalue ($\lambda_{max}$) and Trace ($\lambda_{trace}$) tests;

$$\lambda_{max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \quad (3.37)$$

$$\lambda_{trace}(r) = -T \Sigma \ln(1 - \hat{\lambda}_i). \quad (3.38)$$

These tests determine the number of significant eigenvalues and indicate how many unique relationships exist within the cointegrated system. The determination of r accomplishes the second part of the definition for cointegration defined by Engle and Granger (1987).

With the eigenvalues defined the final step for the reduced form equations for $\hat{\alpha}$, $\hat{\Omega}$, and $\hat{\Pi}$ can be conducted by combining their original forms

$$\hat{\alpha}(\beta) = -S_{0k}\beta(\beta' S_{kk}\beta)^{-1}, \quad (3.39)$$

$$\hat{\Omega}(\beta) = S_{00} - S_{0k}\beta(\beta' S_{kk}\beta)^{-1}\beta' S_{k0}. \quad (3.40)$$

with $\Pi = \alpha\beta'$ and the identity restriction. This reduces to

$$\hat{\alpha} = -S_{0k}\hat{\beta}, \quad (3.41)$$

$$\hat{\Omega} = S_{00} - \hat{\alpha}\hat{\alpha}', \text{ and} \quad (3.42)$$

$$\hat{\Pi} = -S_{0k}\hat{\beta}\hat{\beta}'. \quad (3.43)$$

As can be seen equation (3.41) depends upon the optimization of $\beta$, while (3.42) and (3.43) do only indirectly (Banerjee, et al., 1993).

### 3.3. Persistent Profiles

The underlying aspect of persistent profiles is the use of the difference between the conditional variance at time t and t-1. The presentation of persistent profiles follows that given by Pesaran and Shin (1996) and Lien and Root (1999). Take, $X_t$, an m x 1 vector process that is first difference stationary, represented by

$$\Delta X_t = \mu + \sum_{i=0}^{\infty} A_i L^i \varepsilon_t \qquad \text{for } t = 1,2,\dots T. \qquad (3.44)$$

$\mu$ is an m x 1 column vector, $A_i$ is a matrix of m x m where the diagonal elements have been normalized, L is a lag operator and $\varepsilon_t$ is m x 1 and is distributed with a mean of zero and a constant non-singular variance-covariance matrix, $\Omega$. For $X_t$ to be cointegrated a matrix $\omega$ of order m x r must exist that when combined with $X_t$ yields a stationary vector of r x 1, $Z_t$, where $Z_t = \omega' X_t$. The long run multiplier equals, $A(1) = \sum_{i=0}^{\infty} A_i$ with a rank of m - r, where r equals the number of cointegrated vectors. If $\omega' A(1) = 0$, then the necessary and sufficient condition for cointegration exists. Taking equation (3.42) and applying Beveridge and Nelson's (1981) decomposition yields,

$$X_t = \tau_t + \sum_{i=0}^{\infty} [B_i - A(1)] \varepsilon_{t-i} \qquad (3.45)$$

where $\tau_t = \mu_t + \tau_{t-1} + A(1)\varepsilon_t$

$B_i = A_0 + A_1 + \dots A_i$.

This enables $Z_t$ to be written as,

$$Z_t = \omega'\tau_t + \omega'\sum_{i=0}^{\infty} B_i \varepsilon_{t-i} \ . \qquad (3.46)$$

The impulse response approach proceeds using the Choleski decomposition of the variance-covariance matrix, Ω. This approach does not provide a unique analysis since the decomposition is itself not unique. A system wide shock would provide the uniqueness that these individual shocks do not produce. To conduct this shock it must be based on the change in the conditional variance of X, as mentioned previously, and on the cointegrated system Z. The series of equations (3.47) to (3.50) illustrates this procedure:

$$H_x(n) = Var(X_{t+n}|I_{t-1}) - Var(X_{t+n-1}|I_{t-1}) \qquad (3.47)$$

$$H_z(n) = Var(Z_{t+n}|I_{t-1}) - Var(Z_{t+n-1}|I_{t-1}) \qquad (3.48)$$

where $I_{t-1}$ is the information known up to the t-1 time period. These equations reveal that

$$H_x(n) = B_n\Omega B_n' \text{ and} \qquad (3.49)$$

$$H_z(n) = \omega' B_n \Omega B_n' \omega, \qquad (3.50)$$

where β are the coefficients from the VECM, ω represents the cointegrated coefficients, and Ω is the Choleski decomposed variance/covariance matrix. These last two equations have statistical properties, which reveal that the system wide shocks are now invariant to the orthogonalization of $\varepsilon_t$. This is because $H_x(n)$ gets increasing large and $H_z(n)$ converges to zero as $n \to \infty$. The persistent profile is obtained through $h_z(n)$, which is a normalization of $H_z(n)$:

$$h_z(n) = H_z(n)/ H_z(0) = (\omega' B_n \Omega B_n' \omega)/ B\Omega B' \text{ for } n = 0, 1, 2, \ldots \qquad (3.51)$$

Initially $h_z(n)$ equals unity when n = 0, and converges to zero as $n \to \infty$. The number of time periods that this process requires, n, would reveal the time taken to regain the system's long run equilibrium. Equation (3.51) is the process that is witnessed with the persistent profiles illustrated in the empirical results chapter.

## CHAPTER IV

## Aggregation of the Two Economies

### 4.1. Introduction

The two economies analyzed in this dissertation are the Portland Metropolitan Area (PMA) and the Southwest (SW) Region. Characteristics of these two economies are illustrated to reveal their different industrial structures. Aggregation of economies using the one digit SIC leads to sectors such as manufacturing, retail, and services that may not be statistically appropriate. The aggregation scheme makes use of a series of pairwise cointegration tests, which place the industries identified at the two digit Standard Industrial Code (SIC) into a logical and statistically legitimate grouping. This aggregation technique groups sectors based on statistical commonalities and therefore yields sectors free of aggregation biases. Unique characteristics of an economy can be identified with this technique that are oftentimes overlooked with other aggregation schemes. These unique traits suggest that analyses conducted at the state level are usually too aggregated to identify these regional differences. This chapter concludes with the presentation of the aggregated sectors within the two economies.

## 4.2. The Regional Economies of the PMA and SW Regions

The PMA and the SW Region represent an urban and rural economy, respectively, and were chosen because of their different degrees of diversification. The PMA should reveal greater diversity and stability relative to the SW Region due to its urban nature. These two economies reside in the same state but are geographically separate and have built their economies on different emphases.

Despite being geographically separated they do have similarites: both have the same climate and access to ports. The climate of the two areas is relatively wet as both are on the west side of the Cascade Mountains distinguishing them from the eastern side of the state which is fairly dry. The access to water transportation facilities provides the second piece of common ground. The PMA has the Port of Portland along the Columbia River that runs into the Pacific Ocean and the SW has multiple ports with direct access to the ocean. These two aspects create a more controlled environment to study the effects of diversification and stability in these two areas.

The PMA, located in the northwest portion of the state, consists of five counties that border the state of Washington: Clackamas, Hood River, Multnomah, Washington, and Wasco.[9] The four counties in the SW Region are located along the Rouge River in the southwest region: Coos, Curry, Jackson, and Josephine.[10] The differences in their industrial characteristics are presented below in a series of graphs, Figures 4.1 and 4.2.

Quarterly data was acquired from the Oregon Department of Labor from 1976 to 1998 to conduct this analysis. The graphs below illustrate the 10 sectors identified at the

[9] Shumberger, et al (1992) defined the PMA and the SW regions along with five others when they conducted a study for the Federal Government analyzing the effects of the Northwest Forest Plan in response to the Northern Spotted Owl controversy.
[10] A map of the state of Oregon highlighting the highway and interstate systems can be found in Appendix A.

one digit SIC; Agriculture, Construction, Finance-Insurance-Real Estate, Government, Manufacturing, Mining, Retail, Services, Transportation-Communication-Utilities, and Wholesale. These graphs reveal the general characteristics of each economy through their relative employment levels over time.[11]

**Portland Metropolitan Area (PMA)**

Figure 4.1 demonstrates that the PMA has undergone many changes from 1976 to 1998. The greatest structural change can be seen in the role of services, as employment within this sector has increased from 23% to 32%. While services increased in importance the Manufacturing sector fell from 16.6% to 12.9% of total employment.

Agriculture increased, but still makes up only 1.2% of overall employment. The majority of agricultural jobs within the PMA are administrative given the urban nature of the area. Mining, which is similar to agriculture in that most jobs are administrative, enjoyed a relative boom in employment through the early 1980s that reached a maximum of 2.3% in 1983.

Construction reflects the booms and busts that occurred over this time as it rose through the end of the 1970s and hit a low during the 1982 recession. Since this low it has been on an upward trend except for a brief decline in the early 1990s. Construction ended with roughly 5.9% of total employment in 1998.

Wholesale and Retail are both decreasing throughout this study, which can be partially explained by the boom in the high technological sectors within the PMA. The declines have been relatively small, however, as this regional economy offers a large

[11] Relative employment is calculated taking the employment in an industry divided by the total employment within that region, therefore creating a percentage of total employment.

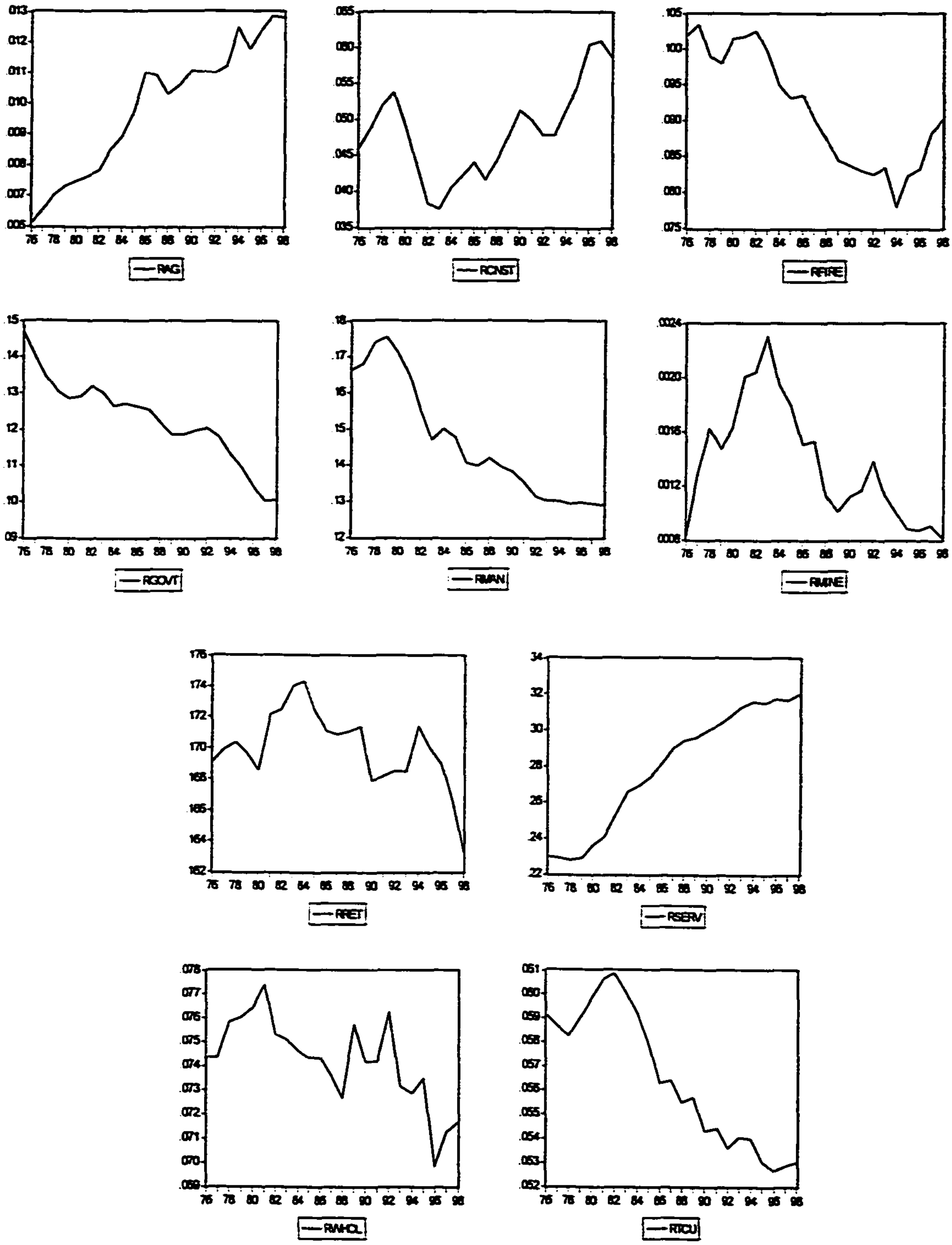



**Figure 4.1. Relative Employment in PMA**

variety of retail options for the rest of the state as well as people from Washington. Oregon's lack of a sales tax attracts shoppers from Washington and other non-residents, which can lead to a large amount of export money brought in from the retail sector.

TCU and Government have also declined in importance. TCU's decline started after 1982 when it attained a high of 6.1% and ended with 5.3% of total employment in 1998. Government's relative employment began at 14.8% in 1976 and ended at 10.2%. FIRE decreased through most of the study period with the biggest decline occurring after the 1982 recession. This decline continued until 1994 and has been on an upward trend since.

A major change which the graphs do not reveal is the surge in the high technological industries. These industries are: computer and office machinery, electronic equipment, instruments and related products, and software and data processing services. The first three are within manufacturing and the last is housed in services. These high technology industries, while not new to the PMA, have experienced huge increases since 1992 (ODL, Portland PMSA). These industries provide employment in high income professions and attract highly skilled labor to the PMA.

These technological industries combined with the geographical location of the PMA make it an attractive area for companies to locate. They can take advantage of the skilled labor force and the transportation services in the PMA making supply and demand linkages easy to make and maintain. The later is made possible because the PMA lies along the Interstate 5 corridor, has the state's major airport, and the Port of Portland along the Columbia River.

**Southwest Region (SW)**

The SW Region has some of the highest timber density in the Pacific Northwest region. This aspect has linked the economy to the timber industry both directly and indirectly. The decline of the timber industry since the 1950s, and the Northwest Forest Plan of 1992 have had noticeable effects in the SW. The direct effect of the timber industry can be seen in the employment levels of forestry, and lumber and wood manufacturing. Forestry is located within Agriculture at the one digit SIC, and lumber and wood is in Manufacturing. Indirect effects can be seen in the booms and busts of the economy as a result of the price of timber and the evolution of the economy around its comparative advantage of timber cultivation.

Analysis of the relative employment in this region, as seen in Figure 4.2, reveals an economy with changes within its industrial structure. Manufacturing has declined in importance while the Services sector has increased. Most of the loss in manufacturing has been felt by the lumber and woods sector, due partially to the mandated timber cut reductions, as it fell from 81.9% of manufacturing employment to 49.5%. Manufacturing overall fell from around 19.5% to 11.2%, while Services increased 19.2% to 30.6%.

Agriculture increased throughout but the percentage of the forestry makeup declined. Forestry started at roughly 40% of total agricultural employment and ended at about 24.5% in 1998. Agriculture increased from 2.1% to 2.5% while most of the other sectors saw a decline in importance.

Mining oscillated between 2.1% and 3.2%. These swings can be interpreted similarly to those found in the timber industry as both are highly responsive to the price of their respective resource. When prices are high employment levels increase as does

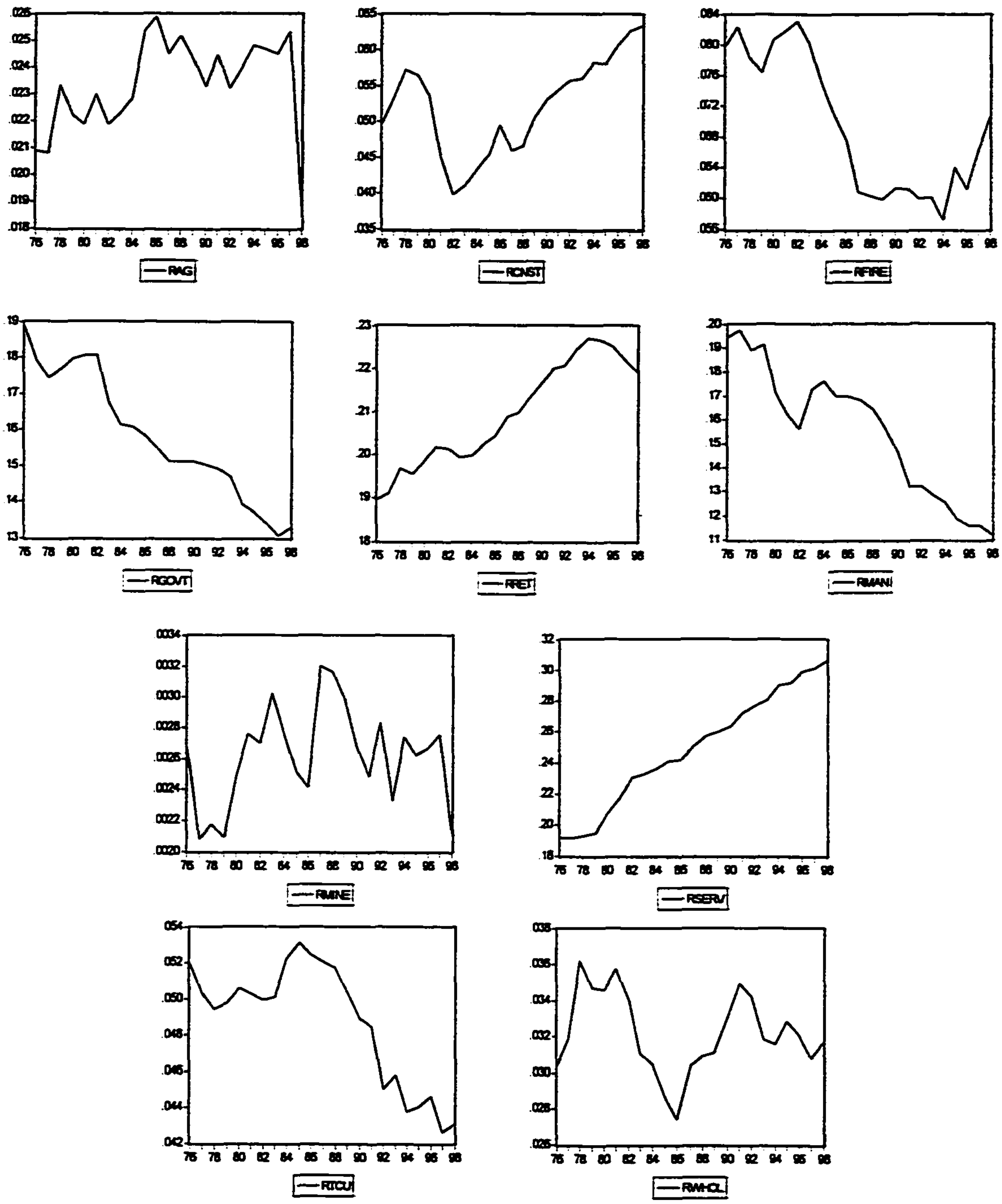


**Figure 4.2. Relative Employment in SW Region**

the amount extracted. This large supply incidentally reduces next year's price and leads to a fall in employment, which makes mining a volatile industry.

Construction in the SW felt the effects of the 1982 recession as employment fell to a low of 4%. After 1982, however, the relative employment increased with only a few downturns and ended at 6.3%.

Wholesale has been on a downward trend since 1991, but ended at about the same level as it started, 3.1%. Despite Wholesale's similar importance at the beginning and end it was another volatile sector. Wholesale attained a high of 3.6% in 1978 followed by a low of 2.7% in 1986. Retail grew from 18.9% to 21.9% but has fallen in importance since 1994. The increase in the Retail sector may be a result of the displacement felt in the timber industry, as retail provides low skill employment opportunities for an area dominated by lower skilled workers.

TCU, FIRE, and Government all declined over the study period. TCU rapidly declined from its high of 5.3% in 1985 to 4.4%. FIRE revealed a similar story as it decreased from a high of 8.3% in 1982 to a low of 5.7% in 1994, but has been on an upward trend since. Government has been on a continual downward trend from its start of about 19% to an end of 13.2%.

Similar to the PMA, the SW Region has access to ports making water transportation a valuable industry. Most of the areas within this region are not close to the interstate system, however, making transportation to other areas in the state more difficult. This difficulty results in a decreased ability to service supply and demand linkages and therefore is less attractive to potential companies. This aspect along with the fact that the area is dominated by lesser skilled industries makes the area less diversified.

