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An Economic Indicator for the State of the Economy in the Southeastern U.S.

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Abstract. A state space model is constructed so that a state variable representing the unobservable state of the economy is estimated from information on new orders, production, employment, supplier delivery time, and finished inventory obtained from the purchasing managers' survey for Georgia. This state variable captures the co-movements of the time series used in its construction and serves as an economic indicator for Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee. Even though this economic indicator is estimated from information from the purchasing managers' survey on manufacturing activity for just Georgia, it produces reasonable forecasts for the real growth rates of the gross domestic products of Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee for 1991 through 2008.

1. Introduction

Stock and Watson (1991 and 1993) have shown how to construct a state space model which can be used to estimate a state variable that captures the co-movements of a set of economic time series. When appropriate time series variables are employed, the estimated state variable for the state space model can be thought of as a measure of the unobservable state of the economy. This study uses information from the purchasing managers' survey of manufacturing activity for the state of Georgia to produce an economic indicator which represents the unobservable state of the economy for the southeastern U.S. The state variable produced by the state space model for this study is shown to be an economic indicator for Georgia and all of the states that share a border with Georgia: Alabama, Florida, North Carolina, South Carolina, and Tennessee. Collectively, these states make up the southeastern U.S. The estimated state variable is used to produce forecasts for real growth rates for 1991 through 2012 for these states. Even though the information used to estimate the economic indicator is from the purchasing managers' survey of manufacturing activity for just the state of Georgia, much of the variation in the growth rates for the real gross domestic products for Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee is explained by the estimated state variable from the state space model used in this study. This suggests that regional purchasing managers' surveys of manufacturing activity for other regions in the U.S. are obtaining information on the state of the economy in a much broader geographic area.

The manufacturing sector's sensitivity to economic shocks and changes in economic conditions provides a valuable link between manufacturing activity and overall economic activity. The manufacturing sector is an important barometer of overall economic activity because it has a range of upstream and downstream operations and services that support the production and operation of the products produced. Economists recognize it is not only manufacturing's direct and indirect contributions to gross domestic product that make the manufacturing sector important, but also how quickly and the degree to which the manufacturing sector responds to economic shocks and changes in economic conditions. An estimated 66 percent of all variation in gross domestic product is related to changes in the manufacturing sector, and manufacturing changes by an estimated 2.1 times the change in gross domestic product (Harris, 1991). Other sectors in the U.S. economy do not experience such sizable swings. The sensitivity of manufacturing to economic shocks and changes in economic conditions gives added validity to the position that data from surveys of manufacturing activity will have the ability to give early warning signals for the economy and to forecast future changes in economic activity.

In the United States, the grouping of states into regions by the Bureau of Economic Analysis is the most frequently used grouping for economic analysis. This grouping is based primarily on cross-sectional similarity of socioeconomic characteristics. The Bureau of Economic Analysis has grouped Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee together in the Southeast Region of the United States since the 1950s. States have also been grouped into regions based on common patterns in their economies over business cycles. K-means cluster analysis was applied to the cyclical components of single dynamic factors for each state that capture the co-movements of major economic variables to group the 48 contiguous states into eight regions with similar business cycles (Crone, 2003). This approach to regional grouping, which produces a high level of cohesion among the states in a region, is designed to produce more significant results when examining the regional effects of economic stocks and monetary and fiscal policies because the states in a region are more homogeneous in terms of their economies (Crone, 2003). Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee are also grouped together in the Southeast Region when this approach to regional grouping is used.

When there is a high level of cohesion among the states in a region in terms of their economies, a single common dynamic factor for the region will capture the co-movements of major economic variables for all of the states in the region. Principal components analysis was used to determine the portions of the real growth rates for Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee that are captured by a single common dynamic factor, the first principle component. Principal components analysis for real growth rates for 1991 through 2008 for Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee shows that 81 percent of the variation in the data is explained by a single common dynamic factor. Regressions of the real growth rate for each state on the single common dynamic factor constructed using the eigenvector for the first principle component show that this factor explains 79 percent, 76 percent, 92 percent, 81 percent, 79 percent, and 74 percent of variation in the real growth rates for Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee, respectively.

Because of the economic and social interconnectedness in this region, Georgia and its surrounding states share flows of population, labor force, income, exports and imports, intermediate and finished goods, services, communications, capital investment, regional banking, and interstate road and railroad systems. Georgia's central location in the southeast positions it as a major hub for the southeastern U.S. The Purchasing Managers' Index for Georgia, which relies on purchasing managers whose responses are weighted by the Georgia manufacturing makeup, is a good indicator for the gross domestic products of Georgia and its border states because it measures changes in the manufacturing sector of Georgia which mirror economic activity in all of these states due to spillovers, common shocks, shared workforces, interstate supply chains, and upstream and downstream operations and services that cross state borders.

This paper is organized in the following manner. Section 2 describes national and regional surveys on manufacturing activity, the kind of information produced by such surveys on manufacturing activity, and the use of information on manufacturing activity as an indicator of economic activity. Section 3 analyzes the times series behavior and identifies autoregressive and moving average structures of the information produced by the purchasing managers' survey on manufacturing activity for the state of Georgia so that it can be incorporated in a state space model used to estimate the state variable for the unobservable state of the economy. Section 4 describes state space models and their advantages, presents the state space model used in this study to estimate the coefficients and forecast the state variable for the unobservable state of the economy, and provides and discusses estimates produced by the state space model when monthly data from the purchasing managers' survey on manufacturing activity for the state of Georgia for November 1990 through December 2009 are used. Section 5 presents a state space model used in this study to estimate the coefficients and forecast real growth rates for gross domestic product for 1991 through 2012 for Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee when monthly data from the purchasing managers' survey on manufacturing activity for the state of Georgia for November 1990 through December 2009 and annual data for 1991 through 2008 from the Bureau of Economic Analysis (BEA) on the real gross domestic products for these states are used. Section 6 discusses the forecasts of real growth rates for Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee for 1991 through 2012. The state space model forecasts improvements in real growth rates for all of these states for 2010 through 2012. Section 7 provides conclusions and suggestions for future research.

2. National and regional surveys of manufacturing activity

2.1. National survey of manufacturing activity

In 1982, the U.S. Department of Commerce and the National Association of Purchasing Management developed what was known as the Report on Business (Klein and Moore, 1989). The National Association of Purchasing Managers has changed its name to the Manufacturing Institute of Supply Management, and the Report on Business continues to be produced. This report, which is released on the first working day of each month, provides information on the state of the economy obtained from a survey focusing on manufacturing activity for the U.S. It has the advantage of providing the earliest release of manufacturing data that does not require later revision. The monthly release of data in the Report on Business leads the release of related government data such as industrial production (Federal Reserve Bank), factory orders (Census Bureau), and the producer price index (Bureau of Labor Statistics) by four to six weeks. The initial data released for industrial production, factory orders, and the producer price index are subject to later revision, which further extends the lead time for the information from the Report on Business.