### 4.3. Aggregation Methods

The data collected for the two economies represents 92 observations. This data covers employment in 74 and 69 sectors for the PMA and SW Region, respectively. The process of aggregating these sectors is vital because improper aggregation will yield inadequate representations of individual components. When the effects of dominant sectors dwarf smaller sector the aggregate is biased. Biases can be prevented if the aggregate preserves the properties of each individual component.

Traditionally, aggregation has been conducted using the sectors identified at the one digit SIC code. This method reduces the number of sectors to the 10 sectors introduced in the last section, which is a significant decrease, but still may not be enough.

The need for a relatively small number of variables within a cointegrated system can be traced back to previous literature. The most complex system analyzed with cointegration is that of Johansen and Juslieus (1992), who analyzed only five variables and estimated two cointegrated vectors (CIVs).[11] The use of a small number of variables, and therefore a small number of CIVs, maintains an easier interpretation of the cointegrated system.

Another possible aggregation method would be to follow the work of Brown, Coulson, and Engle (1992) who aggregate all the series into two sectors, basic (export) and non-basic (local). Aggregation in this form requires, as a first step, a determination of whether sectors are basic or non-basic. This calculation can be made from a location quotient (LQ). Once the LQ has identified the two groups aggregation is easily accomplished. This aggregation scheme takes care of the problem of too many variables

[11] Also see Brown, Coulson and Engle (1992), Crane and Nourzad (1998), LeSage (1990a and 1990b), Phillips and Chang (1995), and Shoesmith (1992) who also analyze only a few variables.

that the traditional one digit SIC could not, but still leads to biases as the aggregate obviously masks the characteristics of the individual sectors.

A third approach to aggregation of an economy is a method suggested by Gonzalo (1993) and Ghose (1994). They propose that any aggregation scheme should find evidence of cointegration between the sectors aggregated. Their method implies that aggregation free of estimation bias occurs when cointegration exists among the I(1) variables. When cointegration exists there is at least one common trend that links all the variables under consideration for aggregation. The existence of common trend(s) maintains the nonstationarity of the variables within the system (Gonzalo, 1993). When this is found the aggregated variable is comprised of the same properties of the individual sectors and therefore any bias disappears asymptotically (Ghose, 1994).

**Common Trends and Pairwise Cointegration**

Before identifying the sectors that this cointegration aggregation scheme suggested, a discussion and mathematical representation of common trends must be presented. This presentation is necessary to understand the statistical validation of the aggregation scheme. The existence of a common trend between two variables indicates that the variables have the same data generating process (DGP). Variables with the same DGP can be seen to behave similarly over time and when added together they do not mask each other's individuality. This implies that when variables are cointegrated they are simply scalars of one another and the process of aggregation preserves each sectors' characteristics.

This idea of common trends suggests proper aggregation takes place only when all sectors within an aggregate are pairwise cointegrated. Pairwise cointegration implies sector A is cointegrated with sector B, B with C, and A with C. The law of transitivity cannot be assumed to exist, however, as cointegration only finds long run relationships.

The aggregation of the two regional economies was based on this idea of pairwise cointegration. The mathematical representation of common trends is presented below through a two variable model. This presentation illustrates the actual tests conducted on the various series within the economies and reveals the needed validation for the aggregation conducted.

The discussion on common trends follows Enders (1995) presentation. Cointegration exists between two or more I(1) series when some linear combination of the series results in a stationary outcome. The series are then seen to be related by their common trend(s). A two variable vector, $x_t$, illustrates this idea, where $x_t = (y_t\ z_t)'$. The equations for $y_t$ and $z_t$ are as follows:

$$y_t = \mu_{yt} + \varepsilon_{yt} \qquad (4.1)$$

$$z_t = \mu z_t + \varepsilon z_{yt}, \qquad (4.2)$$

where $\mu_{it}$ = a random walk (or the trend component for variable i in time t)

$\varepsilon_{it}$ = the stationary component of variable i in time t.

Even though $y_t$ and $z_t$ are both I(1) cointegration is not guaranteed. Cointegration necessitates when some combination of nonzero parameters are applied to $y_t$ and $z_t$ a stationary outcome results. These parameters for the two variable model are $\beta_1$ and $\beta_2$. Once these two parameters are applied the random walk components for $y_t$ and $z_t$ offset one another and yield the stationary components $\varepsilon_{it}$, which imply

$$\beta_1\mu_{yt} + \beta_2\mu_{zt} = 0. \quad (4.3)$$

Equation (4.3) holds for all t if and only if

$$\mu_{yt} = -\beta_2\mu_{zt}/\beta_1, \quad (4.4)$$

which occurs if the random walk components are of the same DGP or are identical when use of a scalar is implemented.

An illustration using the two variable system above is now presented. Since, it has been shown in equation (4.4) that the random walk components are identical up to a scalar, one can be used to represent both, $\mu_t$, making the equations for $y_t$ and $z_t$

$$y_t = \mu_t + \varepsilon_{yt} \quad (4.5)$$

$$z_t = \mu_t + \varepsilon_{Zt} \quad (4.6)$$

where

$$\mu_t = \mu_{t-1} + \varepsilon_{yt}. \quad (4.7)$$

$\mu_t$ is based solely on past values of itself plus a random error component. The combination of (4.6) and (4.7) yields

$$y_t - z_t = \mu_t + \varepsilon_{yt} - \mu_t - \varepsilon z_{yt} \quad (4.8)$$

leaving

$$y_t - z_t = \varepsilon_t. \quad (4.9)$$

Equation (4.9) is simplified as the two error components have been combined into one, $\varepsilon_t$, and reveals that the two I(1) variables have been linearly combined to create a stationary outcome.

Equation (4.9) illustrates that $y_t$ and $z_t$ are pairwise cointegrated enabling them to be added together. When this is done the properties of the nonstationary component of both series have been maintained, and can be represented as $2\mu_t$. This idea has been illustrated through use of the Spanish aggregate farm price index (Martin-Alvarez et. al., 1999) and United States forestry prices (Jung et al., 1997).[12] Both of these studies concluded that past aggregation with these indices have created statistical violations because of the lack of cointegrated relationships. A conclusive result of these papers is that the proper level of aggregation takes place when "all components of the series are pairwise cointegrated" (Martin-Alvarez et al, 1999). This verifies that a properly aggregated variable must have all components cointegrated with one another.

### 4.4. Aggregation of the Two Regional Economies

The industries within the PMA and SW Region were first separated into basic and non-basic sectors using LQs and then aggregate according to pairwise cointegration. LQs identify the distinction of each sector through a calculation of their propotional employment:

$$LQ = (E_{ij}/E_i)/(E_{state,j}/E_{state}). \qquad (4.10)$$

Where $E_{ij}$ is employment in region i for industry j, $E_i$ is total employment in the region. $E_{state,j}$ is employment in the state for industry j, and $E_{state}$ is total employment for the state. An LQ value less than one indicates a non-basic (local) sector, while a value greater than one is a basic (export) sector. Non-basic sectors are sectors that exist to satisfy local demands and basic sectors are more export oriented.

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[12] Using the study of Jung, et al (1997), this idea of common trends and cointegrated variables is confirmed. Their study consisted of analyzing the composite forestry product price index through use of cointegration. They ran tests on various stumpage prices to verify if one stumpage price could be used as a proxy for all species of trees. Cointegration was used to test this hypothesis. Their finding was that not all stumpage prices analyzed were pairwise cointegrated with the other prices so an aggregate price would be an invalid procedure. A second test examined one species of tree's stumpage, log, and lumber prices to see if they were cointegrated. Both tests resulted in little to no cointegration amongst the different prices, thereby they concluded that the use of regionally disaggregated prices would be the best approach when analyzing the forestry sector.

The determination of these two sectors is important because of the behavior of the two within a local economy. The non-basic sectors are those that respond to changes within the immediate vicinity while basic sectors respond to state and national factors outside the local economy. Given this aspect and the interpretation of cointegrated systems it is necessary to determine the nature of the sectors modeled. LQs were essential in providing the first direction toward the aggregation of the variables, which follows the work conducted by Brown, Coulson, and Engle (1992).

After calculation of the LQs for both regions it was determined that a value greater than one would be used to divide the sectors into predominately non-basic and basic sectors. This decision was made on the basis that the PMA dominates the LQ analysis and therefore biases the PMA economy to one of greater export oriented sectors than would otherwise occur. The value of the LQ chosen was 1.4 for the PMA and 1.29 for the SW Region.

The choice of the division between basic and non-basic was determined partially due to the sectors identified. Within the SW Region three sectors existed above one to 1.29 with values from 1.03 to 1.08, which did not seem strong enough to warrant treatment as solely export. The Forestry sector existed at 1.29 and was the first that could be indicated as a strong export sector with Miscellaneous Retail second at 1.41. The determination of Forestry's 1.29 value as the first export sector was based on the SW region having one of the highest densities of timber within the state of Oregon. This alone should indicate the Forestry sector as basic. After these adjustments to the LQ analysis were made, and adding in the Federal Government to each, there were 33 export sectors within the PMA and eight in the SW. This split of the sectors provided the first direction as to how the aggregation should take place.

After defining the sectors as basic and non-basic the aggregation scheme turned to pairwise cointegration tests and economic theory. The tests used to identify evidence of cointegration were the Maximum Eigenvalue ($\lambda_{max}$) and Trace ($\lambda_{trace}$) tests that analyze the eigenvalues, or characteristic roots. The formulas for these are:

$$\lambda_{max}(r,r+1) = -T \ln(1-\hat{\lambda}_{r+1}) \quad (4.11)$$

$$\lambda_{trace}(r) = -T \Sigma \ln(1-\hat{\lambda}_i). \quad (4.12)$$

The $\lambda$s are eigenvalues found from the determinant of the variance/covariance matrix of residuals. This matrix must have a rank less than full for the existence of cointegration. The number of cointegrated vectors, r, found from these tests is equivalent to the number of significant eigenvalues, which at most can be one with two variables. Results that indicate that r = 1 validates the aggregation of those variables because pairwise cointegration exists.

The method of pairwise cointegration broke away from the traditional use of sectors identified at the one digit SIC because cointegration is not preserved in these sectors. The flaw of the traditional method led to use of economic theory to place the sectors together that had perceived relationships. These aggregated sectors are unique to each identified economic area in which data is collected because of the lack of uniformity across regions, so even the sectors in the PMA and SW regions are different. The actual sectors created along with their individual components are presented in Tables 4.1 and 4.2.

**Sectors in the PMA**

The sectors created through the aggregation technique in the PMA are: AGMN, CRE, LOCMR, SVRET, MSCEX, and SVEXP.[13] The first four are non-basic sectors and the last two basic. AGMN contains six sectors in agricultural and mining minus agricultural services, which is located in SVRET. These six sectors were all pairwise cointegrated with one another providing statistical justification for the placement of these within one aggregate.[14] Economically, the relationship between the agricultural sectors can be understood as well as the mining sectors in isolation of each other. The placement of these together requires recognizing the nature of the jobs that would exist in the metropolitan area as primarily white collared, whereas in a more rural area they would be blue collared oriented.

CRE consists of construction, real estate, building materials, and utilities. Construction is composed of three industries, which were all pairwise cointegrated with the sectors within CRE except general and special construction were not with commercial real estate. The three real estate sectors were strongly cointegrated with the others but not completely. Building materials was completely cointegrated with all the sectors and utilities were cointegrated with all but holding offices. This combination of industries was established because of the similar employment patterns one would see in construction and real estate as they both react similarly to economic stimuli. Building materials would react similarly as well. The addition of utilities in this aggregate was done because as created structures increase so too does the need for utility services.

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[13] It is impossible, with so many sectors, to get all of them to be pairwise cointegrated so some biases will exist in the estimation of the parameters. The actual cointegration tests for both the PMA and SW region can be found in the appendix.

[14] The results of the individual pairwise cointegration tests can be found in Appendix B.

**Table 4.1. Aggregated Sectors for the PMA**

| **AGMN** | **MSCEX** | **SVEXP** |
|---|---|---|
| Agricultural Production - Crops | Apparel and Accessory Stores | Business Services |
| Agricultural Production - livestock | Apparel and Other Textile Products | Communication |
| Forestry | Chemicals and Allied Products | Education Services |
| Metal Mining | Depository Institutions | Federal Government |
| Nonmetallic Minerals (Fuels) | Electric and Electronic Equipment | Insurance Agents Brokers and Service |
| Oil and Gas Extraction | Engineering and Management Services | Insurance Carriers |
| | Fabricated Metal Products | Legal Services |
| **CRE** | Furniture and Fixtures | Museums, Gardens and Zoos |
| Building Material and Garden Supplies | Industrial Machinery and Equipment | Nondepository Institutions |
| Comb. Real Estate | Instruments and Related Products | Securities Commodity Brokers/Services |
| Electric, Gas and Sanitary Services | Leather and Leather Products | |
| General Building Contractors | Misc. Manufacturing Industries | **SVRET** |
| Heavy Construction Contractors | Miscellaneous Services | Agricultural Services |
| Holding Offices | Paper and Allied Products | Amusement and Recreation Services |
| Real Estate | Petroleum and Coal Products | Eating and Drinking Places |
| Special Trade Contractors | Primary Metal Industries | Fishing, Hunting and Trapping |
| | Rubber and Related Products | Food Stores |
| **LOCMR** | Textile Mill Products | Health Services |
| Auto Dealers and Service Stations | Transportation by Air | |
| Auto Repair, Services and Garages | Transportation Equipment | Hotels and Other Lodgings |
| Food and Kindred Products | Transportation Services | Local Government |
| Furniture and Home Furnishing Stores | Water Transportation | Membership Organizations |
| General Merchandise Stores | Wholesale Durable Goods | Motion Pictures |
| Local and Interurban Transit | Wholesale Nondurable Goods | Personal Services |
| Lumber and Wood | | Private Households |
| Miscellaneous Repair | | Social Services |
| Miscellaneous Retail | | State Government |
| Printing and Publishing | | |
| Stone, Clay and Glass Products | | |
| Trucking and Warehousing | | |

LOCMR consists of 12 sectors that were determined as primarily local manufacturing and retail. These series, through their LQs, are perceived as satisfying local demand, which can be further understood through the realization that on average 42.3% of the state's population resided within the PMA. This aggregate revealed strong, but not complete, pairwise cointegration. The relationships of these industries are hard to theorize due to the sectors representing different stages of the production process; manufacturing, retail, and services. Statistically, however, the aggregation is justified and these sectors have little to do with the last local sector, SVRET.

SVRET closes out the final 14 non-basic sectors in the PMA, which is comprised of a variety of services and some retail. These sectors did not demonstrate complete pairwise cointegration but were cointegrated enough to provide justification for their aggregation. The relationship between the service oriented industries can be justified from their previous grouping together under the SIC approach. The addition of agricultural services, hunting guides, and state and local government, which are also service jobs to the SVRET sector seems economically sound. The last two industries are eating/drinking places (restaurants) and food stores. The restaurant industry is also perceived as service oriented lending economic validation for placement within this group and food stores are grocery stores from which restaurants would purchase some of their needs.

The two export sectors, MSCEX and SVEXP, are made up of the sectors identified as basic. The 23 industries within MSCEX are mainly manufacturing; along with wholesale and a few retail and service sectors which would not normally be perceived as export industries. Since Oregon has no sales tax and the PMA borders the state of Washington it is an attractive shopping location pushing some of these sectors that are normally local to become export. The PMA also provides a wide variety of retail experiences for the rest of the state, which may not be available in their respective economies. The individual components were pairwise cointegrated at an acceptable level, with some completely pairwise whole and others only limitedly. There was, however, enough overlap between the series to place them together.

Nine of the 23 industries in MSCEX were not in manufacturing. Transportation equipment is economically related to transportation services and water and air transportation, which are within this aggregate. Apparel at both the manufacturing and retail levels were placed in MSCEX. Wholesale's, both durable and nondurable, placement here with the manufacturing industries seems plausible. Depository institutions, engineering, and miscellaneous services needed to be placed here because they were not cointegrated with any other sectors.

SVEXP consisted of 10 export sectors from the remaining services that were in abundance within the PMA. These industries are easily identified as basic given that the majority of the state's business takes place within the PMA. The placement of these sectors together is economically sound due to their similar white collar descriptions. Nondepository institutions and the insurance sectors, however, did not fall into complete pairwise cointegration, but it was felt this was their proper placement.

**Sectors in SW Region**

In the SW Region seven sectors were created: BLUESV, WHTSV, MSCSV, CREAL, MAN, WR, and EXPORT. The first six are non-basic and the seventh the only basic sector, which are presented in Table 4.2. The economic logic behind the first two is based upon the nature of the jobs that exist within those industries. BLUESV consists of the 14 sectors that would be thought of as blue collar oriented by the job descriptions within its individual sectors. The pairwise cointegration results yielded strong but not full cointegration among these industries. Similarly, WHTSV are the industries that are white collar oriented. Other sectors can be seen as either blue or white collar in nature, but these had the strongest pairwise cointegration results and were therefore placed in their respective aggregates.

**Table 4.2. Aggregated Sectors for the SW Region**

| | | |
|---|---|---|
| **BLUESV** | **MSCSV** | **CREAL** |
| Agricultural Services | Agricultural Production - Crops | Electric, Gas and Sanitary Services |
| Amusement and Recreation Services | Agricultural Production - livestock | General Building Contractors |
| Auto Repair, Services and Garages | Chemicals and Allied Products | Heavy Construction Contractors |
| Communication | Depository Institutions | Holding Offices |
| Hotels and Other Lodgings | Insurance Carriers | Real Estate |
| Local and Interurban Transit | Local Government | Special Trade Contractors |
| Miscellaneous Repair | Nondepository Institutions | **WR** |
| Miscellaneous Services | State Government | Apparel and Accessory Stores |
| Motion Pictures | | Auto Dealers and Service Stations |
| Personal Services | | Building Material and Garden Supplies |
| Private Households | **MAN** | Eating and Drinking Places |
| Transportation Equipment | Apparel and Other Textile Products | Food Stores |
| Transportation Services | Electric and Electronic Equipment | Furniture and Home Furnishing Stores |
| Trucking and Warehousing | Fabricated Metal Products | General Merchandise Stores |
| | Food and Kindred Products | Wholesale Durable Goods |
| **WHTSV** | Furniture and Fixtures | Wholesale Nondurable Goods |
| Business Services | Industrial Machinery and Equipment | |
| Education Services | Instruments and Related Products | **EXPORT** |
| Engineering and Management Services | Leather and Leather Products | Federal Government |
| Health Services | Misc. Manufacturing Industries | Fishing, Hunting, Trapping |
| Insurance Agents Brokers and Service | Printing and Publishing | Forestry |
| Legal Services | Rubber and Related Products | Lumber and Wood Products |
| Membership Organizations | Stone, Clay and Glass Products | Metal Mining |
| Museums, Gardens and Zoos | Textile Mill Products | Miscellaneous Retail |
| Securities Commodity Brokers/Services | | Transportation by Air |
| Social Services | | Water Transportation |

MSCSV holds nine sectors that could have either gone in the blue or white collar categories but were not cointegrated with the sectors in those categories, but were amongst themselves. This sector does not contain any service sectors as identified by the SIC but all of these industries, except for a couple, are essentially service oriented.

CREAL holds the construction, real estate, and utilities industries. This sector is similar to CRE within the PMA model, except that commercial real estate does not exist separately from real estate in the SW data and building materials was placed in WR.

MAN consists exclusively of manufacturing industries within the SW economy. The pairwise cointegration for this aggregate was the best of any large grouping as almost every sector exhibited pairwise cointegration. Five sectors did not display complete pairwise cointegration: electric and electronic equipment, instruments and related products, industrial machinery and equipment, rubber and related products, and miscellaneous manufacturing. These five overlapped considerably amongst themselves and exhibited strong pairwise cointegration with the other sectors in MAN.

WR has all of the wholesale and retail industries except miscellaneous retail, which is an export sector in the SW Region. The placement of wholesale and retail together makes economic sense because they represent different stages along the production process to the final consumer. Their existence in the same aggregate directly links these industries together as they share similar employment patterns.

EXPORT consists of only a few sectors within the SW Region due to the rural characteristics of the economy. The sectors within the counties of the SW produce primarily for the consumption of the local residents. This bears truth in these areas, because anything that is not produced within their economy is purchased from the more urbanized Willamette Valley or the PMA. These two areas are responsible for an overwhelming majority of economic activity within the state. This phenomenon leaves little for the more rural counties to produce other than what is needed locally. The eight sectors that are export oriented could have been ascertained with some familiarity of the region. The cointegration tests revealed they could all be aggregated together without a bias as they were completely pairwise cointegrated.

## CHAPTER V

## Empirical Results

### 5.1. Introduction

This chapter reveals the Portland Metropolitan Area (PMA) as more diverse and stable relative to the Southwest (SW) Region. This phenomenon is illustrated through the Entropy and Regional Economic Instability (REI) indices introduced in the literature review chapter. The nonstationarity of the aggregated sectors are discussed followed by the cointegrated systems of the two economies. The basic/non-basic theory is tested for the PMA and SW Region through their Vector Error Correction Models (VECMs). Their stability is analyzed with persistent profiles. Impulse response functions for the PMA and SW Region conclude the chapter, which are used for policy recommendations.

### 5.2. Diversity and Stability of the PMA and SW Region

Diversity and stability are compared in the PMA and SW Region using the Entropy and REI indices. The Entropy index quantifies the level of diversity through the following formula:

$$\text{Entropy}_i = \sum_{1}^{k} (E_{ij}/ E_i) \ln (E_i/ E_{ij}), \qquad (5.1)$$

where $i$ refers to the $i$th region and $j$ is the $j$th industry, $k$ is the total number of industries in the $i$th region, $E_{ij}$ is employment in the $j$th industry in region $i$ and $E_i$ is the total employment in region *i* (Malizia and Ke, 1993). The entropy value takes on larger values as diversity increases.

Figure 5.1 shows the PMA as more diverse as it has greater entropy values for each of the years studied. An important observation, however, is that the PMA has been fairly constant in terms of overall diversity while the SW Region has been continually improving. The behavior of the SW's diversity is not an unexpected outcome because an underdeveloped area must ultimately become more diversified. Failure to diversify leads to obsolescence as industries become outdated. The maximum entropy value for each of these economies in any given year is 4.304 for the PMA and 4.234 for the SW Region.

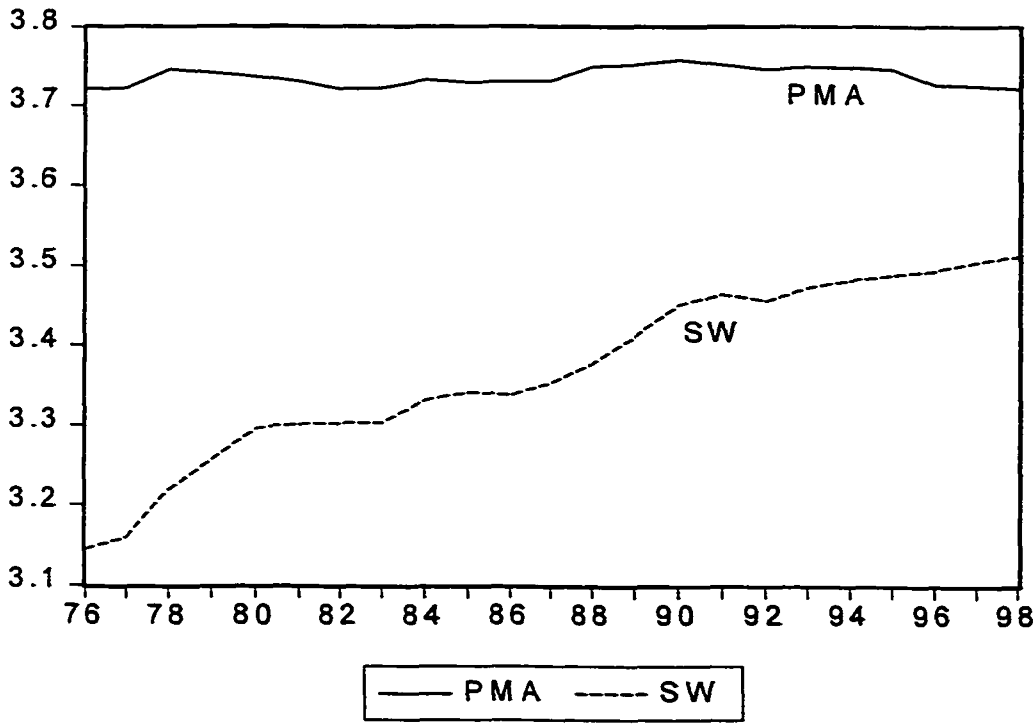


**Figure 5.1. Entropy values for the PMA and SW Region, 1976-1998**

The REI index was used to analyze relative stability of the PMA and SW Region:

$$REI_i = [\Sigma ((E_{it} - E_{ithat}) / E_{ithat})^2 / (T-2)]^{1/2}. \quad (5.2)$$

$E_{it}$ is total quarterly employment adjusted for seasonality for region *i* at time *t*, $E_{it}$ is an approximation of the long-run growth trend in employment in region *i* at time *t*, and T equals four as the data is quarterly. Values of the REI index increase as instability increases, therefore a low value is desirable. These values are reported in Figure 5.2.

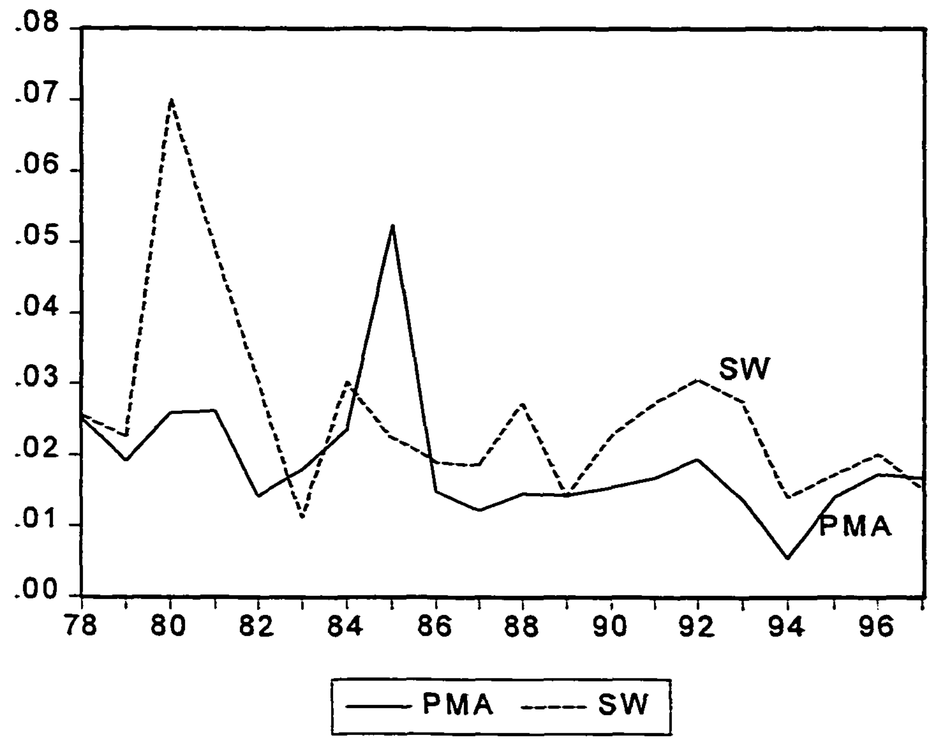


**Figure 5.2. REI Values for PMA and SW Region**

The instability index indicates that the PMA economy is more stable relative to the SW Region, in all years except, 1983, 1985, 1989, and 1997. Distances in those years ranged from a maximum of 0.03 in 1985 to a minimum of 0.0001 in 1989. These values were calculated from the difference in the predicted and actual employment levels. Years of high cyclical unemployment would therefore create a large instability value, which is seen more frequently in the SW Region.

### 5.3. Specifying and Analyzing the PMA and SW Regions

The Augmented Dickey-Fuller (ADF) Test was used to test the stationarity/nonstationarity of the sectors within the economies.[15] The results of these tests for the aggregated sectors in the PMA and the SW Region are presented in Tables 5.1 and 5.2; the results indicated all aggregated sectors are nonstationary.[16]

**Table 5.1. Augmented Dickey-Fuller Tests for the PMA, 10 Lags**

| Variable | ADF:Intercept | ADF: Intercept & Trend | ADF: None |
|---|---|---|---|
| LOCMR | -0.26 | -2.73 | 1.31 |
| CRE | 0.19 | -1.94 | 1.43 |
| SVRET | 0.48 | -2.76 | 2.42 |
| AGMN | -1.06 | -2.28 | 1.88 |
| MSCEX | 0.98 | -1.49 | 2.05 |
| SVEXP | 1.62 | -0.58 | 2.69 |
| **Critical Values:** | **Intercept**<br>1%: -3.5121<br>5%: -2.8972<br>10%: -2.5855 | **Intercept & Trend**<br>1%: -4.0742<br>5%: -3.4652<br>10%: -3.1589 | **None**<br>1%: -2.5915<br>5%: -1.9442<br>10%: -1.6178 |

[15] Consider the relation $y_t = a_1 y_{t-1} + u_t$. If $a_1 = 1$, then the series is I(1) but if $a_1 < 1$, then the series is I(0). Subtracting $y_{t-1}$ from both sides results in $\Delta y_t = \gamma Y_{t-1} + u_t$, where $\gamma = a_1 - 1$. If $\gamma = 0$, then the series is non-stationary and if $\gamma < 0$, then the series is stationary. Dickey and Fuller used simulations to generate the distribution of $\gamma$ since the t-distribution gave biased results. A more general version of this test allows for lagged rates of change, $\Sigma \Delta y_{t-i}$ to capture persistence in the series. This is referred to as the Augmented Dickey-Fuller (ADF) test and has the form, $\Delta y_t = \gamma Y_{t-1} + \Sigma \Delta y_{t-i} + u_t$. The Dickey -Fuller (DF) statistic and the Augmented Dickey-Fuller (ADF) statistic refers to the t-statistic for $\gamma$.

[16] The ADF results for the individual sectors can be found in Appendix C.

The determination that these series are nonstationary is concluded from the calculated values presented in the table relative to the critical values. The ADF test imposes a null hypothesis of nonstationarity versus the alternative hypothesis of stationarity. The decision rule follows: if the absolute calculated value is lower than the absolute critical value then the series is nonstationary while absolute calculated values that are greater reveal stationary series.

The appropriate model choice, Intercept and Trend, Trend, or None is determined through an F-test. The test indicates whether the unrestricted model (Intercept and Trend) is preferred to the two restricted models (Intercept or None). The F-test proceeds through a calculation that is distributed as an F(r,T-k), where r equals the number of restrictions imposed, T-k the number of observations minus the number of regressors in the unrestricted model. These results indicate that the appropriate ADF models in the

**Table 5.2. Augmented Dickey-Fuller Tests for the SW Region, 7 Lags**

| Variable | ADF:Intercept | ADF: Intercept & Trend | ADF: None |
|---|---|---|---|
| **BLUE** | -0.52 | -2.22 | 1.95 |
| **WHITE** | 2.26 | -0.69 | 3.42 |
| **MISC** | -0.48 | -1.86 | 1.28 |
| **MAN** | -0.65 | -3.31 | 2.33 |
| **CREAL** | -0.18 | -2.02 | 0.81 |
| **WR** | 0.06 | -2.22 | 1.86 |
| **EXPORT** | -2.14 | -2.42 | -0.90 |

| **Critical Values:** | **Intercept** | **Intercept & Trend** | **None** |
|---|---|---|---|
| | 1%: -3.5092 | 1%: -4.0700 | 1%: -2.5906 |
| | 5%: -2.8959 | 5%: -3.4632 | 5%: -1.9440 |
| | 10%: -2.5849 | 10%: -3.1578 | 10%: -1.6178 |

PMA were Intercept and Trend for all but SVEXP which should be modeled as None. Within the SW Region the Intercept and Trend model is correct for all except EXPORT which required the Trend model.[17]

The lag length for the two economies was chosen according to the Akaike Information Criteria (AIC) and the Schwarz Bayesian Criterion (SBC) tests, which minimize the sum of squared residuals. These tests indicated that 10 lags should be used in the PMA and seven in the SW Region.

After determination of the lag length, the number of vectors was determined by identification of the number of significant eigenvalues. λ. The Maximum Eigenvalue ($\lambda_{max}$) and Trace ($\lambda_{trace}$) Tests were used to determine these,

$$\lambda_{max}(r,r+1) = -T\ln(1-\hat{\lambda}_{r+1}) \qquad (5.3)$$

$$\lambda_{trace}(r) = -T\,\Sigma\ln(1-\hat{\lambda}_i). \qquad (5.4)$$

The results of these tests are presented in Tables 5.3 and 5.4.

Table 5.3 illustrates the test results for the PMA where four eigenvalues were found to be significant. The null hypothesis of less than four cointegrated vectors (CIVs), r, was rejected in favor of the alternative hypothesis of at least four CIVs. As is common in this test, one vector was rejected in favor of two vectors, two vectors were rejected in favor of three, and finally three vectors were rejected in favor of four. The PMA model was estimated using unrestricted intercepts and no trends.

Within the SW Region the process was repeated and six significant eigenvalues were found. These tests proceeded exactly like those of the PMA, except the model was estimated without trends or intercepts.

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[17] The results of the F-Tests for both the PMA and SW Region can be found in Appendix C.

**Table 5.3. Maximum Eigenvalue and Trace Tests for the PMA**

| Test | Ho/Ha | 95% Critical Value | 90% Critical Value | Calculated Value |
|---|---|---|---|---|
| Maximum Eigenvalue | Ho: $r \leq 4$<br>Ha: $r = 4$ | 21.12 | 19.02 | 31.66 |
| Trace | Ho: $r \leq 4$<br>Ho: $r \geq 4$ | 31.54 | 28.78 | 40.86 |

**Table 5.4. Maximum Eigenvalue and Trace Tests for the SW Region**

| Test | Ho/Ha | 95% Critical Value | 90% Critical Value | Calculated Value |
|---|---|---|---|---|
| Maximum Eigenvalue | Ho: $r \leq 6$<br>Ha: $r = 6$ | 11.03 | 9.28 | 10.82 |
| Trace | Ho: $r \leq 6$<br>Ha: $r \geq 6$ | 12.36 | 10.25 | 13.78 |

**PMA Cointegrated System**

The Johansen multivariate cointegration technique requires a normalization process to be conducted in order to estimate the system. This requirement forces the cointegrated system to have a unique variable in each of the CIVs to enable an analysis of the individual relationships. The determination of which variables to normalize around is based upon economic theory. Regional literature heavily emphasizes that a distinction be made between basic and non-basic sectors. The sectors within these two regional economies have been aggregated according to this literature. Knowledge of the behavior of these sectors would suggest that the non-basic sectors be normalized around, which is the method used by Brown, Coulson, and Engle (1992).

Within the PMA there were four aggregated sectors which represented non-basic sectors and there were four CIVs identified by the Maximum Eigenvalue and Trace Tests. Since these two findings are equal, given the previous discussion, these non-basic sectors were normalized. This is seen in the cointegrated system, Table 5.5 where these sectors have coefficients of unity in their respective CIV.[18] The values in parentheses are the standards errors, which reveal that the non-normalized (basic) sectors are all significant at least at the 10 percent level.

**Table 5.5. PMA Cointegrated System**

| | |
|---|---|
| $1.0LOCMR_t - 2.0MSCEX_t + 1.07SVEXP_t = \varepsilon_{LOCMR(t)}$<br>(.51) (.43) | (5.5) |
| $1.0CRE_t - 1.84MSCEX_t + .173SVEXP_t = \varepsilon_{CRE(t)}$<br>(.09) (.08) | (5.6) |
| $1.0SVRET_t - 2.13MSCEX_t + .84SVEXP_t = \varepsilon_{SVRET(t)}$<br>(.48) (.42) | (5.7) |
| $1.0AGMN_t - 4.46MSCEX_t + 2.57SVEXP_t = \varepsilon_{AGMN(t)}$<br>(1.24) (1.07) | (5.8) |

**LOCMR** - local manufacturing and retail sectors
**CRE** - construction, real estate, and building materials sectors
**SVRET** - local services and retail sectors
**AGMN** - agriculture and mining sectors
**MSCEX** - miscellaneous service oriented export sectors
**SVEXP** - service export sectors

The individual equations furnish considerable insights into interrelationships between sectors. The system enables an analysis of the relationships of the non-basic sectors, LOCMR, CRE, SVRET, and AGMN, to the basic sectors, MSCEX and SVEXP. For illustration consider equation (5.5), the LOCMR vector, which describes how local manufacturing and retail employment is related to employment in the MSCEX and SVEXP sectors. The negative coefficient on MSCEX implies that LOCMR and MSCEX employment move together to maintain the stationarity of $\varepsilon_{LOCMR(t)}$ over time. As

[18] Obtaining the above structure involves several steps. The unconstrained cointegrating vectors, which proved to be the final system, created a 6x4 matrix and identification requires that at least one unique variable exist in each vector. In the case of the PMA, the unique variables are the four locally determined sectors. Johansen (1995) imposes a triangularization of the unconstrained matrix such that the upper 4x4 component is an identity matrix. This results in basic sectors being present in each of the four vectors, but it is necessary to evaluate the statistical significance of these variables in each vector. Johansen refers to this maximum likelihood procedure as imposing over-identifying restrictions and the objective is whether the log of the likelihood function changes significantly as additional restrictions are imposed. Since the restrictions are contained in the null hypothesis, the concern is with the probability of a type II error and therefore, Johansen uses a minimum of a 0.15 probability value to accept a series of restrictions. In the cases presented in this paper none of the restrictions imposed were statistically significant leaving the models in their unconstrained forms.

employment expands in the export sector additional earnings flow into the economy, which creates increased demand for local goods and a subsequent expansion of employment in LOCMR. This parallel growth in these two sectors contributes to the stationarity of the disequilibrium residuals, $\varepsilon_{LOCMR(t)}$.

SVEXP enters equation (5.5) with a positive coefficient, implying that employment in this sector and LOCMR are inversely related. To maintain the stationarity of the disequilibrium residuals, growth in one requires a decline in the other. The interpretation of this relationship is that these sectors compete for workers, which would be true if the jobs in these sectors have similar skill requirements. Inspection of the industries within these two aggregated sectors shows a lack of similarities between job descriptions, however. It is more plausible that the SVEXP sector crowds out the local sectors forcing them to contract. The other three vectors in the system can be seen to have the same directional relationships but with differing magnitudes.

**SW Region Cointegrated System**

The cointegration procedure was repeated for the SW Region in which the Maximum Eigenvalue and Trace tests indicated six vectors existed. There were also six local sectors within this economy leading the normalization process to be conducted around them. The cointegrated system is presented in Table 5.6. The values in parentheses are the standards errors, which show that the non-normalized sector, EXPORT is significant in each CIV at the one percent level.

The individual equations can be interpreted similarly to those in the PMA system. The EXPORT sector enters each equation with a negative coefficient implying that a

**Table 5.6. SW Region Cointegrated System**

| | |
|---|---|
| $1.0BLUE_t - 1.01EXPORT_t = \varepsilon_{BLUE(t)}$<br>(.08) | (5.9) |
| $1.0WHITE_t - 1.14EXPORT_t = \varepsilon_{WHITE(t)}$<br>(.18) | (5.10) |
| $1.0MISC_t - 1.05EXPORT_t = \varepsilon_{MISC(t)}$<br>(.05) | (5.11) |
| $1.0MAN_t - .96EXPORT_t = \varepsilon_{MAN(t)}$<br>(.09) | (5.12) |
| $1.0CREAL_t - .96EXPORT_t = \varepsilon_{CREAL(t)}$<br>(.13) | (5.13) |
| $1.0WR_t - 1.09EXPORT_t = \varepsilon_{WR(t)}$<br>(.09) | (5.14) |

**BLUE** - blue collared sectors
**WHITE** - white collared sectors
**MISC** - miscellaneous blue and white collared sectors
**MAN** - manufacturing sectors
**CREAL** - construction and real estate sectors
**WR** - wholesale and retail sectors
**EXPORT** - miscellaneously identified export sectors (includes lumber and wood products and forestry)

direct relationship exists between the non-basic and basic sectors. This suggests that there is a parallel growth and decline pattern displayed in these sectors that lead to stationary disequilibrium residuals.

## 5.4. Speeds of Adjustment

The robustness of the derived cointegrated systems can be further verified by the speeds of adjustment indicating that the basic and non-basic sectors move as theory would predict. Regional literature hypothesizes that local or non-basic sectors should adjust to clear their markets when a state of disequilibrium exists. The export or basic sectors should be unresponsive to disequilibrium conditions at the local level, as they are determined exogenously. Basic sectors can sometimes be seen to respond to disequilibria, however, as they still have major local components. An accurate representation of an economy would yield results that behave as described above. This means that if sectors identified as non-basic are seen as unresponsive to disequilibrium an improper aggregation or imprecise geographical definition of the local economy has probably occurred.