One economic indicator, formerly known as the Purchasing Managers' Index and currently known as the Institute of Supply Management Business Survey Index, is the most broadly monitored data provided in the Report on Business. In this paper, this index will be referred to as the PMI. The PMI is a composite indicator of economic activity. It is widely used by economists, forecasters, and professional purchasing managers as an early indicator of cyclical change and direction for the manufacturing sector and the broader economy. It has been shown to be a leading indicator for the stock and bond markets (Niemira and Zukowski, 1998). Based on its significance, Niemira and Zukowski rank the PMI in the second best group of economic indicators along with the consumer price index, the producer price index, and retail sales. The PMI also has been used to enhance forecasting models. Incorporating the PMI into economic models adds significantly to their explanatory power (Harris, 1991).

The current PMI was developed and tested in 1979 (Torda, 1985). This index had indicators for five measures with equal weights assigned to each measure. The five measures were new orders, production, employment, supplier delivery time, and finished inventory. In 1982, the Department of Commerce and NAPM changed the PMI's weighting scheme so that new orders had a weight of 0.30, production had a weight of 0.25, employment had a weight of 0.20, supplier delivery time had a weight of 0.15, and finished inventory had a weight of 0.10 (Bretz, 1990). The optimal weighting scheme for the measures used for the PMI has been an ongoing subject of debate and research. Later research has shown that equal weights tend to improve the explanatory power of the PMI (Pelaez, 2003). As of January 2008, the weighting scheme for the PMI was returned to equal weights of 0.20 for each of the five underlying measures.

The Manufacturing Institute of Supply Management Report on Business is generated from a compilation of approximately 400 purchasing professionals' responses to a monthly survey. The participants are members of the Manufacturing Institute of Supply Management Business Survey Committee. The survey participant list is designed to approximate the characteristics of the manufacturing sector of the U.S. economy. Participants are chosen to be consistent with the contribution of each of twenty Standard Industrial Classification (SIC) manufacturing categories to total manufacturing for the economy. For example, if one of category contributes 10 percent of total manufacturing, then 40 of the 400 participants in the survey will represent that SIC category. In addition, each of twenty Standard Industrial Classification manufacturing categories is divided to reflect subcategories and different firm sizes. This design is thought to enhance the survey's ability to measure the movements of the manufacturing sector and the economy.

For variables of interest such as new orders, production, employment, supplier delivery time, and finished inventory, survey participants are asked to report the direction of change, if any, from the prior month (up, down, or the same). The advantages of gathering qualitative data over quantitative data are improving the participation level, shortening the time for filling out the survey, shortening the time for release of the results, and absence of any requirement for revision. Each participant's response, regardless of company size, is treated equally. The sum of the number of responses marked "up" is added to 0.5 times the sum of the number of responses marked the "same" to produce an index for each variable of interest. If 240 out of 400 responses are "up" and 40 are the "same", the resulting index number equals 65 because the index is normalized so that its minimum value is 0 and its maximum value is 100. A separate index is calculated in the same manner for each of the five underlying measures of the PMI. A composite index, the PMI, is constructed by multiplying the index for each measure by its assigned weight and summing all five weighted measures. The indices produced by this data collection and calculation process are referred to as diffusion indices. The composite index and the indices for its components measure the current month-to-month changes for manufacturing firms.

The PMI is a composite indicator of economic strength or weakness. An index value of 50 indicates no change overall. An index value above 50 indicates growth. An index value below 50 indicates that the manufacturing sector is contracting. The PMI is a measure of the breadth of growth and not the depth. A higher value of the PMI indicates that the growth is more widespread, and vice versa. An advantage of this approach is that, since each participant's response is treated the same, unusual changes for a few large firms do not dominate the more widespread changes. Diffusion indices are designed to measure the directions of the changes, but not the sizes of the changes.

2.2. *Regional surveys of manufacturing activity*

The Bureau of Economic Analysis adopted census divisions in 1910 and divided states into nine regional groups. In 1950, these nine regions were further condensed into eight regions based on similarities of socioeconomic characteristics. The divergence of economic and manufacturing performance in different regions, states, and metropolitan areas has led to the creation of regional, state, and local manufacturing surveys. Many surveys are designed to match the geographic areas of the Federal Reserve System's district banks. The data from such surveys are utilized in Beige Book Reports on regional manufacturing sectors. The BEA's Southeast Region includes the state of Georgia. Information from the purchasing managers' survey of manufacturing activity for the state of Georgia is used by the Federal Reserve Bank of Atlanta in its reports on regional economic activity. Other surveys are conducted or sponsored by local associations and other institutions. Some local surveys of manufacturing activity, such as the Chicago survey, predate the Manufacturing Institute of Supply Management survey.

The purchasing managers' survey of manufacturing activity for the state of Georgia was created in 1990 by the National Association of Purchasing Management of Georgia (now known as the Atlanta Institute of Supply Management) and the Econometric Center at Kennesaw State University. The survey includes approximately 75 participants (professional purchasing managers) located in the state of Georgia. The Georgia survey is designed to collect monthly data on the same five measures of manufacturing activity (new orders, production, employment, supplier delivery time, and finished inventory) used to calculate the national PMI index as well as some additional relevant manufacturing data. The information obtained from the survey is used to produce diffusion indices for new orders, production, employment, supplier delivery time, and finished inventory and a composite diffusion index using the same weights as the national PMI. As with the national survey, each participant's data is treated equally regardless of the size of the company. The manufacturing industries participating in the survey are generally consistent with the mix of manufacturers in the state of Georgia. Information is obtained from survey participants during the second and third weeks of the month. Diffusion indices are calculated and analyzed, and a report is released on the first working day of the next month. The release date of the information from the Georgia survey coincides with the release date for the Manufacturing Institute of Supply Management Report on Business. The composite diffusion index for the purchasing managers' survey for Georgia is known as the Georgia Purchasing Managers' Index (GPMI). It has been produced from qualitative data collected monthly beginning in November 1990. The GMPI provides timely monthly information about economic activity while other monthly measures at the state level such as personal income and employment are delayed by three or more months and are subject to later revisions.