Analysis of the speeds of adjustment can be conducted through use of the VECM representation of the cointegrated system. The Tables 5.7 and 5.8 present the estimates of the general VECM equation for the two economies:

$$\Delta X_t = \Pi_1 \Delta X_{t-1} + \Pi_2 \Delta X_{t-2} + ... + \Pi_{k-1} \Delta X_{t-k+1} + \Pi_0 X_{t-k} + e_t. \quad (5.15)$$

**Table 5.7. Speeds of Adjustment for PMA**

| Variable | $\varepsilon_{LOCMR(t-1)}$ | $\varepsilon_{CRE(t-1)}$ | $\varepsilon_{SVRET(t-1)}$ | $\varepsilon_{AGMN(t-1)}$ |
|---|---|---|---|---|
| ΔLOCMR | -0.56* | 0.36 | 0.54* | 0.02 |
| | (0.29) | (0.23) | (0.28) | (0.04) |
| ΔCRE | -0.97*** | -3.43*** | 1.88*** | -3.85*** |
| | (0.34) | (0.00) | (0.07) | (0.00) |
| ΔSVRET | 2.12*** | 0.86** | -2.49*** | 1.42*** |
| | (0.05) | (0.40) | (0.02) | (0.17) |
| ΔAGMN | -0.54 | 2.01*** | 1.91*** | -5.60*** |
| | (0.60) | (0.06) | (0.07) | (0.00) |
| ΔMSCEX | -0.90*** | 3.21*** | 0.98*** | -1.34*** |
| | (0.38) | (0.00) | (0.34) | (0.19) |
| ΔSVEXP | -0.23 | 1.30*** | 0.32 | -0.96*** |
| | (0.82) | (0.21) | (0.76) | (0.35) |

**Notes: a) Standard errors are in parantheses**
**b) ***significant at 1%, **significant at 5%, * significant at 10%**

Illustrated in the VECM for the PMA all local sectors are seen to respond as theory would predict. This is verified by the significance of the estimates along the main diagonal of the upper 4x4 cells within table 5.7. CRE, SVRET, and AGMN are all significant at the five percent level while LOCMR only at the 10 percent. The coefficients of the VECM not only have to be significant to reveal the proper movement to reequilibrate their CIV, but they also need to have the opposite sign than what existed in the cointegrated system. All four of the local sectors come in with a positive sign in the cointegrated system and a negative sign within the VECM thereby passing both levels of the test.

The two export sectors MSCEX and SVEXP have significant coefficients implying some responsiveness to disequilibrium. MSCEX entered the cointegrated system with negative values across the four CIVs, so to clear a vector it must come in positively. MSCEX is positive in the CRE and SVRET (2nd and 3rd) vectors and negative in LOCMR and AGMN (1st and 4th) vectors. This means that MSCEX clears the second and third vectors and causes further disequilibrium in the first and fourth vectors. SVEXP came in positively in the cointegrated system, and the VECM reveals a positive value for the second and third vector, and negative in the first and fourth vector. SVEXP was not significant in LOCMR and SVRET so does respond to disequilibrium within these vectors. SVEXP does move to reequilibrate the fourth vector and cause further disequilibrium in the second.

**Table 5.8. Speeds of Adjustment for SW Region**

| Variable | $\varepsilon_{BLUE(t-1)}$ | $\varepsilon_{WHITE(t-1)}$ | $\varepsilon_{MISC(t-1)}$ | $\varepsilon_{MAN(t-1)}$ | $\varepsilon_{CREAL(t-1)}$ | $\varepsilon_{WRt-1)}$ |
|---|---|---|---|---|---|---|
| ΔBLUE | -4.46*** (0.00) | 2.71*** (0.01) | 1.80*** (0.08) | 0.19 (0.85) | -1.88*** (0.07) | 2.70*** (0.01) |
| ΔWHITE | 1.96*** (0.06) | -1.88*** (0.07) | -1.04*** (0.31) | -0.87* (0.39) | 0.37 (0.71) | 0.63 (0.53) |
| ΔMISC | -0.31 (0.76) | 0.04 (0.97) | -2.32*** (0.03) | -1.06** (0.30) | 1.30** (0.20) | 1.55** (0.13) |
| ΔMAN | 2.71*** (0.01) | 1.47*** (0.15) | -0.69 (0.50) | -5.79*** (0.00) | -2.49*** (0.02) | -1.09*** (0.28) |
| ΔCREAL | -0.61 (0.54) | 1.97*** (0.06) | -0.51 (0.61) | -2.26*** (0.03) | -3.01*** (0.01) | 1.13*** (0.27) |
| ΔWR | 0.27*** (0.11) | 0.12*** (0.04) | 0.03 (0.05) | -0.21*** (0.05) | -0.10*** (0.02) | -0.16* (0.09) |
| ΔEXPORT | 0.91*** (0.37) | 2.10*** (0.04) | 2.51*** (0.02) | -3.29*** (0.00) | -3.23*** (0.00) | -1.95*** (0.06) |

**Notes: a) Standard errors are in parantheses**

**b) *** significant at 1%**significant at 5%, * significant at 10%**

The sectors in the SW Region can be seen to respond similarly to those in the PMA. All six of the local sectors are significant: BLUE, WHITE, MISC, MAN, CRE are significant at one percent, and WR significant at 10 percent. These values are seen along the main diagonal, or the upper 6x6 cells in Table 5.8. The sole basic sector, EXPORT, is also significant in each of the vectors at the one percent level. EXPORT is positive in the first three vectors and negative in the last three. Since EXPORT entered the cointegrated system with negative values across the vectors, it cleared the first three and caused further disequilibrium in the last three vectors.

The movement of the export sectors in the two models, both with clearing and creating further disequilibrium, is contradictory to the theory regarding the behavior of a basic sector. The economic rationale for these occurrences can be explained by the fact that even though the sectors are identified as basic they still have major non-basic components, which do react to local conditions.

## 5.5. Persistent Profiles

The method of persistent profiles allows the speed and volatility in which a cointegrated system returns to its long run equilibrium to be inspected after the introduction of a system wide shock. This shock is introduced through the conditional variances at time t and t-1 of the sectors within the cointegrated system by applying a positive one standard error disequilibrium increase to each equation. Persistent profiles enable a unique result to be found, which does not depend upon the ordering of the sectors or the chosen Choleski decomposition. The methodology of persistent profiles originated with the works of Lee and Pesaran (1993) and Pesaran and Shin (1996).

The profile illustrates how quickly a shock runs its course within a system by calculating the length of time required to reestablish its long run equilibrium. An economy that is more stable should readjust more quickly and have smaller fluctuations within their cointegrated vectors. Therefore persistent profiles can be used to test stability and show that a more diverse economy has a quicker reequilibration process.

For example, consider the cointegrated vector for BLUE, equation (5.9) in the SW system,

$$1.0BLUE_t - 1.02EXPORT_t = \varepsilon_{BLUE(t)}. \quad (5.9)$$

A shock equivalent to one standard error of the variance $\varepsilon_{BLUE(t)}$ is applied to (5.9), which forces the vector out of equilibrium. The state of disequilibrium forces the responsive sector(s) to reequilibrate the vector, to which, as indicated in the VECM, both BLUE and EXPORT respond. The persistent profile maps out this vector's efforts to return to its long run equilibrium from the shock. The length of time required to return to equilibrium reveals the persistence of the shock. A system wide shock would apply a similar shock to the rest of the cointegrated vectors. The combination of all vectors together would reveal the sectors indirect relationships through the export sectors and the relative stability within the system.

The final equations for the persistent profiles, from Chapter IV, are shown in equations (5.16) to (5.18):

$$H_x(n) = B_n \Omega B_n' \text{ and} \quad (5.16)$$

$$H_z(n) = \omega' B_n \Omega B_n' \omega. \quad (5.17)$$

$\beta$ in these two equations represents the coefficients from the VECM, $\omega$ the cointegrated coefficients, and $\Omega$ is the Choleski decomposed variance/covariance matrix. Dividing

(5.16) by (5.17) normalizes the responses of the vectors to the shock and reveals that the shock eventually dies out as $n \rightarrow \infty$. This process is seen in equation (5.18) where n equals the number of periods required to reestablish an equilibrium value

$$h_z(n) = H_z(n)/ H_z(0) = (\omega' B_n \Omega B_n' \omega)/ B\Omega B' \text{ for } n = 0, 1, 2, \ldots \quad (5.18)$$

**Persistent Profiles for PMA**

The persistent profile for the PMA is illustrated below through a series of two graphs, Figures 5.3A and 5.3B. Each figure reveals the response of two of the cointegrated vectors to shocks in their respective equations. All of the CIVs begin at a value of one in $t_0$, representing the normalized one standard error. The remaining time periods reveal the speed at which these two sectors return to their long run equilibriums, which is indicated by a value consistently below 0.01 standard errors (Lien and Root, 1999).

Figure 5.3A reveals LOCMR as more responsive than CRE, but attaining its long run equilibrium quicker. The stationary outcome derived in these two vectors occurs because the shock eventually dies out. The speed at which this is done in each vector can be seen in the relationship between the coefficients from the VECM and cointegrated system. LOCMR initially responds to the positive shock with a reduction in employment followed by an increase. This pattern repeats itself until the seventh quarter after which it declines until the 12$^{th}$ quarter and has limited fluctuations until it attains its long run equilbrium in the 33$^{rd}$ quarter. CRE's employment level declines immediately after the shock until the 5$^{th}$ quarter and has limited volatility until the 41$^{st}$ quarter where its long run equilibrium is attained.

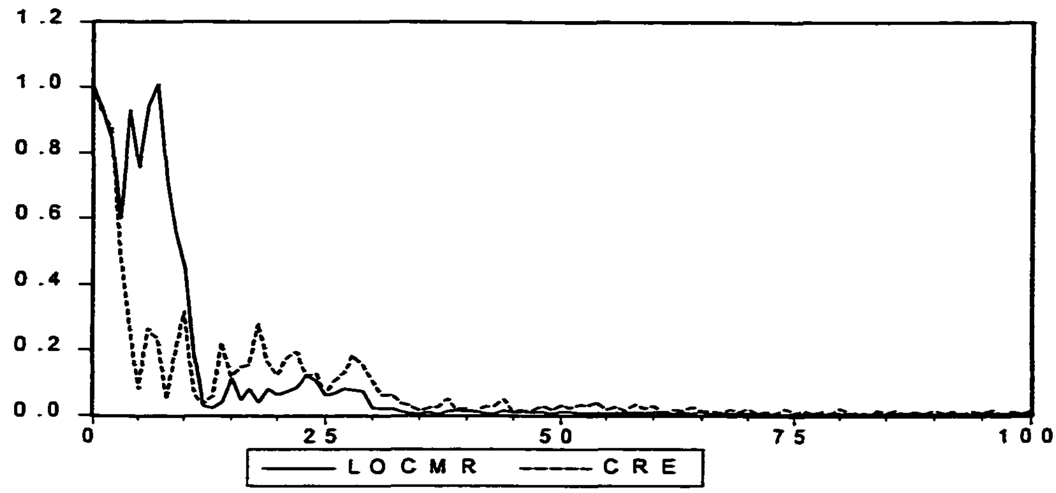


**Figure 5.3A. Persistent Profile for PMA; LOCMR and CRE**

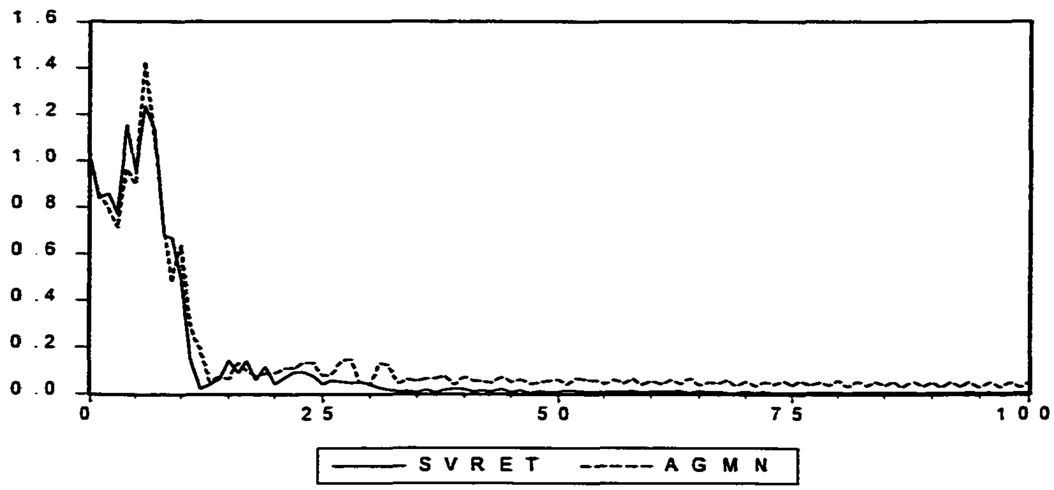


**Figure 5.3B. Persistent Profile for PMA; SVRET and AGMN**

Figure 5.3B contains the persistent profiles for the last two CIVs in the PMA, SVRET and AGMN. These two CIVs are affected similarly to the shock as the employment patterns mirror each other. Their employment levels decline after the initial shock until the 3rd quarter and increase afterwards until the 6th. After the 12th quarter the fluctuations for SVRET become limited within a small range until the 33rd quarter where it is in long run equilibrium. AGMN never really attains its long run equilibrium defined by Lien and Root (1999), of 0.01, but does attain a level of stability at 0.05 standard errors from the 41st quarter.

The persistent profiles for the PMA are summarized in Table 5.9. This table illustrates the significantly different ranges that were previously illustrated: 1st to 12th, 13th to 35th, and 36th to 100th quarter. Each CIV reveals a similar pattern, but the magnitudes of how many standard deviations from zero are slightly different. The first three CIVs attain their long run equilibriums by the end of the 35th quarter, while AGMN never reaches this level.

**Table 5.9. Summary of the PMA's Persistent Profiles, Displayed in Ranges**

| CIV/Quarter | 1 to 12 | 13 to 35 | 36+ |
|---|---|---|---|
| **LOCMR** | 0.027 to 0.94 | 0.01 to 0.11 | 0 to 0.01 |
| **CRE** | 0.03 to 0.93 | 0.01 to 0.22 | 0 to 0.01 |
| **SVRET** | 0.02 to 1.24 | 0.1 to 0.14 | 0 to 0.01 |
| **AGMN** | 0.19 to 1.11 | 0.04 to 0.15 | 0.02 to 0.07 |

**SW Region Persistent Profiles**

The SW region consists of seven sectors and six cointegrated relationships, which are illustrated in a series of three graphs, Figures 5.4A through 5.4C. These CIVs are: BLUE, WHITE, MISC, MAN, CREAL, and WR. These vectors never attain a consistent value of 0.01 standard errors or less, but like AGMN in the PMA system, do attain levels that reveal limited fluctuations. These limited fluctuations can be interpreted as relative stabilization within this system.

Figure 5.4A reveals both BLUE and WHITE with frequent fluctuations in employment from the initial shock at $t_0$. Employment levels decrease and increase without an identifiable trend until the 17th quarter for BLUE and 33rd for WHITE, where they exhibit a downward trend through the 60th quarter. After this quarter the fluctuations range between 0.04 to 0.09 for BLUE and 0.07 to 0.13 for WHITE. These ranges indicate their relative stability but not an attainment of their long run equilibriums.

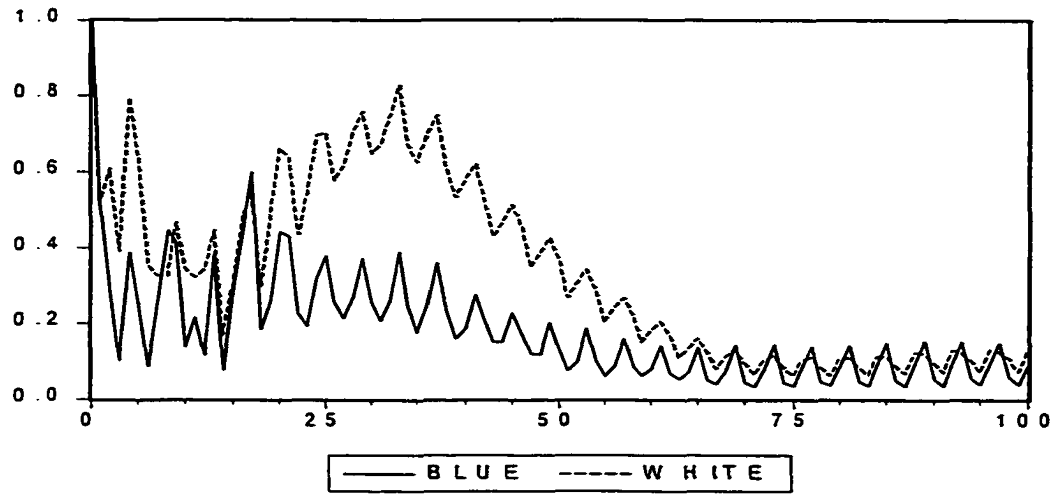


**Figure 5.4A. Persistent Profile for SW; BLUE and WHITE**

Figure 5.4B displays the vectors MISC and MAN stabilizing, but not at values less than 0.01. These two vectors mirror each other in decreases and increases but not in magnitudes. MISC begins a downward trend by the 17th to 18th quarter while MAN does not decrease until the 30th. By the 55th quarter both have limited changes in employment and appear relatively stable. MISC ranges between 0.05 and 0.09, while MAN has an upper bound of 0.055.

The last of the persistent profiles, Figure 5.4C, shows CREAL and WR with similar patterns of employment changes, which began a downward trend around the

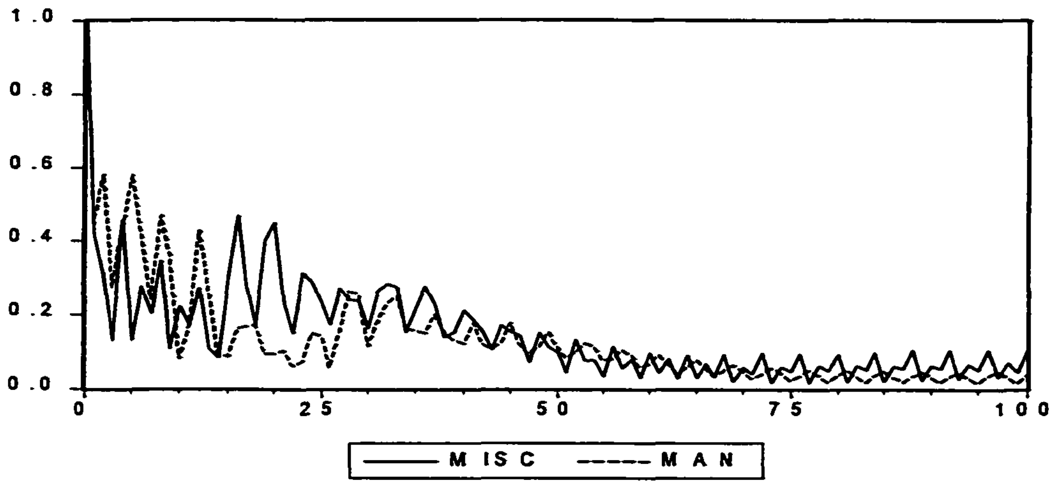


**Figure 5.4B. Persistent Profile for SW; MISC and MAN**

17th quarter. This trend for both continues until a relatively stable state is attained around the 60th quarter. At this point CREAL ranges between 0.02 and 0.035 and hits a low of 0.008 at quarter 67, but does not remain there as it continues with an upward bound of 0.08. WR comes close to 0.01 fluctuating from 0.016 to 0.10 standard errors after the 59th quarter.