2.3. *The manufacturing sector as a barometer of economic activity*

At the national level, the manufacturing sector is an important barometer of economic activity even though its contribution as a percent of gross domestic product has steadily declined in the last 20 years. For 2004 through 2007, the manufacturing sector directly accounted for 12.2 percent, 11.9 percent, 11.7 percent, and 11.7 percent of gross domestic product (Lindberg and Monaldo, 2008). The manufacturing sector indirectly accounted for an even larger percentage of gross domestic product because of purchases from the service sector (Hoagland, 1993). For example, the automobile industry has a range of so-called upstream and downstream services supporting the production and operation of automobiles (McAlinden, Hill, and Swiecki, 2003). Similar utilization of service activities occurs for other manufactured products (Hoagland, 1993). However, it is not only manufacturing's contribution to gross domestic product that makes the manufacturing sector important, but also how quickly and the degree to which the manufacturing sector responds to changes in economic conditions. For example, the year 2001 included the beginning of an economic downturn in March and the beginning of economic expansion in November. During this time period, the manufacturing sector's contribution to real gross domestic product, in percentage terms, changed by more than the contribution of any other sector (Yuskavage and Strassner, 2003). Research has shown that an estimated 66 percent of all variation in gross domestic product is related to changes in the manufacturing sector and that manufacturing changes by an estimated 2.1 times the change in gross domestic product (Harris, 1991). No other sector in the U.S. economy experiences such sizable swings.

The manufacturing sector's sensitivity to economic conditions provides a valuable link between manufacturing activity and economic activity. The increased sensitivity of manufacturing to market condition changes gives added validity to the argument that data from surveys of manufacturing activity should have the ability to give early warning signals for the economy and to forecast future changes. One reason for manufacturing's greater sensitivity to market condition changes is the higher capital intensity of manufacturing, which has increased since the 1990s. A second reason is the higher and growing level of global competition for manufacturing as compared to the service sector. A combination of higher relative labor costs, new technology and increased foreign competition has led many domestic manufacturers to replace labor with capital. In addition, domestic manufacturers that export their products tend to be more capital intensive than non-exporting manufacturers. These manufacturers have grown as a percentage of total domestic manufacturers. Over this same period, productivity per worker has increased for exporting manufacturers (Friedman, 1995).

Manufacturers face volatile sales and revenue, but when sales begin to move downward and inventories move up, manufacturers' first response is to lower production and inventory by reducing the average hours worked per worker. If this downward movement continues accompanied by increasing uncertainty about the market and the broader economy's direction, then manufacturers will begin to cut back their current production and expansion. At this point in time, average hours worked may be further reduced and hiring of new workers reduced or suspended. Information from qualitative surveys will begin to show a decrease in the employment measure along with decreases in new orders and production. Finished inventory might move downward, but its pattern would be less pronounced than new orders, production and employment. At that same time, overall employment in the general economy could still be growing because other sectors of the economy, such as the service sector, are less capital intensive and less sensitive to conditions that accompany the latter stages of an expanding economy. However, the rate of overall job growth would begin to move downward. The greater sensitivity in the manufacturing sector gives it the ability to provide an early signal of a change in the direction for the economy. The manufacturing sector's reduced percentage of overall output and labor contribution in the economy in the last 40 years does not diminish this effect (Friedman, 1995). There are certain segments of manufacturing, auto, building supplies, and furniture which tend to be the most sensitive to changing conditions in the latter stages in an expanding economy and in the early stages of a contracting.

2.4. *Prior research using information on manufacturing activity*

Prior research using diffusion indices on manufacturing at the national level has resulted in substantial empirical evidence supporting the use of the national PMI and its underlying measures as indicators of national economic activity. Harris (1991), Klein and Moore (1998) and Niemira (1991) have shown that the PMI and its underlying measures are correlated with GDP and other measures for the manufacturing sector and that the PMI is a leading indicator with respect to the business cycle turning points for GDP. Harris (1991) has shown that including the PMI as an explanatory variable improves regression estimates of GDP growth. Significantly less research has been published using diffusion indices on manufacturing at the regional level. Harris, Owens, and Sarte (2004) and Keeton and Verba (2004) have shown that regional and national PMI measures are related, but regional PMI measures provide additional information not provided by the national PMI. The Federal Reserve Bank of Kansas City has shown its Manufacturing Survey Data is related to other Tenth District data such as personal income and employment growth (Keeton and Verba, 2004).

3. Time series behavior of the measures of the purchasing managers' survey

3.1. *Descriptive statistics*

Descriptive statistics for monthly data running from November 1990 through December 2009 for the diffusion indices for new orders, production, employment, supplier delivery time, and finished inventory of the purchasing managers' survey for Georgia are presented in Table 1. The means range from a low of 49.37 for employment to a high of 56.34 for new orders. All five of the means are close to 50. The standard deviations range from a low of 6.81 for supplier delivery time to a high of 10.81 for new orders. All of the standard deviations indicate substantial variability. The minimum values and maximum values indicate that none of the five measures approaches its technical minimum of zero or technical maximum of 100. This suggested that the five diffusion indices of the purchasing managers' survey for Georgia do not need to be treated as truncated variables (Brooks, 2008).

Table 1. Descriptive statistics.

Series	Obs	Mean	Std Dev	Min	Max
New orders	230	56.337	10.817	20.455	87.500
Production	230	55.448	10.780	18.182	88.200
Employment	230	49.373	7.781	20.455	69.000
Supplier delivery time	230	53.502	6.811	40.600	77.800
Finished inventory	230	49.772	8.930	25.000	75.000
Indicator (through 2009)	230	0.027	1.630	-6.089	4.808
Indicator (through 2012)	266	0.018	1.518	-6.089	4.808
Real growth rate for Alabama	18	2.512	1.322	0.128	5.040
Real growth rate for Florida	18	3.362	2.062	-1.625	7.171
Real growth rate for Georgia	18	3.418	2.348	-0.562	6.605
Real growth rate for North Carolina	18	3.414	2.240	-0.172	6.730
Real growth rate for South Carolina	18	2.387	1.452	0.195	5.076
Real growth rate for Tennessee	18	3.134	1.764	0.511	7.047

Monthly data for November 1990 through December 2009 for observed data.

Monthly data for November 1990 through December 2012 for economic indicator.

3.2. *Examination of stationarity*

We begin our statistical analysis of the time series behavior of the diffusion indices for the five measures of the purchasing managers' survey, new orders ($y_{1,t}$), production ($y_{2,t}$), employment ($y_{3,t}$), supplier delivery time ($y_{4,t}$), and finished inventory ($y_{5,t}$), by checking for the presence of unit roots using Augmented Dickey-Fuller tests (Dickey and Fuller, 1979 and 1981). The testing procedure is applied to the following time series models for the five diffusion indices for the measures from the purchasing managers' survey for Georgia:

$$
\begin{aligned}
\Delta y_{1,t} &= \alpha_1 + \gamma_1 y_{1,t-1} + \delta_{1,1}\Delta y_{1,t-1} + \varepsilon_{1,t} \\
\Delta y_{2,t} &= \alpha_2 + \gamma_2 y_{2,t-1} + \delta_{2,1}\Delta y_{2,t} + \varepsilon_{2,t} \\
\Delta y_{3,t} &= \alpha_3 + \gamma_3 y_{3,t-1} + \delta_{3,1}\Delta y_{3,t} + \varepsilon_{3,t} \\
\Delta y_{4,t} &= \alpha_4 + \gamma_4 y_{4,t-1} + \delta_{4,1}\Delta y_{4,t} + \varepsilon_{4,t} \\
\Delta y_{5,t} &= \alpha_5 + \gamma_5 y_{5,t-1} + \varepsilon_{5,t}
\end{aligned}
\tag{1}
$$

where Δ is the first difference operator, $y_{j,t}$ is the diffusion index for measure j at time t, α_j is a constant for the diffusion index for measure j, γ_j is the coefficient used to estimate the test statistic for a unit root for the diffusion index for measure j, $\delta_{j,1}$ is the coefficient for the lagged value of the change in the diffusion index for measure j, and $\varepsilon_{j,t}$ is the error term for the change in the diffusion index for measure j at time t. The Bayesian Information Criterion (BIC), which gives a parsimonious lag structure, was used to determine the appropriate number of lagged differences to include in these models. The models for the Augmented Dickey-Fuller tests for new orders, production, employment, and supplier delivery time have one lagged difference included, and the model for finished inventory has zero lagged differences included. The Augmented Dickey-Fuller procedure tests the null hypothesis that a time series variable, $y_{j,t}$, has a unit root by comparing the estimated value of γ_j in each equation shown in (1) with zero. If the estimated value of γ_j is significantly less than zero, the null hypothesis of a unit root is rejected. The t-statistics for the estimated values of γ_j for the five measures of the purchasing managers' survey for Georgia, new orders, production, employment, supplier delivery time, and finished inventory are -6.07, -5.73, -5.35, -6.16, and -9.90, respectively. The critical values for the t-statistics for the estimated values of γ_j are -2.57 at the 0.10 level of significance, -2.88 at the 0.05 level of significance, and -3.46 at the 0.01 level of significance (Enders, 2004). These results for the Augmented Dickey-Fuller test indicate the null hypothesis of unit root can be rejected at a high level of significance for all five measures of the purchasing managers' survey for Georgia. Since all five measures of the purchasing managers' survey are not integrated, they are not co-integrated (Engle and Granger, 1987).

3.3. *Autoregressive moving average models for the measures of economic activity*

Autocorrelations and partial autocorrelations for the diffusion indices for new orders, production, employment, supplier delivery time, and finished inventory indicate the presence of regularities in the time series data that can be represented by the following autoregressive moving average models (Box and Jenkins, 1976; Enders, 2004)

$$
\begin{aligned}
y_{1,t} &= \alpha_1 + \phi_{1,1} y_{1,t-1} + \phi_{1,12} y_{1,t-12} + \\
&\qquad \phi_{1,13} y_{1,t-13} + \varepsilon_{1,t} + \theta_{1,1}\varepsilon_{1,t-1} \\
y_{2,t} &= \alpha_2 + \phi_{2,1} y_{2,t-1} + \phi_{2,12} y_{2,t-12} + \\
&\qquad \phi_{2,13} y_{2,t-13} + \varepsilon_{2,t} + \theta_{2,1}\varepsilon_{2,t-1} \\
y_{3,t} &= \alpha_3 + \phi_{3,1} y_{3,t-1} + \varepsilon_{3,t} + \theta_{3,1}\varepsilon_{3,t-1} \\
y_{4,t} &= \alpha_4 + \phi_{4,1} y_{4,t-1} + \varepsilon_{4,t} + \theta_{4,1}\varepsilon_{4,t-1} \\
y_{5,t} &= \alpha_5 + \phi_{5,1} y_{5,t-1} + \phi_{5,12} y_{5,t-12} + \varepsilon_{5,t}
\end{aligned}
\tag{2}
$$

where $y_{j,t}$ is the diffusion index for measure j at time t, α_j is a constant for the diffusion index for measure j, $\phi_{j,1}$ is the autoregressive coefficient for the diffusion index for measure j at time $t-1$, $\phi_{j,12}$ is the autoregressive coefficient for the diffusion index for measure j at time $t-12$, $\phi_{j,13}$ is the autoregressive coefficient for the diffusion index for measure j at time $t-13$, $\varepsilon_{j,t}$ is the error term for the diffusion index for measure j at time t., and $\theta_{j,1}$ is the moving average coefficient for the error term at time $t-1$.

The estimates for these autoregressive moving average models are shown in Table 2. All of the coefficients in all of the models are significantly different from zero at the 0.01 level of significance except $\theta_{4,1}$, which is significant at the 0.025 level. The adjusted R-squares range from a high of 0.397 for employment to a low of 0.226 for finished inventory. All of the models have autoregressive terms with a lag of one which capture persistence. The models for new orders, production, and finished inventory have autoregressive terms with lags of 12 and 13 that capture seasonality. The models for new orders, production, employment, and supplier delivery time have moving average terms with a lag of one that capture error correction. The Durbin-Watson statistics range from a high of 2.019 to a low of 1.944 and are consistent with white noise. The Q statistics for lags of 36 months range from a low of 23.323 with a p-value of 0.868 to a high of 40.350 with a p-value level of 0.210. After these autoregressive moving average structures are removed, the error terms for all five of the diffusion indices are white noise.

Table 2. Estimates for time series models for survey information.