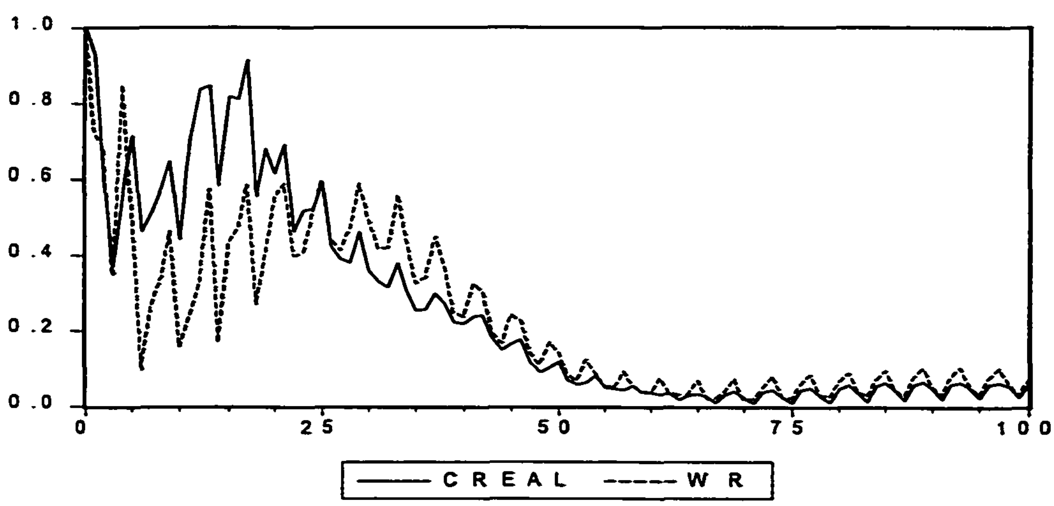


**Figure 5.4C. Persistent Profile for SW, CREAL and WR**

Comparison of the CIVs themselves from the two regions individually would be difficult due to the differences in aggregation. Analysis of the individual sectors they represent, however, can be compared in relative volatility and speed in which they return to equilibrium. This can be done because of the statistically valid aggregation of the pairwise cointegration technique. These comparisons across the two economies illustrate less volatility and quicker reequilibration in the PMA than the SW. This result is an indication of the PMA's greater diversity and stability, which enable it to more easily absorb the shock.

Table 5.10 summarizes the persistent profiles from the SW Region. Similar to Table 5.9 the profiles are broken down into various ranges. Within the SW the patterns did not reveal significant breaks so they are broken into four ranges each equaling 25 quarters. The six CIV all reveal similar patterns with differing magnitudes that do not reach a long run equilibrium.

**Table 5.10. Summary of the SW Region's Persistent Profiles, Displayed in Ranges**

| CIV/Quarter | 1 to 25 | 26 to 50 | 51 to 75 | 76+ |
|---|---|---|---|---|
| BLUE | 0.08 to 0.60 | 0.12 to 0.39 | 0.03 to 0.18 | 0.03 to 0.15 |
| WHITE | 0.17 to 0.70 | 0.35 to 0.83 | 0.10 to 0.34 | 0.06 to 0.13 |
| MISC | 0.11 to 0.47 | 0.11 to 0.28 | 0.02 to 0.13 | 0.02 to 0.10 |
| MAN | 0.07 to 0.58 | 0.06 to 0.26 | 0.03 to 0.12 | 0.01 to 0.05 |
| CREAL | 0.38 to 0.93 | 0.10 to 0.42 | 0.02 to 0.08 | 0.01 to 0.06 |
| WR | 0.10 to 0.85 | 0.11 to 0.59 | 0.02 to 0.12 | 0.02 to 0.10 |

A comparison of the variances of the persistent profiles for the PMA and SW can be conducted through a difference of variance test, summarized in Table 5.11. This test is easily calculated from the following equation,

$$\sigma_x^2/\sigma_y^2 \sim F(m-1, n-1). \qquad (5.19)$$

The degrees of freedom for the numerator and denominator will be equal in this case because the variances will be analyzed over the same time periods. The periods analyzed were determined from the PMA model as this system provided distinct breaks in the profiles.

**Table 5.11. Difference of Variance Test**

| Quarter | PMA | SW | $F_{calc}$ | $F_{Table}$ | $H_O$ | $H_A$ | Decision |
|---|---|---|---|---|---|---|---|
| **1 to 12** | 0.1133 | 0.0272 | 4.1627 | 2.23 | PMA = SW | PMA > SW | Reject $H_O$ |
| **13 to 35** | 0.0021 | 0.0170 | 8.1937 | 1.76 | PMA = SW | PMA < SW | Reject $H_O$ |
| **36 to 68** | 0.0001 | 0.0112 | 155.56 | 1.61 | PMA = SW | PMA < SW | Reject $H_O$ |
| **69 to 100** | 0.0 | 0.0007 | 18.6076 | 1.61 | PMA = SW | PMA < SW | Reject $H_O$ |

Table 5.11 reveals that in the categories identified the PMA has a smaller variance than the SW except from the first to twelfth quarter. The first time period is more volatile in the PMA due to the greater magnitude of the shock, but these wide oscillations quickly die out as indicated by the remaining three time periods. This table reinforces the greater stability of the PMA economy. All table values are at an $\alpha$ of 10% and all calculated values represent averages of the CIVs over the specified time periods. These differences can be explained by the greater slackness that would exist in a rural economy versus urban. Within urban economies unemployed and therefore reemployed workers can be more easily absorbed as jobs in other sectors can be more easily found. Rural areas that

experience wide swings in unemployment are indicative of economies where commuting opportunities to surrounding areas for employment are limited.

The SW Region can improve its diversity and stabilty if certain sectors are manipulated to mimic those in the PMA. This can be done by scaling down the employment of the same sectors in the PMA to fit within the SW Region. Of course these simulations change the nature of the sectors in the SW to that of the PMA so the previous cointegrated relationships no longer exist, however some useful information can still be obtained. For example, if the SW Region mirrored the PMA's Wholesale/Retail sectors the system can be seen to be much more stable, as revealed in Figures 5.5A and 5.5B.

The three CIVs are BLUE, WHITE, and MISC. All three of these have much more limited fluctuations and attain relative stability much quicker. As before, these were still widely volatile until the 30th to 40th quarters, whereas after introduction of the PMA structure these vectors are relatively stable by the 30th. The stability with the initial

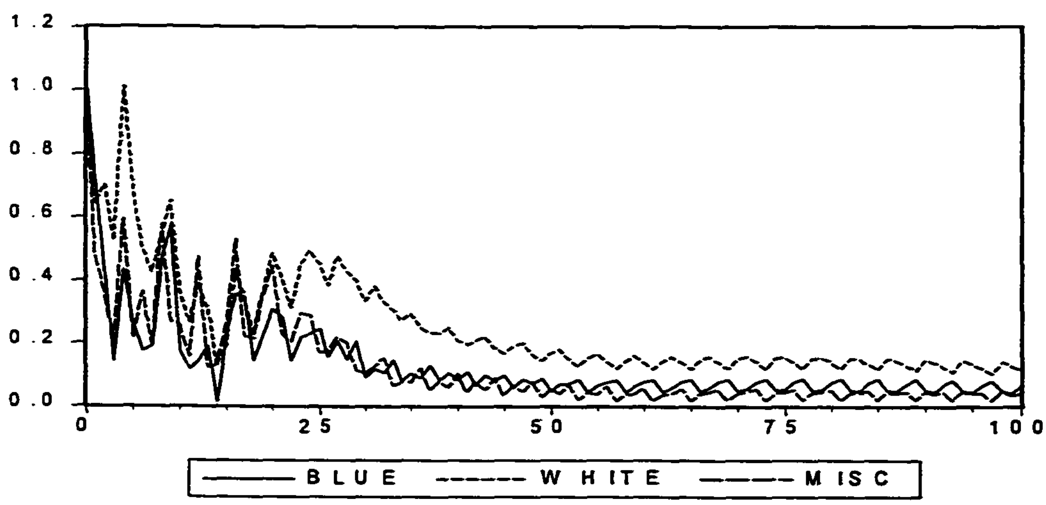


**Figure 5.5A. Persistent Profile for the SW Region with PMA's WR Structure**

analysis did not come until a minimum of the 40th quarter for MISC and 60th for the other two.

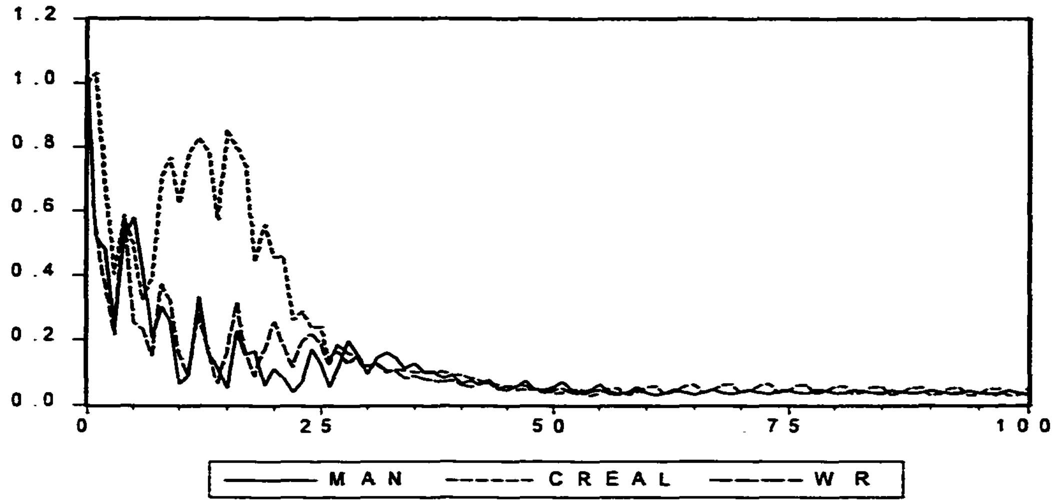


**Figure 5.5B. Persistent Profile for the SW Region with PMA's WR Structure**

The other three CIVs, CIV4 to CIV6, are MAN, CREAL, and WR. The greater speed of reequilibration and lack of volatility is more apparent in these, as the wide swings are completely finished by the 30th quarter and relative stability is attained by the 40th. In the previous analysis MAN behaved similarly, but did not attain its relative stability until the 50th quarter. CREAL and MAN are drastically improved with the introduction of the PMA structure as they were not in a similar stability as revealed in Figure 5.4C until the 60th quarter.

The economic rationale for the results in Figures 5.5A and 5.5B is that greater employment stability has been attained. This occurs because the PMA has a much more stable employment level in these two major sectors, retail and wholesale. The relative stability of the WR sector before and after the introduction of the PMA structure reveals a 26% improvement in stability as indicated by its smaller variance. Prior to the introduction the average change in WR employment, counting both increases and decreases, was 0.96% versus 0.71% afterwards. Even though the growth rate is less after the introduction the greater stability exists as smaller swings in employment levels are realized. The number of increases and decreases in the employment level prior to the change was 43 and 49, respectively, and 66 and 26 afterwards.

Table 5.12 summarizes the persistent profiles after introducing the structure of the PMA's wholesale/retail industries. This table illustrates a much more stable economy than Table 5.10 as the CIVs respond less widely to the shock. Comparison of the variances

**Table 5.12. Summary of the SW's Persistent Profile After the Introduction of the PMA's Wholesale/Retail Structure**

| CIV/Quarter | 1 to 25 | 26 to 50 | 51 to 75 | 76+ |
|---|---|---|---|---|
| **BLUE** | 0.01 to 0.72 | 0.06 to 0.21 | 0.04 to 0.08 | 0.04 to 0.09 |
| **WHITE** | 0.13 to 1.01 | 0.14 to 0.48 | 0.12 to 0.18 | 0.10 to 0.15 |
| **MISC** | 0.12 to 0.59 | 0.03 to 0.22 | 0.02 to 0.07 | 0.02 to 0.05 |
| **MAN** | 0.11 to 0.52 | 0.05 to 0.20 | 0.03 to 0.07 | 0.03 to 0.04 |
| **CREAL** | 0.24 to 1.03 | 0.04 to 0.16 | 0.03 to 0.06 | 0.03 to 0.06 |
| **WR** | 0.12 to 0.59 | 0.04 to 0.19 | 0.03 to 0.05 | 0.03 to 0.05 |

**Table 5.13. Difference of Variance Test Between SW Before and After Introducing PMA's Wholesale/Retail Structure**

| Quarter | $SW_{Before}$ | $SW_{After}$ | $F_{calc}$ | $F_{Table}$ | $H_O$ | $H_A$ | Decision |
|---|---|---|---|---|---|---|---|
| **1 to 25** | 0.0240 | 0.0287 | 1.1958 | 1.70 | $SW_B = SW_A$ | $SW_A > SW_B$ | Fail to Reject $H_O$ |
| **26 to 50** | 0.0100 | 0.0029 | 3.4795 | 1.70 | $SW_B = SW_A$ | $SW_A < SW_B$ | Reject $H_O$ |
| **51 to 75** | 0.0019 | 0.0002 | 11.3850 | 1.70 | $SW_B = SW_A$ | $SW_A < SW_B$ | Reject $H_O$ |
| **76 to 100** | 0.0007 | 0.0001 | 5.4903 | 1.70 | $SW_B = SW_A$ | $SW_A < SW_B$ | Reject $H_O$ |

over these time periods shown in Table 5.13 indicates the same conclusion as all average variance values for each CIV is either not significantly different or is less after the introduction of the new structure.

## 5.6. Impulse Response Functions

Impulse response functions are another approach that can be used to analyze the PMA and SW regions. These functions, which originated within VAR analysis, are applied to the cointegrated system through its VECM representation. Impulse response functions are similar to persistent profiles in that a one standard error shock is introduced, however this shock is applied to only one variable within the VECM. This enables an analysis of how each individually shocked sector affects the system. Use of this procedure enables an analysis to be conducted which isolates the affect of each aggregated sector making it possible to identify which sector creates the largest positive response in total employment. This fact makes this approach valuable in terms of policy implications, and when combined with persistent profiles can yield valuable policy directions.

Within the PMA, for example, the variable SVEXP can be shocked by its standard error, which initially increases employment within SVEXP. After the initial quarter the relationship that SVEXP has with the non-basic sectors, AGMN, LOCMR, and SVRET creates changes in their employment levels. The relationship that these sectors have with SVEXP and the other basic sector MSCEX enable changes to occur in all variables within the system, and it is this interaction that allows a shock to ripple throughout the entire economy.

Basic sectors, which are affected directly from stimuli outside the economy, represent new money into the local economy. This new money represents the initial point in the multiplier process. Non-basic sectors, however, do not have this multiplied effect because these sectors are simply recycling existing money. Given this the basic sectors have the potential to have greater impacts on the local economy.

Both basic and non-basic sectors have impacts on the local economy, because both have large portions of their employment levels determined by local conditions. This aspect implies both types of sectors should be analyzed through impulse response functions; however the interpretations of these responses are different. Basic sectors create the multiplied effect suggested above, but non-basic sectors reveal population growth in response to the shock. This interpretation can be derived from economic base theory which states, "basic sectors are the driving forces for the economy; service [non-basic] sectors are just a derivative" (Nijkamp, Reitveld, and Snickbars, 1986). This piece of information implies that only the basic sectors need to be analyzed.

Shocks to the two export sectors in the PMA, MSCEX and SVEXP, yield multipliers of 1.29 and 0.58, respectively. These values imply for every job created in MSCEX an additional 0.29 jobs are created elsewhere in the economy for an overall increase of 1.29, while in SVEXP 0.42 jobs are lost elsewhere creating an overall increase of 0.58. The derivation of these multipliers was accomplished through analysis of the generalized impulse response values and applying them as growth rates to the last quarter of data, 1998:4. This process was repeated for all impulse values that were significant as indicated by their standard errors. After all significant changes were incorporated the overall change in total employment was calculated and compared to total employment in 1998:4. The difference in the two total employment values was divided by the initial increase in the shocked sector to reveal the multiplier.

The multipliers reveal that the shock to MSCEX had a positive impact while SVEXP contracted the local economy. Within the cointegrated system, it can be seen, that MSCEX comes in with a direct relationship while SVEXP is inverse. The explanation of these relationships is that a direct relationship creates a multiplied effect as growth in MSCEX leads to growth in the non-basic sectors, and growth in SVEXP takes workers away as competition exists for workers within the same job pool. These multipliers therefore agree with the results from the cointegrated system.

This process was repeated to analyze the effect of the EXPORT sector in the SW Region. The analysis revealed a multiplier of 1.74, implying for every job introduced within these sectors an additional 0.74 jobs were created elsewhere. EXPORT, like MSCEX in the PMA, had a direct relationship with the other sectors in the SW cointegrated system leading to the positive impact on the SW economy.

### 5.7. Policy Implications

The implications of the persistent profiles and impulse response functions suggest the following growth strategies. For the PMA, the economy should focus on boosting the sectors within the aggregate MSCEX. Within this sector are many manufacturing industries, including the high technology industries; electric and electronic equipment, and instruments and related products. Greater growth in these industries, which the PMA has developed an agglomeration, would lead to greater growth as these represent high skill/high paying jobs. Transportation industries are also in MSCEX and increased transportation would give people alternatives to personal transportation. Greater mass transit systems would decrease congestion and make the conducting of business easier as delivery vehicles would have less trouble navigating streets in business districts.

In the SW Region, the industries within the EXPORT sector need to be encouraged, which contains the forestry and lumber and wood industries. Given the political environment that surrounds these industries the recommendation that the EXPORT sectors be encouraged does not imply that more timber cultivation take place. The encouragement of secondary manufacturing, which lumber and wood products represent, has been strongly encouraged since 1992. Further encouragement for growth in this sector would be the recommendation from this analysis. To stimulate this sector more timber resources need to be used, which can take place from importing logs rather than increasing local cutting.

The other sectors within this variable, such as the fishing/hunting/trapping industry, represent a true comparative advantage that should be further exploited. Increased awareness of the opportunities provided within the SW need be made through local government intervention. The other two main sectors to encourage growth in are the transportation by air and water. Given the SW's port access an export subsidy can be used to encourage greater shipping and airline usage by businesses.

Transportation is probably of the greatest importance to improve within the SW Region as the cities and towns are fairly wide spread throughout the region. Increasing the ease in which individuals could travel from city to city would enable workers to commute to where jobs are located. This could be accomplished through increases in public transportation, which could enable people to access jobs in more than the immediate area.

These aggregated sectors will give each respective economy the biggest increase in total employment as indicated by the multipliers. This does not necessarily imply greater stability, however. To increase stability an economy needs to have multiple specializations, as suggested by Malizia and Ke (1993). The PMA has agglomerative forces and therefore specialization within computer manufacturing industries which should be further exploited. This is not the only major sector within MSCEX, however, as other manufacturing and wholesale industries are present. All of these industries do have a commonality of producing products with more stable demand functions, which naturally creates greater stability.

Another point to make is that the PMA is the major source of economic activity, so as the export sectors expand there will be increased demand for the other more local sectors from the PMA as well as adjacent economies. This natural gravitation towards growth in the local sectors in response to the boosts in the export sectors will also create greater stability.

The SW's primary need is to generate greater economic activity in the area, which can most easily be accomplished through increases in the EXPORT sectors. Increases in these industries' importance will, as in the PMA, naturally lead to increased importance of the local sectors. Greater stability will also be attained as the economy focuses on the production of goods with stable final demands. This activity will lend itself to greater stability throughout the economy.

# CHAPTER VI

## Conclusions

Within this dissertation cointegration has been used to aggregate sectors, analyze regional economies, and test the diversity/stability theory through persistent profiles. Each of these elements gives justification for greater use of cointegration at the regional level. Persistent profiles combined with impulse response functions provided unique policy recommendations for the two areas studied: the Portland Metropolitan Area (PMA) and the Southwest (SW) Region.

Pairwise cointegration was used to aggregate industries identified at the two-digit Standard Industrial Classification (SIC) code into a small number of sectors. The created sectors were vastly different from those indicated by the traditionally used one-digit SIC, which proved to be statistically invalid. This pairwise technique enables the aggregated sectors to truly represent their individual components and identify unique regional characteristics.

The PMA and SW Region represented two regional economies within the state of Oregon. The considerable differences between these economies as illustrated by the number of aggregated sectors and their components suggests state wide analyses are too broad. State wide studies would not have been able to uncover the unique characteristics of the SW Region as the state is dominated by the PMA. The process of uncovering these traits led to the different construction of the cointegrated systems and ultimately to differing policy recommendations.

The cointegrated systems created from the aggregated sectors illustrate the differences between the two economies. These differences manifest themselves in the relationships between the basic and non-basic sectors as well as the components of these sectors. The PMA consisted of six aggregated sectors with four representing non-basic sectors, and the SW Region had 7 sectors with which six were non-basic. These multiple sector models allow a more accurate analysis to be conducted as the individual relationships can be fully developed.

The use of persistent profiles provided the validation that the PMA was more stable than the SW Region. This technique introduced a system wide shock into each regional system to illustrate their abilities to absorb the disruption. The urbanized PMA, with greater diversification, was able to more quickly return to equilibrium in response to the shock. The relative speed and ease that the PMA was able to re-attain equilibrium revealed its greater stability.

Impulse response functions were used to indicate which sectors have the biggest impact on each economy. These functions introduced a shock to only one sector and analyzed the responses of all the sectors within the system. The total effect of the shock was calculated by adding all of the responses together to create a multiplier. The sectors with the biggest impact were then used to provide policy recommendations, which differed in the two economies.