Dependent Variable: New Orders

Box-Jenkins - Estimation by LS Gauss-Newton
Monthly Data From 1991:12 To 2009:12
Usable Observations = 217 Degrees of Freedom = 212
Centered R**2 = 0.361822 R Bar **2 = 0.349780
Uncentered R**2 = 0.97704 T x R**2 = 212.017
Mean of Dependent Variable = 56.53111
Std Error of Dependent Variable = 10.94656
Standard Error of Estimate = 8.82689
Sum of Squared Residuals = 16517.76692
Durbin-Watson Statistic = 2.01751
Q(36-4) = 23.32306
Significance Level of Q = 0.86786

Num	Variable	Coefficient	Std Error	t-Statistic	P-value
1	α_1	56.65595	2.05090	27.62490	0.00000
2	$\phi_{1,1}$	0.79534	0.07258	10.95858	0.00000
3	$\phi_{1,12}$	0.29110	0.06549	4.44508	0.00001
4	$\phi_{1,13}$	-0.26153	0.07030	-3.72018	0.00025
5	$\theta_{1,1}$	-0.40404	0.10927	-3.69758	0.00028

Dependent Variable: Production

Box-Jenkins - Estimation by LS Gauss-Newton
Monthly Data From 1991:12 To 2009:12
Usable Observations = 217 Degrees of Freedom = 212
Centered R**2 = 0.40648 R Bar **2 = 0.39528
Uncentered R**2 = 0.97782 T x R**2 = 212.186
Mean of Dependent Variable = 55.52955
Std Error of Dependent Variable = 10.96735
Standard Error of Estimate = 8.52864
Sum of Squared Residuals = 15420.41017
Durbin-Watson Statistic = 2.0022
Q(36-4) = 33.39100
Significance Level of Q = 0.39952

Num	Variable	Coefficient	Std Error	t-Statistic	P-value
1	α_2	55.35028	2.42766	22.79984	0.00000
2	$\phi_{2,1}$	0.83532	0.06062	13.78010	0.00000
3	$\phi_{2,12}$	0.24320	0.06729	3.61406	0.00038
4	$\phi_{2,13}$	-0.21555	0.07199	-2.99427	0.00308
5	$\theta_{2,1}$	-0.43056	0.09872	-4.36132	0.00002

Table 2 (continued). Estimates for time series models for survey information.

Dependent Variable: Employment

Box-Jenkins - Estimation by LS Gauss-Newton
Monthly Data From 1990:12 To 2009:12
Usable Observations = 229 Degrees of Freedom = 226
Centered R**2 = 0.40233 R Bar **2 = 0.39704
Uncentered R**2 = 0.98564 T x R**2 = 225.711
Mean of Dependent Variable = 49.415810
Std Error of Dependent Variable = 7.77075
Standard Error of Estimate = 6.03404
Sum of Squared Residuals = 8228.57263
Durbin-Watson Statistic = 1.94385
Q(36-2) = 25.44167
Significance Level of Q = 0.85490

Num	Variable	Coefficient	Std Error	t-Statistic	P-value
1	α_3	49.63421	1.82106	27.25569	0.00000
2	$\phi_{3,1}$	0.90420	0.03954	22.86847	0.00000
3	$\theta_{3,1}$	-0.56484	0.07774	-7.26611	0.00000

Dependent Variable: Supplier Delivery Time

Box-Jenkins - Estimation by LS Gauss-Newton
Monthly Data From 1990:12 To 2009:12
Usable Observations = 229 Degrees of Freedom = 226
Centered R**2 = 0.30489 R Bar **2 = 0.29874
Uncentered R**2 = 0.98891 T x R**2 = 226.461
Mean of Dependent Variable = 53.50026
Std Error of Dependent Variable = 6.82588
Standard Error of Estimate = 5.71610
Sum of Squared Residuals = 7384.27129
Durbin-Watson Statistic = 2.01898
Q(36-2) = 40.34947
Significance Level of Q = 0.20999

Num	Variable	Coefficient	Std Error	t-Statistic	P-value
1	α_4	53.48831	0.99693	53.65314	0.00000
2	$\phi_{4,1}$	0.71816	0.08193	8.76544	0.00000
3	$\theta_{4,1}$	-0.25718	0.11375	-2.26088	0.02472

Table 2 (continued). Estimates for time series models for survey information.

Dependent Variable: Finished Inventory					
Box-Jenkins - Estimation by LS Gauss-Newton					
Monthly Data From 1991:11 To 2009:12					
Usable Observations = 218 Degrees of Freedom = 215					
Centered R**2 = 0.23355 R Bar **2 = 0.22642					
Uncentered R**2 = 0.97611 T x R**2 = 212.791					
Mean of Dependent Variable = 50.09080					
Std Error of Dependent Variable = 9.00601					
Standard Error of Estimate = 7.92108					
Sum of Squared Residuals = 13489.86338					
Durbin-Watson Statistic = 1.95394					
Q(36-2) = 37.77303					
Significance Level of Q = 0.30088					
Num	Variable	Coefficient	Std Error	t-Statistic	P-value
1	α_5	50.05831	1.41933	35.26898	0.00000
2	$\phi_{5,1}$	0.30838	0.06147	5.01636	0.00000
3	$\theta_{5,12}$	0.31362	0.06213	5.04788	0.00000

4. State space models for indicators of economic activity

4.1. *State space models for indicators of national economic activity*

Since the development of composite indexes of coincidental and leading indicators by the National Bureau of Economic Research (Mitchell and Burns, 1938), composite economic indicators have been used to encapsulate the state of the economy. Stock and Watson (1991 and 1993) have presented state space models for extracting a single economic indicator for the unobservable state of the economy from a group of observable time series variables. The choice of the specific observable variables used to construct the economic indicator of the unobservable state of the economy is of upmost importance (Stock and Watson, 1993). This kind of model requires identification and specification of the times series properties of the state variable which serves as the economic indicator for the unobservable state of the economy and indication of how the observable variables are related to the state variable. When all of the parameters of such a state space model are estimated freely, the scale of the process for the economic indicator is not identified and must be normalized by setting the variance of the stochastic shock to the economic indicator equal to some finite number. One is usually used.

State space models are dynamic linear models that have unobservable states, observable data, stochastic shocks, and mapping matrices:

$$X_t = A_t X_{t-1} + Z_t + F_t w_t \tag{3}$$

$$Y_t = \mu_t + c_t' X_t + v_t \tag{4}$$

X_t is a vector that represents the unobservable state variables at time *t*. Y_t is a vector that represents the observable data at time *t*. A_t is the transition matrix for the states at time *t*. Z_t is a vector that represents exogenous variables at time *t*. w_t is a vector that represents the stochastic shocks to the states at time *t*. F_t is a matrix that maps the shocks to the states at time *t*. μ_t is a vector that represents the portions of the observable data at time *t* that do not depend on the unobservable state variables. v_t is a vector that represents the stochastic measurement errors at time *t*. w_t and v_t are assumed to be normally distributed with means of zero, independent across time, and independent of each other at time *t*. The covariance matrix for w_t is SW_t and the covariance matrix for v_t is SV_t. SW_t and SV_t are called hyperparameters of the state space model. State space models can provide estimates of the unobservable states, decompose observable variables into unobservable measures, provide estimates of parameters and hyperparameters, and predict observable variables

(Commandeur and Koopman, 2007; Durbin and Koopman, 2001).