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## Appendix A

## Map of Oregon Illustrating the Freight System

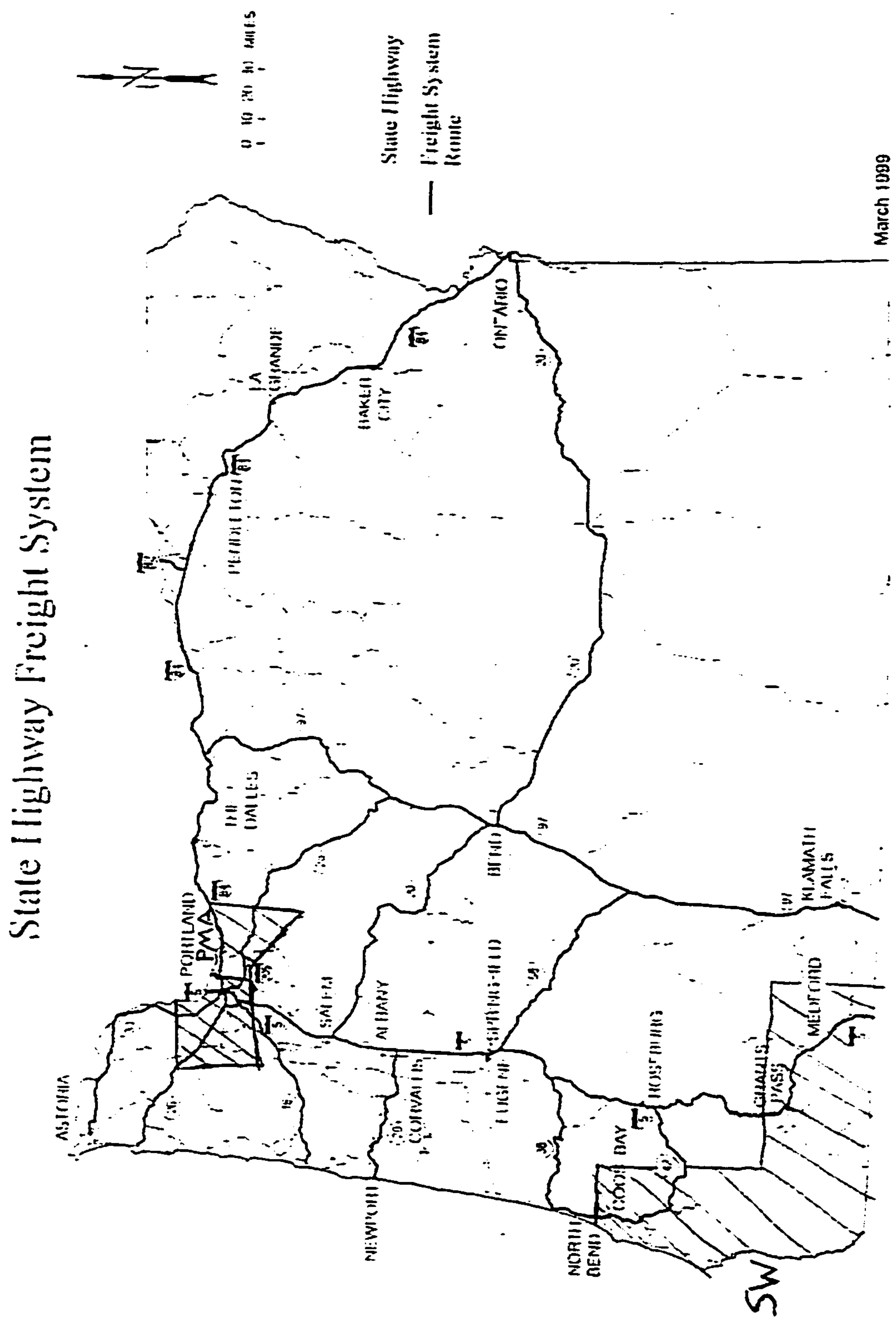


**Figure Appendix A.1. State Highway Freight System**

## Appendix B

## Pairwise Cointegration Test Results for PMA and SW Region

## Table Appendix B.1. Pairwise Cointegration Tests for PMA's LOCMR

| LOCMR | | truck | stone | print | miscret | miscrep | lumber | localtran | relgen | retfurn | f&k | autorep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| auto | Max | 19.84 | 13.81 | 17.98 | 17.36 | 13.93 | 15.51 | 13.37 | 50.92 | 23.27 | 47.01 | 14.27 |
| | Trace | 21.65 | 14.46 | 20.95 | 17.46 | 15.97 | 15.58 | 13.47 | 51.39 | 23.28 | 47.03 | 14.41 |
| | Lag | 12 | 1 | 12 | 1 | 11 | 5 | 5 | 1 | 1 | 1 | 10 |
| autorep | Max | 10.22 | 15.62 | 13.46 | 34.72 | 14.12 | 15.42 | 20.22 | 34.03 | 24.25 | 45.90 | |
| | Trace | 10.24 | 15.62 | 16.88 | 34.73 | 16.44 | 15.55 | 20.24 | 34.11 | 24.25 | 45.91 | |
| | Lag | No | 10 | 12 | 1 | 12 | 12 | 1 | 1 | 1 | 1 | |
| f&k | Max | 49.62 | 47.13 | 47.84 | 71.51 | 40.59 | 40.88 | 40.62 | 93.63 | 65.81 | | |
| | Trace | 51.71 | 49.41 | 51.47 | 74.25 | 43.66 | 42.42 | 43.83 | 121.08 | 65.95 | | |
| | Lag | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | |
| retfurn | Max | 7.00 | 7.82 | 6.15 | 17.30 | 3.38 | 16.91 | 15.54 | 27.58 | | | |
| | Trace | 7.17 | 7.82 | 6.84 | 17.32 | 3.78 | 18.24 | 15.58 | 27.58 | | | |
| | Lag | No | No | No | 4 | No | 10 | 1 | 1 | | | |
| relgen | Max | 27.73 | 56.47 | 23.09 | 26.34 | 23.62 | 28.55 | 26.34 | | | | |
| | Trace | 30.39 | 59.51 | 27.42 | 28.17 | 26.85 | 31.15 | 30.37 | | | | |
| | Lag | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | |
| localtran | Max | 15.47 | 24.27 | 13.60 | 18.88 | 9.78 | 13.49 | | | | | |
| | Trace | 17.20 | 27.16 | 16.98 | 21.00 | 12.81 | 15.55 | | | | | |
| | Lag | 5 | 8 | 1 | 1 | No | 3 | | | | | |
| lumber | Max | 14.30 | 16.06 | 17.38 | 17.05 | 11.84 | | | | | | |
| | Trace | 15.36 | 16.14 | 19.46 | 18.94 | 15.75 | | | | | | |
| | Lag | 10 | 9 | 9 | 1 | 7 | | | | | | |
| miscrep | Max | 13.01 | 17.03 | 9.06 | 7.17 | | | | | | | |
| | Trace | 16.31 | 21.81 | 13.16 | 10.21 | | | | | | | |
| | Lag | 8 | 10 | No | No | | | | | | | |
| miscret | Max | 14.43 | 9.89 | 23.64 | | | | | | | | |
| | Trace | 16.94 | 11.25 | 27.38 | | | | | | | | |
| | Lag | 1 | No | 1 | | | | | | | | |
| print | Max | 12.59 | 15.76 | | | | | | | | | |
| | Trace | 16.16 | 19.15 | | | | | | | | | |
| | Lag | 1 | 10 | | | | | | | | | |
| stone | Max | 15.78 | | | | | | | | | | |
| | Trace | 17.52 | | | | | | | | | | |
| | Lag | 10 | | | | | | | | | | |

## Table Appendix B.2. Pairwise Cointegration Tests for PMA's CRE

| CRE | | real | cnstspec | holding | cnstheav | cnstgen | utils | commercial |
|---|---|---|---|---|---|---|---|---|
| buildret | Max | 17.01 | 14.39 | 13.14 | 35.56 | 13.53 | 25.20 | 15.73 |
| | Trace | 17.99 | 14.71 | 14.95 | 36.32 | 14.34 | 26.53 | 15.73 |
| | Lag | 1 | 2 | 9 | 1 | 5 | 3 | 11 |
| commercial | Max | 14.99 | 3.44 | 16.76 | 17.63 | 3.52 | 13.11 | |
| | Trace | 16.14 | 4.96 | 19.93 | 20.79 | 4.50 | 16.45 | |
| | Lag | 6 | No | 12 | 1 | No | 1 | |
| utils | Max | 21.30 | 15.78 | 5.88 | 17.69 | 13.86 | | |
| | Trace | 22.91 | 16.16 | 7.42 | 21.51 | 14.39 | | |
| | Lag | 3 | 3 | No | 1 | 3 | | |
| cnstgen | Max | 14.34 | 22.02 | 13.22 | 32.25 | | | |
| | Trace | 14.41 | 23.12 | 16.02 | 33.40 | | | |
| | Lag | 3 | 5 | 9 | 1 | | | |
| cnstheav | Max | 22.67 | 29.71 | '18.19 | | | | |
| | Trace | 25.02 | 29.71 | 21.32 | | | | |
| | Lag | 1 | 1 | 1 | | | | |
| holding | Max | 16.05 | 14.19 | | | | | |
| | Trace | 19.00 | 14.65 | | | | | |
| | Lag | 9 | 8 | | | | | |
| cnstspec | Max | 20.25 | | | | | | |
| | Trace | 20.59 | | | | | | |
| | Lag | 2 | | | | | | |

## Table Appendix B.3. Pairwise Cointegration Tests for PMA's SVRET

| SVRET | | stateg | social | privhhs | personal | motion | member | localg | hotels | health | grocery | fish | eat | amuse |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| agserv | Max | 5.40 | 28.45 | 13.68 | 41.89 | 20.57 | 14.32 | 65.89 | 20.17 | 27.90 | 7.49 | 45.24 | 16.70 | 42.87 |
| | Trace | 5.60 | 28.84 | 15.05 | 41.45 | 20.85 | 14.50 | 66.50 | 20.28 | 34.40 | 9.01 | 46.49 | 18.89 | 43.12 |
| | Lag | No | 1 | 4 | 1 | 1 | 1 | 1 | 4 | 1 | No | 1 | 1 | 1 |
| amuse | Max | 4.70 | 20.26 | 13.68 | 28.75 | 32.84 | 17.51 | 106.53 | 18.73 | 23.58 | 27.08 | 48.74 | 30.32 | |
| | Trace | 4.72 | 20.34 | 19.08 | 28.98 | 32.91 | 17.55 | 106.62 | 19.03 | 24.43 | 27.18 | 49.01 | 30.69 | |
| | Lag | No | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 1 | 1 | |
| eat | Max | 7.24 | 18.86 | 20.77 | 39.99 | 17.51 | 13.67 | 71.89 | 13.69 | 14.75 | 5.16 | 44.26 | | |
| | Trace | 8.52 | 19.35 | 21.11 | 42.13 | 18.31 | 14.01 | 75.34 | 16.69 | 19.38 | 9.21 | 48.66 | | |
| | Lag | No | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | No | 1 | | |
| fish | Max | 47.68 | 44.68 | 46.64 | 44.48 | 48.63 | 49.18 | 48.32 | 44.56 | 45.27 | 42.93 | | | |
| | Trace | 50.54 | 45.02 | 52.69 | 48.25 | 49.14 | 49.23 | 61.01 | 45.77 | 49.34 | 45.60 | | | |
| | Lag | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | |
| grocery | Max | 4.75 | 4.97 | 11.05 | 19.46 | 15.98 | 9.21 | 36.18 | 5.36 | 4.59 | | | | |
| | Trace | 5.61 | 6.00 | 15.86 | 21.43 | 19.88 | 16.27 | 38.86 | 6.89 | 8.65 | | | | |
| | Lag | No | No | 3 | 1 | 8 | 4 | 1 | No | No | | | | |
| health | Max | 6.56 | 23.23 | 16.16 | 30.38 | 17.68 | 16.19 | 60.59 | 14.10 | | | | | |
| | Trace | 7.59 | 24.72 | 17.84 | 32.82 | 18.64 | 17.63 | 64.43 | 16.14 | | | | | |
| | Lag | No | 1 | 2 | 1 | 1 | 2 | 1 | 1 | | | | | |
| hotels | Max | 5.32 | 14.04 | 13.84 | 24.86 | 16.21 | 13.64 | 69.57 | | | | | | |
| | Trace | 5.59 | 15.48 | 13.90 | 25.05 | 16.52 | 13.85 | 70.02 | | | | | | |
| | Lag | No | 8 | 4 | 1 | 1 | 5 | 1 | | | | | | |
| localg | Max | 16.11 | 58.09 | 22.22 | 53.57 | 58.80 | 53.12 | | | | | | | |
| | Trace | 18.79 | 58.52 | 28.15 | 57.47 | 59.14 | 53.12 | | | | | | | |
| | Lag | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | |
| member | Max | 4.15 | 8.00 | 13.57 | 18.52 | 19.38 | | | | | | | | |
| | Trace | 4.18 | 8.19 | 13.57 | 18.53 | 19.38 | | | | | | | | |
| | Lag | No | No | 4 | 1 | 1 | | | | | | | | |
| motion | Max | 4.77 | 11.83 | 13.56 | 18.70 | | | | | | | | | |
| | Trace | 5.21 | 12.08 | 13.59 | 18.90 | | | | | | | | | |
| | Lag | No | No | 4 | 1 | | | | | | | | | |

| SVRET | | stateg | social | privhhs |
|---|---|---|---|---|
| personal | Max | 8.39 | 21.75 | 13.58 |
| | Trace | 9.54 | 22.03 | 14.29 |
| | Lag | No | 1 | 4 |
| privhhs | Max | 21.25 | 22.96 | |
| | Trace | 23.88 | 22.99 | |
| | Lag | 5 | 4 | |
| social | Max | 4.08 | | |
| | Trace | 4.43 | | |
| | Lag | No | | |

## Table Appendix B.4. Pairwise Cointegration Tests for PMA's MSCEX

| MSCEX | | rubber | wholnon | wholdur | water | transerv | trneq | air | mantext | metalprim | petrol | paper | miscsv | miscman |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| retapp | Max | 25.89 | 19.18 | 14.54 | 3.88 | 10.24 | 15.02 | 22.72 | 14.05 | 15.70 | 6.14 | 16.49 | 13.82 | 14.33 |
| | Trace | 26.81 | 19.61 | 14.58 | 5.99 | 14.97 | 15.23 | 23.12 | 14.18 | 15.76 | 8.62 | 17.95 | 13.93 | 16.98 |
| | Lag | 1 | 1 | 7 | No | No | 9 | 1 | 6 | 4 | No | 1 | 7 | 9 |
| manapp | Max | 3.39 | 6.14 | 4.67 | 5.07 | 13.74 | 15.26 | 5.59 | 15.28 | 13.19 | 7.62 | 18.30 | 3.32 | 5.09 |
| | Trace | 3.96 | 6.56 | 5.69 | 5.95 | 17.32 | 15.37 | 5.83 | 19.63 | 13.37 | 8.41 | 19.45 | 4.33 | 5.95 |
| | Lag | No | No | No | No | 5 | 12 | No | 3 | 5 | No | 1 | No | No |
| chems | Max | 4.51 | 3.31 | 4.95 | 14.70 | 6.48 | 13.57 | 13.54 | 15.37 | 13.86 | 14.57 | 14.58 | 11.85 | 10.46 |
| | Trace | 5.28 | 3.31 | 5.22 | 16.35 | 7.02 | 16.32 | 13.66 | 16.51 | 15.15 | 17.63 | 15.84 | 16.01 | 16.73 |
| | Lag | No | No | No | 1 | No | 12 | 10 | 11 | 8 | 3 | 1 | 8 | 3 |
| deposit | Max | 5.74 | 13.73 | 15.66 | 15.67 | 5.14 | 14.41 | 6.21 | 16.94 | 14.17 | 5.41 | 15.31 | 8.63 | 17.67 |
| | Trace | 6.65 | 14.26 | 18.04 | 19.27 | 9.11 | 14.83 | 6.37 | 17.47 | 14.99 | 6.99 | 16.82 | 9.91 | 20.11 |
| | Lag | No | 3 | 5 | 8 | No | 10 | No | 11 | 11 | No | 1 | No | 7 |
| elec | Max | 46.82 | 21.17 | 26.79 | 16.86 | 15.66 | 24.76 | 24.66 | 53.68 | 13.62 | 25.38 | 25.03 | 17.61 | 14.38 |
| | Trace | 47.23 | 22.43 | 28.29 | 19.26 | 17.65 | 25.75 | 24.78 | 59.35 | 16.73 | 30.54 | 33.22 | 19.61 | 15.79 |
| | Lag | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| engine | Max | 7.26 | 17.41 | 7.91 | 12.18 | 7.22 | 5.87 | 6.19 | 4.81 | 14.31 | 5.98 | 16.68 | 16.33 | 22.16 |
| | Trace | 7.7 | 17.44 | 8.42 | 15.90 | 9.86 | 6.39 | 6.50 | 5.61 | 15.60 | 6.53 | 17.45 | 16.86 | 23.93 |
| | Lag | No | 4 | No | 10 | No | No | No | No | 8 | No | 1 | 1 | 1 |
| metfab | Max | 5.74 | 13.73 | 15.66 | 15.67 | 5.14 | 14.17 | 2.92 | 11.29 | 6.55 | 15.49 | 13.57 | 3.33 | 13.07 |
| | Trace | 6.65 | 14.26 | 18.04 | 19.27 | 9.11 | 17.82 | 3.03 | 15.98 | 9.03 | 17.62 | 17.02 | 4.75 | 16.26 |
| | Lag | No | 3 | 5 | 8 | No | 9 | No | 3 | No | 12 | 2 | No | 9 |
| manfurn | Max | 14.15 | 14.35 | 13.21 | 16.13 | 13.58 | 17.12 | 16.42 | 15.57 | 16.25 | 6.58 | 14.82 | 14.56 | 14.46 |
| | Trace | 14.28 | 14.85 | 13.97 | 18.42 | 14.40 | 17.96 | 16.51 | 16.50 | 17.17 | 7.15 | 15.70 | 15.65 | 17.88 |
| | Lag | 1 | 7 | 1 | 8 | 2 | 10 | 7 | 9 | 8 | No | 1 | 9 | 7 |
| industrial | Max | 23.89 | 13.84 | 12.90 | 11.91 | 7.39 | 13.53 | 14.01 | 18.59 | 5.94 | 13.80 | 14.80 | 5.85 | 5.74 |
| | Trace | 24.71 | 13.85 | 14.45 | 17.06 | 9.18 | 14.21 | 14.48 | 22.05 | 9.56 | 15.60 | 17.22 | 7.00 | 7.26 |
| | Lag | 1 | 4 | No | 7 | No | 9 | 11 | 1 | No | 12 | 1 | No | No |
| instr | Max | 20.2 | 11.76 | 13.91 | 9.75 | 18.96 | 13.32 | 14.39 | 14.33 | 15.51 | 5.95 | 18.13 | 7.15 | 13.89 |
| | Trace | 20.27 | 11.77 | 13.93 | 9.75 | 19.17 | 13.68 | 14.91 | 14.38 | 15.51 | 5.97 | 18.14 | 7.19 | 15.00 |
| | Lag | 1 | No | 4 | No | 1 | 1 | 5 | 1 | 7 | No | 1 | No | 1 |
| leather | Max | 17.49 | 14.15 | 14.31 | 13.72 | 15.38 | 14.30 | 14.06 | 13.08 | 12.85 | 11.63 | 18.99 | 13.47 | 14.33 |
| | Trace | 17.97 | 14.15 | 15.18 | 17.21 | 18.38 | 15.77 | 14.94 | 18.44 | 15.75 | 16.85 | 25.70 | 14.70 | 15.64 |
| | Lag | 1 | 3 | 3 | 1 | 1 | 2 | 1 | 3 | 1 | 3 | 1 | 1 | 1 |

## Table Appendix B.4. Pairwise Cointegration Tests for PMA's MSCEX

| mSCEX | | rubber | wholnon | wholdur | water | transerv | trneq | air | mantext | metalprim | petrol | paper | miscsv |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| miscman | Max | 4.95 | 1.93 | 3.30 | 12.61 | 5.09 | 13.16 | 4.64 | 13.58 | 13.32 | 6.43 | 18.30 | 22.51 |
| | Trace | 6.69 | 3.66 | 4.44 | 16.45 | 7.70 | 17.87 | 5.55 | 16.35 | 16.06 | 7.87 | 19.74 | 24.23 |
| | Lag | No | No | No | 7 | No | 10 | No | 11 | 5 | No | 1 | 1 |
| miscsv | Max | 7.36 | 18.01 | 8.67 | 17.24 | 7.43 | 6.09 | 6.72 | 4.57 | 15.84 | 6.64 | 16.63 | |
| | Trace | 7.86 | 18.01 | 9.30 | 21.63 | 10.46 | 6.91 | 7.07 | 5.86 | 17.60 | 7.93 | 17.98 | |
| | Lag | No | 4 | No | 12 | No | No | No | No | 8 | No | 1 | |
| paper | Max | 19.70 | 19.28 | 20.31 | 13.53 | 21.78 | 14.28 | 18.89 | 14.19 | 16.05 | 11.14 | | |
| | Trace | 20.52 | 19.71 | 21.71 | 17.52 | 25.38 | 16.21 | 19.22 | 17.66 | 19.30 | 16.41 | | |
| | Lag | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | |
| petrol | Max | 5.49 | 13.60 | 12.99 | 12.20 | 6.15 | 13.62 | 21.08 | 12.11 | 15.43 | | | |
| | Trace | 6.55 | 14.28 | 13.00 | 16.12 | 10.23 | 13.71 | 22.40 | 16.69 | 20.47 | | | |
| | Lag | No | 10 | 12 | 10 | No | 10 | 12 | 3 | 8 | | | |
| metalprim | Max | 10 | 13.00 | 13.32 | 15.35 | 14.21 | 15.41 | 4.53 | 12.16 | | | | |
| | Trace | 10.63 | 13.00 | 14.92 | 17.61 | 16.50 | 17.51 | 4.87 | 16.07 | | | | |
| | Lag | No | 4 | 5 | 7 | 12 | 2 | No | 12 | | | | |
| mantext | Max | 13.99 | 13.00 | 15.17 | 5.22 | 8.01 | 16.25 | 13.01 | | | | | |
| | Trace | 14.52 | 13.02 | 17.39 | 7.29 | 11.81 | 16.39 | 14.15 | | | | | |
| | Lag | 5 | 5 | 5 | No | No | 11 | 10 | | | | | |
| air | Max | 15.30 | 13.79 | 19.68 | 4.10 | 14.10 | 7.78 | | | | | | |
| | Trace | 15.56 | 14.26 | 20.27 | 4.20 | 14.52 | 7.87 | | | | | | |
| | Lag | 12 | 1 | 5 | No | 2 | No | | | | | | |
| tranequip | Max | 13.30 | 18.93 | 14.02 | 13.03 | 13.60 | | | | | | | |
| | Trace | 13.45 | 19.56 | 15.70 | 15.67 | 16.83 | | | | | | | |
| | Lag | 11 | 9 | 9 | 9 | 10 | | | | | | | |
| transerv | Max | 5.91 | 5.94 | 6.36 | 6.37 | | | | | | | | |
| | Trace | 6.46 | 8.04 | 9.08 | 9.56 | | | | | | | | |
| | Lag | No | No | No | No | | | | | | | | |

| | | rubber | wholnon | wholdur |
|---|---|---|---|---|
| water | Max | 6.43 | 3.69 | 4.27 |
| | Trace | 8.24 | 4.05 | 7.02 |
| | Lag | No | No | No |
| wholdur | Max | 23.71 | 15.45 | |
| | Trace | 24.93 | 15.47 | |
| | Lag | 1 | 4 | |
| wholnon | Max | 23.76 | | |
| | Trace | 23.77 | | |
| | Lag | 4 | | |

## Table Appendix B.4. Pairwise Cointegration Tests for PMA's MSCEX

| MSCEX | | leather | instr | industrial | manfurn | metfab | engine | elec | deposit | chems | manapp |
|---|---|---|---|---|---|---|---|---|---|---|---|
| retapp | Max | 13.19 | 15.28 | 13.79 | 15.47 | 1.91 | 15.33 | 29.83 | 21.07 | 9.87 | 6.46 |
| | Trace | 14.34 | 15.29 | 13.89 | 15.51 | 3.67 | 15.72 | 32.89 | 22.12 | 18.37 | 6.93 |
| | Lag | 1 | 6 | 1 | 7 | No | 1 | 1 | 1 | 12 | No |
| manapp | Max | 16.15 | 20.13 | 7.56 | 14.74 | 2.63 | 2.80 | 32.55 | 2.19 | 2.47 | |
| | Trace | 17.81 | 20.39 | 11.20 | 15.20 | 3.29 | 3.48 | 39.04 | 3.65 | 2.53 | |
| | Lag | 1 | 1 | No | 7 | No | No | 1 | No | No | |
| chems | Max | 14.08 | 13.36 | 6.73 | 12.18 | 17.41 | 10.30 | 28.18 | 13.59 | | |
| | Trace | 15.30 | 15.40 | 7.02 | 18.68 | 18.79 | 15.80 | 28.23 | 16.91 | | |
| | Lag | 2 | 6 | No | 7 | 6 | 8 | 1 | 12 | | |
| deposit | Max | 13.94 | 13.86 | 6.53 | 13.47 | 2.52 | 6.51 | 25.86 | | | |
| | Trace | 15.00 | 14.15 | 8.13 | 14.16 | 3.94 | 7.30 | 27.39 | | | |
| | Lag | 3 | 5 | No | 8 | No | No | 1 | | | |
| elec | Max | 14.80 | 22.88 | 22.70 | 37.47 | 36.27 | 19.54 | | | | |
| | Trace | 23.46 | 23.13 | 24.79 | 37.81 | 38.09 | 20.73 | | | | |
| | Lag | 1 | 1 | 1 | 1 | 1 | 1 | | | | |
| engine | Max | 13.41 | 6.93 | 5.87 | 16.80 | 3.11 | | | | | |
| | Trace | 14.07 | 6.97 | 6.63 | 17.70 | 4.14 | | | | | |
| | Lag | 17 | No | No | 9 | No | | | | | |
| metfab | Max | 17.19 | 13.29 | 8.87 | 12.16 | | | | | | |
| | Trace | 18.20 | 15.07 | 10.34 | 21.41 | | | | | | |
| | Lag | 3 | 1 | No | 1 | | | | | | |
| manfurn | Max | 14.40 | 24.93 | 19.64 | | | | | | | |
| | Trace | 15.75 | 25.90 | 20.56 | | | | | | | |
| | Lag | 1 | 1 | 1 | | | | | | | |
| industrial | Max | 14.13 | 13.37 | | | | | | | | |
| | Trace | 16.68 | 13.40 | | | | | | | | |
| | Lag | 4 | 6 | | | | | | | | |
| instr | Max | 15.19 | | | | | | | | | |
| | Trace | 15.20 | | | | | | | | | |
| | Lag | 1 | | | | | | | | | |

**Table Appendix B.5. Pairwise Cointegration Tests for PMA's SVEXP**

| SVEXP | | securities | nondep | museums | legal | inscarr | insag | fedg | educ | comm |
|---|---|---|---|---|---|---|---|---|---|---|
| business | Max | 16.62 | 1.76 | 36.69 | 18.14 | 16.74 | 7.12 | 14.01 | 28.13 | 14.82 |
| | Trace | 16.65 | 1.81 | 36.70 | 19.16 | 16.74 | 7.12 | 14.01 | 28.14 | 15.05 |
| | Lag | 12 | No | 1 | 1 | 3 | No | 1 | 1 | 9 |
| comm | Max | 13.49 | 4.73 | 14.09 | 16.62 | 19.30 | 23.38 | 21.54 | 20.47 | |
| | Trace | 14.52 | 6.28 | 16.30 | 22.97 | 20.39 | 23.74 | 23.82 | 20.95 | |
| | Lag | 9 | No | 5 | 1 | 1 | 9 | 9 | 4 | |
| educ | Max | 14.24 | 2.21 | 46.33 | 15.91 | 16.14 | 19.49 | 18.26 | | |
| | Trace | 14.25 | 2.74 | 47.15 | 20.90 | 17.20 | 19.60 | 19.44 | | |
| | Lag | 11 | No | 1 | 1 | 1 | 1 | 1 | | |
| fedg | Max | 12.76 | 9.37 | 29.41 | 21.74 | 17.27 | 13.49 | | | |
| | Trace | 19.38 | 10.84 | 33.80 | 36.50 | 20.11 | 13.64 | | | |
| | Lag | 12 | No | 1 | 1 | 1 | 1 | | | |
| insag | Max | 16.22 | 2.14 | 38.15 | 15.27 | 13.26 | | | | |
| | Trace | 16.45 | 2.61 | 38.29 | 15.94 | 13.26 | | | | |
| | Lag | 12 | No | 1 | 1 | 5 | | | | |
| inscarr | Max | 14.25 | 6.92 | 25.41 | 17.36 | | | | | |
| | Trace | 14.26 | 7.97 | 29.22 | 18.47 | | | | | |
| | Lag | 7 | No | 1 | 1 | | | | | |
| legal | Max | 16.65 | 16.05 | 27.24 | | | | | | |
| | Trace | 16.70 | 17.67 | 42.40 | | | | | | |
| | Lag | 1 | 1 | 1 | | | | | | |
| museums | Max | 20.61 | 6.41 | | | | | | | |
| | Trace | 20.90 | 7.94 | | | | | | | |
| | Lag | 1 | No | | | | | | | |
| nondep | Max | 8.57 | | | | | | | | |
| | Trace | 8.72 | | | | | | | | |
| | Lag | No | | | | | | | | |

**Table Appendix B.6. Pairwise Cointegration Tests for PMA's AGMN**

| AGMN | | oil | mnnon | metalmn | forest | aglive |
|---|---|---|---|---|---|---|
| agcrops | Max | 21.66 | 11.86 | 10.99 | 41.94 | 15.97 |
| | Trace | 23.94 | 19.68 | 15.89 | 50.53 | 24.64 |
| | Lag | 5 | 1 | 2 | 1 | 1 |
| aglive | Max | 15.05 | 9.96 | 11.82 | 47.79 | |
| | Trace | 17.04 | 18.36 | 16.74 | 56.88 | |
| | Lag | 4 | 1 | 3 | 1 | |
| forest | Max | 26.17 | 27.34 | 25.91 | | |
| | Trace | 28.77 | 33.80 | 29.36 | | |
| | Lag | 1 | 1 | 1 | | |
| metalmn | Max | 14.36 | 10.32 | | | |
| | Trace | 15.82 | 18.08 | | | |
| | Lag | 8 | 6 | | | |
| mnnon | Max | 20.06 | | | | |
| | Trace | 22.65 | | | | |
| | Lag | 1 | | | | |

Critical Value:
Maximum Eigenvalue at 95% = 14.88 — Trace at 95% = 17.86
At 90% = 12.98 — at 90% = 15.75

Max = Calculated value under the Maximum Eigenvalue Test
Trace = Calculated value under the Trace Test
Lag = Number of lags required to find evidence of cointegration
No = not cointegrated (values shown are for one lag)

* These critical values and definitions are the same for all pairwise tests for the PMA and SW Region.

**Table Appendix B.7. Pairwise Cointegration Tests for the SW's WHTSV**

| WHTSV | | social | securities | museums | member | legal | insag | health | engine | educ |
|---|---|---|---|---|---|---|---|---|---|---|
| business | Max | 14.15 | 15.60 | 5.01 | 4.45 | 14.62 | 17.08 | 14.42 | 6.25 | 22.58 |
| | Trace | 14.18 | 15.66 | 5.20 | 4.61 | 14.87 | 17.23 | 14.90 | 6.42 | 22.96 |
| | Lag | 10 | 8 | No | No | 3 | 9 | 3 | No | 1 |
| educ | Max | 16.91 | 13.75 | 17.48 | 18.44 | 12.47 | 16.23 | 17.54 | 15.66 | |
| | Trace | 17.08 | 15.29 | 17.88 | 18.61 | 17.81 | 16.27 | 23.63 | 16.35 | |
| | Lag | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | |
| engine | Max | 5.14 | 15.78 | 35.14 | 15.18 | 13.63 | 3.28 | 10.84 | | |
| | Trace | 5.34 | 17.61 | 35.89 | 15.72 | 16.47 | 3.77 | 12.34 | | |
| | Lag | No | 8 | 1 | 1 | 2 | No | No | | |
| health | Max | 18.88 | 15.20 | 13.76 | 13.61 | 18.01 | 13.22 | | | |
| | Trace | 20.15 | 17.06 | 15.02 | 14.08 | 19.21 | 13.75 | | | |
| | Lag | 1 | 2 | 4 | 4 | 1 | 1 | | | |
| insag | Max | 6.61 | 13.76 | 3.68 | 3.80 | 14.25 | | | | |
| | Trace | 7.05 | 14.68 | 4.30 | 4.19 | 14.28 | | | | |
| | Lag | No | 7 | No | No | 2 | | | | |
| legal | Max | 13.55 | 14.78 | 15.89 | 13.07 | | | | | |
| | Trace | 14.20 | 24.39 | 17.89 | 13.67 | | | | | |
| | Lag | 2 | 1 | 2 | 3 | | | | | |
| member | Max | 5.76 | 14.59 | 28.65 | | | | | | |
| | Trace | 5.97 | 14.73 | 29.18 | | | | | | |
| | Lag | No | 7 | 1 | | | | | | |
| museums | Max | 6.69 | 13.07 | | | | | | | |
| | Trace | 6.82 | 14.10 | | | | | | | |
| | Lag | No | 7 | | | | | | | |
| securities | Max | 14.17 | | | | | | | | |
| | Trace | 14.17 | | | | | | | | |
| | Lag | 6 | | | | | | | | |

**Table Appendix B.8. Pairwise Cointegration Tests for the SW's CREAL**

| CREAL | | cnstspec | real | holding | cnstheav | cnstgen |
|---|---|---|---|---|---|---|
| utils | Max | 14.89 | 14.25 | 7.42 | 32.11 | 16.65 |
| | Trace | 16.05 | 15.52 | 10.05 | 34.83 | 20.37 |
| | Lag | 11 | No | 1 | 1 | 9 |
| cnstgen | Max | 14.66 | 12.11 | 13.23 | 39.82 | |
| | Trace | 15.43 | 18.71 | 14.07 | 41.85 | |
| | Lag | 9 | 8 | 9 | 1 | |
| cnsthev | Max | 43.04 | 24.89 | 22.88 | | |
| | Trace | 43.49 | 26.36 | 28.21 | | |
| | Lag | 1 | 1 | 1 | | |
| holding | Max | 16.47 | 13.43 | | | |
| | Trace | 17.61 | 14.07 | | | |
| | Lag | 10 | 3 | | | |
| real | Max | 10.95 | | | | |
| | Trace | 16.50 | | | | |
| | Lag | 8 | | | | |

**Table Appendix B.9. Pairwise Cointegration Tests for the SW's WR**

| WR | WR | wholnon | wholdur | retgen | retfurn | grocery | eat | build | auto |
|---|---|---|---|---|---|---|---|---|---|
| appret | Max | 29.35 | 20.55 | 21.81 | 17.10 | 26.77 | 32.59 | 20.91 | 27.41 |
| | Trace | 44.28 | 20.72 | 22.79 | 20.02 | 29.11 | 37.58 | 22.81 | 28.43 |
| | Lag | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| auto | Max | 35.13 | 17.69 | 34.09 | 34.65 | 13.70 | 24.47 | 3.66 | |
| | Trace | 35.68 | 17.70 | 35.65 | 36.57 | 13.95 | 24.47 | 5.77 | |
| | Lag | 1 | 9 | 1 | 1 | 4 | 3 | No | |
| retbuild | Max | 33.46 | 13.43 | 13.27 | 9.93 | 4.25 | 16.98 | | |
| | Trace | 33.77 | 13.86 | 14.06 | 11.91 | 6.17 | 19.52 | | |
| | Lag | 1 | 1 | 2 | No | No | 12 | | |
| eat | Max | 45.76 | 13.92 | 38.99 | 20.19 | 15.21 | | | |
| | Trace | 49.44 | 15.35 | 41.85 | 25.14 | 18.98 | | | |
| | Lag | 1 | 7 | 1 | 1 | 1 | | | |
| grocery | Max | 30.66 | 15.32 | 14.16 | 9.83 | | | | |
| | Trace | 32.96 | 17.73 | 18.26 | 16.24 | | | | |
| | Lag | 1 | 4 | 1 | 4 | | | | |
| retfurn | Max | 26.81 | 16.06 | 17.61 | | | | | |
| | Trace | 30.95 | 16.55 | 17.61 | | | | | |
| | Lag | 1 | 4 | 4 | | | | | |
| retgen | Max | 27.29 | 13.45 | | | | | | |
| | Trace | 28.93 | 13.86 | | | | | | |
| | Lag | 1 | 11 | | | | | | |
| wholdur | Max | 29.67 | | | | | | | |
| | Trace | 29.83 | | | | | | | |
| | Lag | 1 | | | | | | | |

**Table Appendix B.10. Pairwise Cointegration Tests for the SW's MSCSV**

| MSCSV | MSCSV | stateg | nondep | localg | inscarr | deposit | chems | aglive |
|---|---|---|---|---|---|---|---|---|
| agcrops | Max | 15.30 | 14.73 | 55.33 | 13.29 | 12.66 | 12.35 | 21.45 |
| | Trace | 24.96 | 17.57 | 65.20 | 14.58 | 16.39 | 17.46 | 31.00 |
| | Lag | 1 | 3 | 1 | 2 | 2 | 2 | 1 |
| aglive | Max | 14.90 | 13.28 | 54.31 | 13.74 | 15.74 | 10.41 | |
| | Trace | 20.78 | 17.91 | 60.16 | 14.54 | 18.41 | 16.09 | |
| | Lag | 1 | 7 | 1 | 7 | 8 | 3 | |
| chems | Max | 15.87 | 12.56 | 58.41 | 14.57 | 13.07 | | |
| | Trace | 20.92 | 17.14 | 63.90 | 16.37 | 17.04 | | |
| | Lag | 1 | 4 | 1 | 12 | 4 | | |
| deposit | Max | 29.83 | 14.82 | 73.64 | 13.33 | | | |
| | Trace | 33.21 | 17.71 | 76.88 | 14.93 | | | |
| | Lag | 1 | 5 | 1 | 8 | | | |
| inscarr | Max | 36.20 | 16.45 | 75.23 | | | | |
| | Trace | 37.37 | 17.97 | 76.36 | | | | |
| | Lag | 1 | 4 | 1 | | | | |
| localg | Max | 79.90 | 52.14 | | | | | |
| | Trace | 84.39 | 54.49 | | | | | |
| | Lag | 1 | 1 | | | | | |
| nondep | Max | 20.25 | | | | | | |
| | Trace | 22.21 | | | | | | |
| | Lag | 1 | | | | | | |

**Table Appendix B.11. Pairwise Cointegration Tests for the SW's EXPORT**

| EXPORT | EXPORT | water | air | miscret | metalmn | l&w | forest | fish |
|---|---|---|---|---|---|---|---|---|
| fedg | Max | 25.72 | 27.71 | 30.28 | 25.78 | 26.50 | 32.51 | 42.67 |
| | Trace | 34.12 | 28.75 | 54.89 | 30.09 | 27.90 | 53.23 | 57.21 |
| | Lag | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| fish | Max | 13.54 | 14.40 | 20.34 | 14.23 | 13.55 | 19.58 | |
| | Trace | 22.36 | 15.23 | 30.38 | 18.72 | 14.77 | 34.84 | |
| | Lag | 1 | 1 | 1 | 1 | 1 | 1 | |
| forest | Max | 31.35 | 42.74 | 51.50 | 25.34 | 26.33 | | |
| | Trace | 37.64 | 43.94 | 58.02 | 29.26 | 27.60 | | |
| | Lag | 1 | 1 | 1 | 1 | 1 | | |
| l&w | Max | 18.00 | 13.16 | 64.86 | 13.19 | | | |
| | Trace | 19.10 | 13.37 | 66.36 | 14.31 | | | |
| | Lag | 1 | 4 | 1 | 10 | | | |
| metalmn | Max | 20.39 | 13.16 | 33.76 | | | | |
| | Trace | 23.22 | 14.42 | 37.18 | | | | |
| | Lag | 1 | 12 | 1 | | | | |
| miscret | Max | 49.87 | 32.40 | | | | | |
| | Trace | 56.26 | 33.24 | | | | | |
| | Lag | 1 | 1 | | | | | |
| air | Max | 15.10 | | | | | | |
| | Trace | 16.55 | | | | | | |
| | Lag | 1 | | | | | | |