The state-space model has state equations (3) and measurement equations (4). The state equations show how the unobservable state variables evolve over time. The measurement equations show how the observable variables are related to the unobservable state variables. The model is cast in state-space form so that estimates can be produced by the Kalman filter. The Kalman filter is a way to obtain the maximum likelihood, minimum mean square error estimates for the state variables and unknown parameters given a set of starting values for the parameters. When $A_t = A$, $Z_t = Z$, $F_t = F$, and $SW_t = SW$ are time invariant, an ergodic, steady-state solution for pre-sample information on the means and variances for the states is used to start the Kalman filter. The Kalman filter produces forward forecasts of the states and observable variables while maintaining the time series sequencing of the data. The Kalman smoother produces estimates based on the entire sample, but does not maintain the time series sequencing of the data (Harvey, 1981).

One of the greatest advantages of the state space framework is that not every value of the observable data needs to be available. Missing values of data are handled in very simple fashion. The Kalman filter does a prediction and then a correction at each time period. To handle missing values, the filter does not do the correction. The range of the Kalman filter is extended beyond the end of the data to generate a dynamic multi-step ahead, out-of-sample forecast. A static one-step forecast is produced for the range of the data by the Kalman filter. This means that data with different frequencies such as annual and monthly can both be handled in the same model by assuming that the annual data is monthly data with eleven missing monthly values each year. The Kalman filter will provide a prediction for each of the eleven missing monthly values each year for the annual data and will produce a multi-period forecast beyond the end of the sample.

4.2. *A state space model for an indicator of economic activity for the southeastern U.S.*

Methods from time series analysis and state space models for time series analysis are used to identify and construct a state space variable which serves as an indicator of economic activity for the southeastern U.S. The model developed and employed in this study is based on the idea that co-movements in new orders, production, employment, supplier delivery time, and finished inventory from the purchasing managers' survey for Georgia have a common element that can be represented by a single unobservable variable that can be thought of as state of the regional economy. The problem is to estimate the state variable for the unobservable state of the economy so that it incorporates the common element in the fluctuations of the five measures of manufacturing activity. Specification of an appropriate time series model for the unobservable state of the economy is required to capture the co-movements in new orders, production, employment, supplier delivery time, and finished inventory.

A linear state-space time-series model is formulated assuming there is a single unobserved state variable for the state of the economy that is common to new orders, production, employment, supplier delivery time, and finished inventory. Monthly diffusion indices for November 1990 through December 2009 for new orders, production, employment, supplier delivery time, and finished inventory from the purchasing managers' survey for Georgia were examined for possible lead or lag relationships. Cross-correlations at all leads and lags were found to be insignificant at the 0.05 level of significance (Box and Jenkins, 1976). Contemporaneous cross-correlations were found to be significant at the 0.05 level of significance for all unique pairs. New orders, production, employment, supplier delivery time, and finished inventory move contemporaneously with an unobserved state variable. New orders, production, employment, supplier delivery time, and finished inventory were found to have autoregressive terms with lags of one, 12, and 13 indicating persistence and seasonality. When a time series has a first-order autoregressive structure and a multiplicative seasonal component, the expanded model has lags at one, 12, and 13. New orders, production, employment, supplier delivery time, and finished inventory were also found to have moving average terms indicating error correction. The state variable for the unobservable state of the economy is designed to incorporate the autoregressive time series behavior of new orders, production, employment, supplier delivery time, and finished inventory by modeling persistence and seasonality. State variables for the moving average terms are designed to eliminate all remaining time series structure from the residuals. The specifications for the unobservable state variables employed in this study are:

$$
\begin{aligned}
x_t &= \phi_1 x_{t-1} + \phi_{12} x_{t-12} + \phi_{13} x_{t-13} + w_t \\
v_{1,t} &= w_{1,t} + \theta_{1,9} w_{1,t-9} \\
v_{2,t} &= w_{2,t} + \theta_{2,10} w_{2,t-10} \\
v_{3,t} &= w_{3,t} + \theta_{3,1} w_{3,t-1} + \theta_{3,5} w_{3,t-5} + \\
&\qquad \theta_{3,7} w_{3,t-7} \\
v_{4,t} &= w_{4,t} + \theta_{4,1} w_{4,t-1} + \theta_{4,12} w_{4,t-12} \\
v_{5,t} &= w_{5,t} + \theta_{5,1} w_{5,t-1} + \theta_{5,5} w_{5,t-5} + \\
&\qquad \theta_{5,6} w_{5,t-6} + \theta_{5,12} w_{5,t-12}
\end{aligned} \tag{5}
$$

The state variable for the unobserved state of the economy is x_t. Statistically significant autocorrelations and partial autocorrelations are used to identify the lag structures in equation 5. The autoregressive coefficient for the state variable for the unobserved state of the economy with a lag of one is ϕ_1, the autoregressive coefficient for the state variable for the unobserved state of the economy with a lag of 12 is ϕ_{12}, the autoregressive coefficient for the state variable for the unobserved state of the economy with a lag of 13 is ϕ_{13}, and the stochastic shock for the state variable for the unobserved state of the economy is w_t. The variance of w_t is set equal to one so that the scale of the process is identified. The autoregressive coefficient for the state variable for the unobserved state of the economy with a lag of one models persistence and autoregressive coefficients for the state variable for the unobserved state of the economy with lags of 12 and 13 model seasonality. Moving average terms are not included in the equation for state variable for the unobserved state of the economy. State variables are created for the measurement errors so that moving average terms can be included in the models for the observable variables. The stochastic shock for the measurement error term for measure j at time t is $w_{j,t}$. $\theta_{j,k}$ is the moving average coefficient for the measurement error term for measure j at time $t\text{-}k$. All of the moving average terms are created with state variables, but are included in the measurement equations for new orders, production, employment, supplier delivery time, and finished inventory. The unknown variance of $w_{j,t}$ is the hyperparameter σ_j^2. The models for the measurement equations for the observed variables are:

$$
\begin{aligned}
dy_{j,t} &= y_{j,t} - \bar{y}_j \\
dy_{j,t} &= \alpha_j + \gamma_j x_t + v_{j,t}
\end{aligned} \tag{6}
$$

where $dy_{j,t}$ is the deviation of the diffusion index for measure j at time t from its mean, α_j is a constant for the deviation of the diffusion index for measure j. γ_j is the regression coefficient for the unobserved state of the economy at time t for the deviation of the diffusion index for measure j, and $v_{j,t}$ is the measurement error term for measure j at time t.