## Table Appendix B.12. Pairwise Cointegration Tests for the SW's MAN

| MAN | MAN | rub | ind | mantext | stone | print | misceman | leather | instr | manfurn | f&k | fabmet | elec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| manapp | Max | 23.43 | 15.66 | 17.58 | 22.95 | 22.86 | 19.42 | 18.47 | 25.75 | 15.78 | 24.75 | 17.24 | 15.82 |
| | Trace | 27.50 | 23.31 | 22.12 | 30.69 | 27.53 | 19.56 | 21.21 | 28.88 | 29.77 | 40.02 | 25.04 | 17.72 |
| | Lag | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| elec | Max | 3.42 | 8.99 | 18.69 | 14.09 | 13.67 | 14.21 | 13.48 | 3.92 | 15.39 | 30.86 | 13.78 | |
| | Trace | 5.53 | 14.01 | 22.59 | 14.12 | 16.25 | 14.32 | 17.86 | 4.95 | 17.23 | 33.00 | 14.84 | |
| | Lag | No | No | 9 | 8 | 4 | 5 | 9 | No | 4 | 1 | 5 | |
| fabmet | Max | 14.82 | 14.45 | 11.46 | 13.89 | 17.45 | 17.40 | 19.80 | 16.00 | 15.58 | 31.72 | | |
| | Trace | 16.91 | 15.17 | 16.13 | 19.68 | 21.08 | 17.41 | 22.44 | 17.39 | 22.14 | 38.25 | | |
| | Lag | 2 | 11 | 2 | 1 | 1 | 1 | 5 | 1 | 1 | 1 | | |
| f&k | Max | 24.82 | 28.18 | 24.83 | 28.50 | 24.86 | 26.03 | 30.25 | 25.23 | 23.91 | | | |
| | Trace | 26.90 | 35.08 | 29.68 | 33.62 | 29.44 | 26.05 | 33.40 | 26.33 | 32.82 | | | |
| | Lag | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | |
| manfurn | Max | 15.44 | 10.04 | 12.18 | 11.20 | 13.85 | 13.86 | 10.93 | 12.86 | | | | |
| | Trace | 17.93 | 16.51 | 16.47 | 18.31 | 15.73 | 13.90 | 16.66 | 16.29 | | | | |
| | Lag | 4 | 1 | 1 | 1 | 2 | 3 | 2 | 2 | | | | |
| instr | Max | 4.51 | 13.72 | 15.73 | 26.31 | 21.33 | 13.26 | 13.54 | | | | | |
| | Trace | 5.95 | 15.07 | 16.27 | 27.41 | 25.21 | 13.26 | 14.39 | | | | | |
| | Lag | No | 4 | 9 | 1 | 1 | 10 | 5 | | | | | |
| leather | Max | 15.82 | 17.27 | 18.87 | 14.59 | 15.40 | 13.60 | | | | | | |
| | Trace | 17.46 | 21.80 | 24.23 | 14.75 | 18.74 | 13.61 | | | | | | |
| | Lag | 3 | 4 | 1 | 6 | 5 | 8 | | | | | | |
| misceman | Max | 14.69 | 7.43 | 17.56 | 19.01 | 15.34 | | | | | | | |
| | Trace | 14.88 | 7.51 | 17.57 | 19.07 | 15.83 | | | | | | | |
| | | 12 | No | 9 | 1 | 3 | | | | | | | |
| print | Max | 12.91 | 14.56 | 16.21 | 24.19 | | | | | | | | |
| | Trace | 16.22 | 16.19 | 18.57 | 28.45 | | | | | | | | |
| | Lag | 12 | 2 | 3 | 1 | | | | | | | | |

| | | rub | ind | mantext |
|---|---|---|---|---|
| stone | Max | 17.74 | 13.94 | 18.33 |
| | Trace | 19.80 | 14.30 | 18.34 |
| | Lag | 1 | 9 | 9 |
| mantext | Max | 13.52 | 12.16 | |
| | Trace | 15.14 | 16.33 | |
| | Lag | 2 | 4 | |
| ind | Max | 19.02 | | |
| | Trace | 22.06 | | |
| | Lag | 4 | | |

## Table Appendix B.13. Pairwise Cointegration Tests for the SW's BLUESV

| BLUESV | BLUESV | truck | transerv | tranequip | privhhs | personal | motion | miscsv | miscrep | localtran | hotel | comm | autorep | agsv | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| amuse | Max | 11.21 | 28.35 | 27.09 | 11.85 | 12.77 | 25.86 | 24.90 | 19.15 | 28.60 | 60.35 | 19.69 | 25.52 | 43.71 | |
| | Trace | 17.94 | 29.14 | 29.08 | 21.09 | 16.92 | 28.44 | 26.17 | 22.32 | 32.92 | 71.50 | 20.74 | 26.14 | 46.74 | |
| | Lag | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | |
| agsv | Max | 13.65 | 22.21 | 16.72 | 11.83 | 10.97 | 10.63 | 12.40 | 6.49 | 30.69 | 55.51 | 13.40 | 18.09 | | |
| | Trace | 17.26 | 23.05 | 16.74 | 18.61 | 13.45 | 13.10 | 13.54 | 10.13 | 32.20 | 57.54 | 13.40 | 18.72 | | |
| | Lag | 1 | 1 | 4 | 1 | No | No | No | No | 1 | 1 | 9 | 1 | | |
| amuse | Max | 16.39 | 13.13 | 15.54 | 17.45 | 7.61 | 13.68 | 7.40 | 4.62 | 40.03 | 46.10 | 14.95 | | | |
| | Trace | 16.83 | 13.75 | 17.16 | 18.02 | 8.38 | 13.74 | 7.92 | 5.79 | 40.39 | 46.40 | 15.06 | | | |
| | Lag | 1 | 5 | 10 | 3 | No | 11 | No | No | 1 | 1 | 1 | | | |
| autorep | Max | 27.93 | 16.14 | 17.55 | 19.25 | 5.59 | 16.12 | 10.01 | 26.18 | 27.52 | 46.29 | | | | |
| | Trace | 28.81 | 16.21 | 19.13 | 21.99 | 7.71 | 17.14 | 10.71 | 26.96 | 29.08 | 48.51 | | | | |
| | Lag | 1 | 1. | 4 | 1 | No | 5 | No | 1 | 1 | 1 | | | | |
| comm | Max | 42.71 | 52.27 | 49.67 | 37.52 | 34.92 | 55.47 | 55.33 | 44.69 | 48.27 | | | | | |
| | Trace | 49.03 | 53.02 | 52.23 | 46.88 | 39.74 | 57.84 | 56.65 | 47.54 | 52.83 | | | | | |
| | Lag | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | truck | transerv | tranequip | privhhs |
| hotel | Max | 27.82 | 25.62 | 19.58 | 12.44 | 12.14 | 15.05 | 19.11 | 20.44 | personal | Max | 7.40 | 6.51 | 9.59 | 13.91 |
| | Trace | 32.06 | 26.28 | 21.43 | 19.30 | 16.45 | 17.06 | 20.27 | 22.37 | | Trace | 12.49 | 7.34 | 11.70 | 16.66 |
| | Lag | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | Lag | No | No | No | 3 |
| localtran | Max | 15.57 | 4.71 | 10.93 | 14.20 | 6.30 | 14.05 | 12.22 | | privhhs | Max | 11.75 | 15.05 | 13.85 | |
| | Trace | 19.26 | 6.98 | 18.17 | 17.26 | 9.34 | 19.33 | 16.84 | | | Trace | 19.08 | 15.35 | 16.08 | |
| | Lag | 1 | No | 12 | 3 | No | 11 | 11 | | | Lag | 1 | 3 | 3 | |
| miscrep | Max | 13.93 | 13.91 | 6.19 | 13.87 | 5.76 | 14.65 | | | transequip | Max | 20.13 | 14.37 | | |
| | Trace | 16.08 | 15.75 | 7.37 | 16.11 | 6.92 | 17.04 | | | | Trace | 22.54 | 14.72 | | |
| | Lag | 1 | 6 | No | 3 | No | 10 | | | | Lag | 1 | 2 | | |
| miscsv | Max | 8.42 | 10.39 | 15.73 | 14.12 | 7.18 | | | | transerv | Max | 17.51 | | | |
| | Trace | 11.76 | 11.26 | 18.80 | 15.72 | 10.04 | | | | | Trace | 19.18 | | | |
| | Lag | No | No | 4 | 3 | No | | | | | Lag | 1 | | | |

## Appendix C

## Augemented Dickey-Fuller Tests and F-Tests for PMA and SW Region

**Table Appendix C.1. Augmented Dickey-Fuller Tests for the PMA**

| Sector | Trend & Inter | Trend | None | Sector | Trend & Inter | Trend | None |
|---|---|---|---|---|---|---|---|
| agcrops | -0.57 | -2.27 | 1.54 | lumber | -2.77 | -2.08 | -1.4 |
| aglive | -3.25 | -1.91 | -0.79 | manapparel | -2.34 | -2.21 | -2.34 |
| agserv | -0.67 | 1.96 | 2.72 | manfood | -1.8 | -1.29 | 0.02 |
| air | 0.32 | 2.38 | 2.96 | manmisc | -1.17 | -1.46 | 0.01 |
| amuse | -1.02 | 1.6 | 2.29 | mantext | -4.06 | -3.51 | -1.65 |
| apparelret | -2.03 | 0.29 | 1.52 | member | -1.89 | 0.41 | 1.68 |
| auto | -1.84 | 1.63 | 2.85 | metalfab | -1.6 | -1.75 | -0.06 |
| autorep | -1.79 | -2.12 | 0.57 | metalprimary | -2.63 | -1.81 | 0.13 |
| business | -1.45 | 1.25 | 2.3 | minemetal | -2.63 | -2.38 | -2.07 |
| chemicals | -1.29 | -1.74 | -0.03 | minenonmetal | -2.77 | -1.93 | -0.71 |
| cnstgen | -1.53 | -0.12 | 0.77 | miscrepair | -0.46 | -1.44 | 1.03 |
| cnstheavy | -2.09 | -0.75 | 0.22 | miscret | -2.12 | 0.02 | 2.74 |
| cnstspec | -1.55 | 0.31 | 1.52 | miscserv | -2.29 | -0.97 | -1.27 |
| comb | -2.65 | -3.91 | -4.21 | motion | -1.72 | 0.46 | 1.4 |
| comm | -3.36 | -2.41 | 0.08 | museums | -2.99 | -0.9 | 1.52 |
| depository | -1.93 | -0.67 | 1 | nondeposit | -1.02 | -1.27 | 0.41 |
| eat | -2.19 | 0.76 | 2.47 | oil | -2.23 | -1.57 | -1.16 |
| educational | -2.54 | 1.68 | 2.8 | paper | -2.57 | -1.77 | -0.96 |
| electric | -1.65 | 0.36 | 1.47 | personal | -1.7 | 0.49 | 1.68 |
| engineer | -2.35 | -0.38 | 0.52 | petrol | -2.49 | -2.49 | -1.1 |
| fed | -2.18 | -1.77 | 0.88 | printing | -0.95 | -0.88 | 2.57 |
| fish | -3.03 | -0.85 | -0.52 | privHHs | -1.92 | -1.08 | 1.03 |
| foodRET | -1.9 | -1.3 | 1.19 | real | -2.24 | 1.03 | 1.92 |
| forestry | -2.64 | -1.86 | -0.26 | retbuild | -2.23 | -0.12 | 0.79 |
| furnitureman | -1.55 | 1.38 | 2.4 | retgen | -2.43 | -1.93 | 0.03 |
| furnitureret | -2.08 | -0.52 | 1.01 | rubber | -1.76 | 0.59 | 1.56 |
| health | -2.42 | 0.22 | 2.32 | securities | -1.86 | -0.11 | 1.73 |
| holding | -0.6 | -1.69 | 1.88 | social | -1.71 | 0.99 | 1.76 |
| hotel | -0.23 | -1.69 | 1.88 | state | -1.01 | -1.56 | -0.67 |
| industrial | -2.67 | -1.48 | 0.04 | stone | -2.4 | -1.5 | 0.3 |
| insagents | -1.74 | 1.2 | 3.08 | transequip | -2.15 | -0.55 | 0.46 |
| inscarriers | -3.09 | -0.28 | 1.54 | transerv | -2.96 | -0.39 | 2.08 |
| instruments | -2.25 | -1.86 | -2.41 | trucking | -0.82 | -2.06 | 1.1 |
| leather | -1.96 | -1.07 | -0.13 | utils | -2.41 | -1.77 | 0.64 |
| legal | -2.73 | -1.77 | 0.53 | water | -1.2 | -1.57 | 0.05 |
| local | 1.67 | -0.42 | 1.99 | wholdur | -2.22 | -0.18 | 1.32 |
| localtrans | -3.36 | -1.14 | 1.79 | wholnon | -0.38 | 2.12 | 3.51 |

| Critical Values: | Trend & Intercept | Intercept | None |
|---|---|---|---|
| | 1%: -4.07 | 1%: -3.51 | 1%: -2.59 |
| | 5%: -3.47 | 5%: -2.90 | 5%: -1.94 |
| | 10%: -3.16 | 10%: -2.59 | 10%: -1.62 |

$H_O$: Series is Nonstationary
$H_A$: Series is Stationary
If Absolute Calculated Value > Absolute Table Value ⇒ Reject $H_O$
If Absolute Calculated Value < Absolute Table Value ⇒ Fail to reject $H_O$

**Table Appendix C.2. Augmented Dickey-Fuller Tests for the SW Region**

| Sector | Trend & Inter | Trend | None | Sector | Trend & Inter | Trend | None |
|---|---|---|---|---|---|---|---|
| agcrops | -2.9 | -3.03 | 1.23 | legal | -2.32 | -2.54 | 1.51 |
| aglivestock | -2.21 | -1.91 | 0.79 | local | -1.67 | -0.61 | 0.86 |
| agserv | -1.84 | -0.26 | 1.5 | localtrans | -2.99 | -0.91 | 0.61 |
| air | -1.39 | -0.52 | 0.7 | lumber | -2.54 | -1.5 | -1.74 |
| amuse | 0.36 | 2.64 | 4.48 | manapparel | -2.39 | -1.63 | 0.48 |
| apparel | -2.15 | -2.5 | 1.02 | manfood | -2.02 | -2.03 | -0.05 |
| auto | -2.11 | 0.75 | 1.75 | manfurniture | -3.51 | -1.56 | 0.09 |
| autorep | -2.39 | -0.19 | 2.09 | mantextiles | -2.61 | -2.01 | -1.53 |
| buildret | -1.55 | -0.15 | 0.97 | member | -1.62 | 0.55 | 1.78 |
| business | -1.15 | 0.09 | 2.07 | minemetal | -3.28 | -2.22 | -1.74 |
| chemicals | -3.58 | -2.74 | -0.93 | minenonmetal | -1.67 | -0.43 | 1.01 |
| cnstgen | -2.36 | -1.66 | -0.28 | miscman | -1.85 | 0.61 | 1.91 |
| cnstheavy | -1.97 | -1.52 | 0.07 | miscrep | -1.12 | -1.52 | 0.17 |
| cnstspecial | 0.09 | -1.57 | 1.02 | miscret | -1.63 | 1.11 | 3.6 |
| comm | -2.32 | -1.8 | -0.52 | miscserv | -2.39 | -1.12 | -1.44 |
| deposit | -2.22 | -1.71 | 0.46 | motion | -1.56 | -1.03 | 0.37 |
| eat | -2.41 | -0.24 | 1.63 | museums | -1.73 | -0.33 | 0.51 |
| educational | -0.51 | 1.71 | 3.38 | nondep | -2.25 | -1.31 | -0.72 |
| electronic | -1.68 | -1.54 | -0.07 | personal | -1.39 | 0.88 | 0.87 |
| engineer | -1.98 | -0.42 | 0.6 | printing | -2.27 | -0.8 | 1.86 |
| fabmetal | -1.82 | -0.17 | 1.42 | privateHHs | -2.44 | -1.31 | 0.95 |
| fed | -2.68 | -2.48 | -0.04 | real | -1.81 | 0.27 | 3.17 |
| fish | -2.7 | -2.8 | -0.28 | rubber | -2.03 | -1.21 | 0.5 |
| food | -1.29 | -1.25 | 2 | securities | -2.31 | -0.67 | 1.3 |
| forestry | 1.03 | -0.21 | 2.02 | social | 0.69 | 4.04 | 4.75 |
| furniture | -2.59 | -0.83 | 0.62 | state | -1.49 | 0.21 | 1.95 |
| genret | -2.17 | 0.18 | 1.94 | stone | -2.16 | 0.23 | 1.71 |
| health | -2.06 | 0.54 | 3.24 | tranequip | -2.52 | -1.2 | 0.62 |
| holding | -1.99 | 0.1 | 1.54 | transerv | -2.55 | -0.24 | 1.15 |
| hotel | -1.22 | -1.34 | 0.62 | trucking | -1.49 | -1.55 | 0.62 |
| indmachine | -2.29 | -2.35 | -0.03 | utils | -2.62 | -1.5 | 0.23 |
| insagents | -1.31 | 0.72 | 1.89 | water | -2.43 | -0.53 | -1.63 |
| inscarriers | -1.75 | -0.57 | 1.02 | wholdur | -1.61 | -0.01 | 0.95 |
| instruments | -1.82 | 0.62 | 1.65 | wholnondur | -4.36 | -3.94 | 0.61 |
| leather | -4.19 | -2.77 | -1.96 | | | | |

| Critical Values: | Trend & Intercept | Intercept | None |
|---|---|---|---|
| | 1%: -4.07 | 1%: -3.51 | 1%: -2.59 |
| | 5%: -3.47 | 5%: -2.90 | 5%: -1.94 |
| | 10%: -3.16 | 10%: -2.59 | 10%: -1.62 |

$H_O$: Series is Nonstationary
$H_A$: Series is Stationary
If Absolute Calculated Value > Absolute Table Value ⇒ Reject $H_O$
If Absolute Calculated Value < Absolute Table Value ⇒ Fail to reject $H_O$

**F-Tests for the ADF Tests for PMA and SW Region**

$H_O$: Restricted Model is Preferred
$H_A$: Unrestricted Model is Preferred
If $F_{Calculated} > F_{Table} \Rightarrow$ Reject $H_O$
If $F_{Calculated} < F_{Table} \Rightarrow$ Fail to reject $H_O$

$F_{Calculated} = [(SSR_R - SSR_U)/r]/[SSR_U/(T-k)] \sim F(r, T-k)$

$SSR_R$ = sum of squared residuals of restricted model
$SSR_U$ = sum of squared residuals of unrestricted model
r = number of restriction imposed in restricted model
T = number of observations
k = number of parameters estimated in the unrestricted model

**PMA**
Used $F_{Table}(1,68)$ for tests between Intercept & Trend and Trend = 2.75 at 10%
Used $F_{Table}(1,69)$ for tests between Trend and None = 2.75 at 10%

AGMN: $F_{Calculated} = 3.68 \Rightarrow$ Reject $H_O \Rightarrow$ Intercept & Trend
CRE: $F_{Calculated} = 5.32 \Rightarrow$ Reject $H_O \Rightarrow$ Intercept & Trend
LOCMR: $F_{Calculated} = 7.85 \Rightarrow$ Reject $H_O \Rightarrow$ Intercept & Trend
MSCEX: $F_{Calculated} = 4.67 \Rightarrow$ Reject $H_O \Rightarrow$ Intercept & Trend
SVRET: $F_{Calculated} = 8.11 \Rightarrow$ Reject $H_O \Rightarrow$ Intercept & Trend

SVEXP: $F_{Calculated} = 0.41 \Rightarrow$ Fail to Reject $H_O \Rightarrow$ Trend (Now check if None is preferred)
SVEXP: $F_{Calculated} = 0.82 \Rightarrow$ Fail to Reject $H_O \Rightarrow$ None

**SW Region**
Used $F_{Table}(1,74)$ for tests between Intercept & Trend and Trend = 2.75 at 10%
Used $F_{Table}(1,75)$ for tests between Trend and None = 2.75 at 10%

BLUE: $F_{Calculated} = 5.95 \Rightarrow$ Reject $H_O \Rightarrow$ Intercept & Trend
WHITE: $F_{Calculated} = 4.75 \Rightarrow$ Reject $H_O \Rightarrow$ Intercept & Trend
MISC: $F_{Calculated} = 4.12 \Rightarrow$ Reject $H_O \Rightarrow$ Intercept & Trend
MAN: $F_{Calculated} = 7.88 \Rightarrow$ Reject $H_O \Rightarrow$ Intercept & Trend
CREAL: $F_{Calculated} = 7.38 \Rightarrow$ Reject $H_O \Rightarrow$ Intercept & Trend
WR: $F_{Calculated} = 6.93 \Rightarrow$ Reject $H_O \Rightarrow$ Intercept & Trend
EXPORT: $F_{Calculated} = 1.36 \Rightarrow$ Fail to Reject $H_O \Rightarrow$ Trend (Now check to see if None is preferred)
$F_{Calculated} = 4.26 \Rightarrow$ Reject $H_O \Rightarrow$ Trend