The state space model provides estimates of the unobservable states, decomposes observable variables into unobservable measures, provides estimates of parameters and hyperparameters, predicts the observable variables, and forecasts the state variable for the state of the economy. The state space model is estimated using monthly observations for the diffusion indices for new orders, production, employment, supplier delivery time, and finished inventory from November 1990 to December 2009 from the purchasing managers' survey for Georgia. The estimates for this state space model are shown in Table 3. All of the coefficients are significant at the 0.05 except the constants in the five measurement equations. Table 4 presents pseudo R-squares and pseudo adjusted R-squares for the state space model. About 80 percent of the variation in new orders, 90 percent of the variation in production, 62 percent of the variation in employment, 23 percent of the variation in supplier delivery time, and 30 percent of the variation in finished inventory are explained by the state space model. The state variable for the unobserved state of the economy incorporates much of the variation in new orders, production, and employment, but little of the variation in supplier delivery time and finished inventory.

Forecasted values for the state variable for the unobservable state of the economy are produced by the model for December 1990 through December 2012. These values are shown in Figure 1. The forecasted values for November 1990 through December 2009 are one-step forecasts, and the forecasted values for January 2010 through December 2012 are multiple-step forecasts. Descriptive statistics for the state variable for the unobservable state of the economy are provided in Table 1 for November 1990 through December 2009 (230 observations) and November 1990 through December 2012 (266 observations). The state variable for the unobservable state of the economy has a mean that is close to zero and a standard deviation of 1.63 for November 1990 through December 2009 and 1.53 for November 1990 through December 2012. Because the measurement variables in the state space model are deviations from their means, numerical values of the state variable for the unobservable state of the economy below zero indicate that economic activity is below average, numerical values of the state variable for the unobservable state of the economy above zero indicate that economic activity is above average, and numerical values of the state variable for the unobservable state of the economy near zero indicate that economic activity is average. For the period from January 2010 through December 2012, the state space model is forecasting that economic activity will be near average.

Table 3. Estimates for state space model for economic indicator.

Num	Coefficient	Estimate	Std Error	t-Statistic	P-value
1	ϕ_1	0.76225	0.04220	18.06477	0.00000
2	ϕ_{12}	0.45094	0.04537	9.93952	0.00000
3	ϕ_{13}	-0.39675	0.05628	-7.05012	0.00000
4	$\theta_{1,9}$	0.30423	0.08164	3.72668	0.00019
5	$\theta_{2,10}$	0.22919	0.06845	3.34836	0.00081
6	$\theta_{3,1}$	0.47781	0.05896	8.10405	0.00000
7	$\theta_{3,5}$	0.20074	0.06215	3.23012	0.00124
8	$\theta_{3,7}$	-0.28970	0.08958	-3.23377	0.00122
9	$\theta_{4,1}$	0.20171	0.07091	2.84444	0.00445
10	$\theta_{4,12}$	-0.14273	0.06011	-2.37432	0.01758
11	$\theta_{5,1}$	-0.12657	0.06291	-2.01191	0.04423
12	$\theta_{5,5}$	0.18522	0.06215	2.98035	0.00288
13	$\theta_{5,6}$	0.25523	0.06298	4.05275	0.00005
14	$\theta_{5,12}$	0.12078	0.05971	2.02290	0.04308
15	$\gamma_{1,1}$	5.62454	0.47318	11.88664	0.00000
16	$\gamma_{2,1}$	5.80301	0.42586	13.62662	0.00000
17	$\gamma_{3,1}$	3.17431	0.32914	9.64414	0.00000
18	$\gamma_{4,1}$	1.65281	0.31069	5.31981	0.00000
19	$\gamma_{5,1}$	2.46381	0.46815	5.26291	0.00000
20	α_1	-0.14682	0.51422	-0.28551	0.77525
21	α_2	-0.16017	0.45032	-0.35568	0.72208
22	α_3	-0.16114	0.49267	-0.32708	0.74361
23	α_4	-0.01883	0.60492	-0.03112	0.97517
24	α_5	-0.26675	0.85507	-0.31196	0.75507
25	σ_1^2	28.62098	3.87343	7.38905	0.00000
26	σ_2^2	19.72806	0.80773	24.42407	0.00000
27	σ_3^2	23.85278	1.09132	21.85675	0.00000
28	σ_4^2	28.52991	1.52933	18.65520	0.00000
29	σ_5^2	48.26689	2.25487	21.40563	0.00000

Monthly data for November 1990 through December 2009.

Table 4. Measures of variation explained by the state space model.

Variable	Obs	Degrees of Freedom	Psuedo R-Square	Psuedo Adjusted R-Square
New orders	230	228	0.80001	0.79914
Production	230	228	0.89682	0.89636
Employment	230	228	0.61873	0.61706
Supplier delivery time	230	228	0.23112	0.22775
Finished inventory	230	228	0.30581	0.30276
Real growth rate for Alabama	18	16	0.54343	0.51489
Real growth rate for Florida	18	16	0.42103	0.38484
Real growth rate for Georgia	18	15	0.77618	0.74634
Real growth rate for North Carolina	18	15	0.66940	0.62532
Real growth rate for South Carolina	18	16	0.47001	0.43689
Real growth rate for Tennessee	18	16	0.49036	0.45850

Monthly data from November 1990 through December 2009.

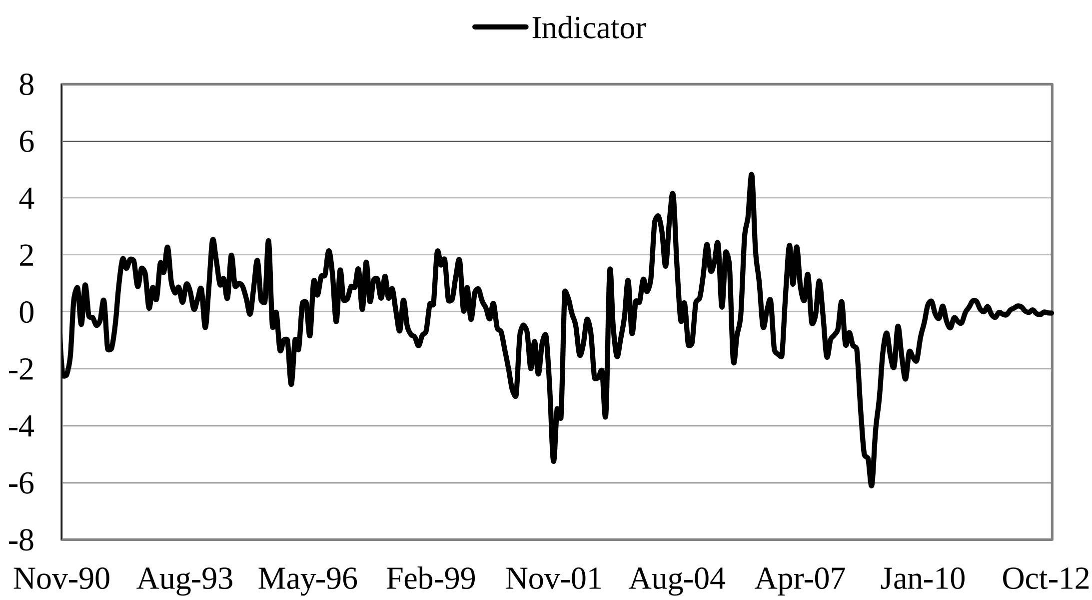

Figure 1. Forecasted values of the economic indicator.

The standard errors for the forecasts are used to create 95 percent confidence intervals for the forecasted values of the state variable for the unobservable state of the economy. The 95 percent confidence intervals for the forecasted values of the state variable for the unobservable state of the economy are shown in Figure 2. In the Figure 2, the upper limit is labeled UL and the lower limit is labeled LL. The confidence intervals are relatively tight for the one-step forecasts and are relatively wide for the multiple-step forecasts. For the period from January 2010 through December 2012, the state space model is forecasting that economic activity will be near average and the 95 percent confidence intervals indicate there is a good deal of uncertainty during this period.

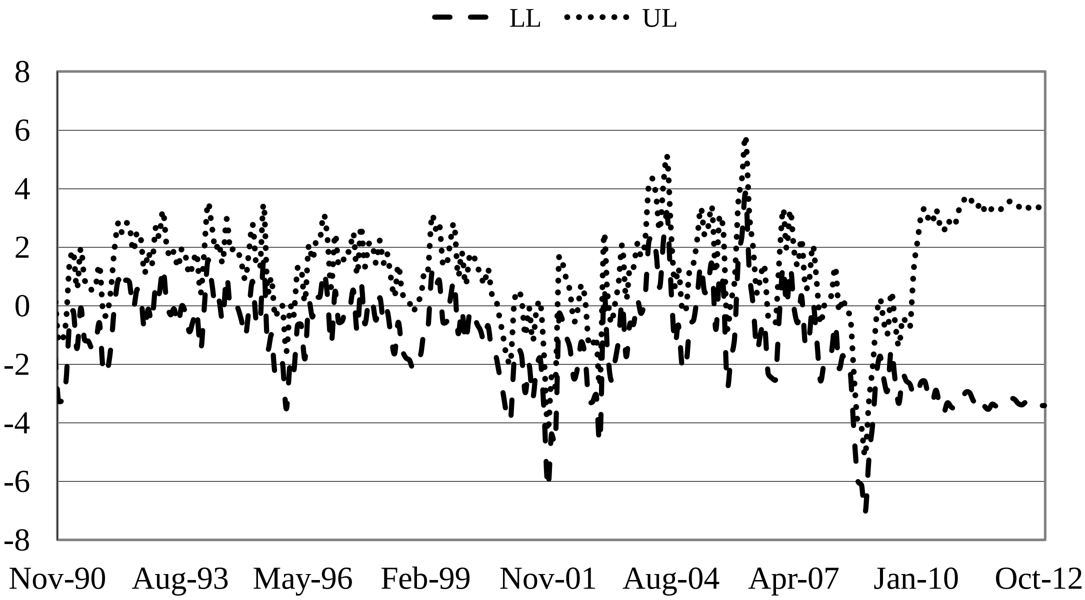

Figure 2. 95% confidence intervals for the forecasted values of the economic indicator.

5. A state space model for real GDP growth for the southeastern U.S.

The rate of growth in gross domestic product is a broad-based measure of economic activity. At the national level, data on the gross domestic product are available on a quarterly basis. However, at the state level, only annual data are available. The Bureau of Economic Analysis makes available the gross domestic products of states in both current dollars and constant dollars. These data are used to calculate continuously-compounded annual rates of growth for gross domestic products in constant dollars for all of the states in this study. The growth rate for gross domestic product in constant dollars is referred to as the real growth rate. The real growth rates are given by

$$g_{i,t} = \ln(RGDP_{i,t} / RGDP_{i,t-1}) \tag{7}$$

where $g_{i,t}$ is the real growth rate for southeastern state i for time t, $RGDP_{i,t}$ is the gross domestic product in constant dollars for southeastern state i for time t, and $RGDP_{i,t-1}$ is the gross domestic product in constant dollars for southeastern state i for time $t-1$. The real growth rates for the gross domestic products are observed measures of changes in the level of economic activity for the various states. The observed variables for this state space model are annual growth rates for the real gross domestic products for Alabama ($g_{1,t}$), Florida ($g_{2,t}$), Georgia ($g_{3,t}$), North Carolina ($g_{4,t}$), South Carolina ($g_{5,t}$), and Tennessee ($g_{6,t}$) from 1991 to 2008. The state variable for the unobservable state of the economy is an indicator of changes in the level of economic activity. An indicator of changes in the level of economic activity should be related to observed measures of changes in the level of economic activity.

The state variable for the unobserved state of the economy from the state space model is used in a second state space model to produce annual forecasts of the growth rates for the real gross domestic products of Georgia and its border states of Alabama, Florida, North Carolina, South Carolina, and Tennessee from 1991 through 2012. Descriptive statistics for the annual growth rates for the real gross domestic products for these states are presented in Table 1. The means range from a low of 2.4 percent for South Carolina to a high of 3.4 percent for both Georgia and North Carolina. The overall minimum is -1.6 percent and the overall maximum is 7.2 percent. Both the overall minimum and maximum are for Florida. The standard deviations range from a low of 1.3 percent for Alabama to a high of 2.3 percent for Georgia.

Using information from the purchasing managers' survey for Georgia to forecast real growth rates for the southeastern U.S. requires that data with different frequencies, monthly and annual, be combined in a state space model. The state variable provides twelve pieces of information about the economy for a year while the real growth rate provides one piece of information about the economy for a year. When the state space framework is used, not every value of the observable data needs to be available. Missing values of data are handled simply by making a prediction and then not making a correction. The Kalman filter produces a static one-step forecast for the range of the data. A dynamic multi-step, out of sample forecast is generated by extending the Kalman filter beyond the end of the data. Employing a state space model means that both monthly data and annual data can be handled in the same model by assuming that the annual data is monthly data with eleven missing monthly values each year. The Kalman filter will provide a prediction for each of the eleven missing monthly values each year for the annual data and will produce a multi-period forecast beyond the end of the sample.

The state variables for this state space model are the same state variables that were used in the previous state space model. The big difference is that now all of the coefficients in the state equations are set at their estimated values from the previous model. The estimated values for these coefficients are shown in Table 3. The model developed and employed in this study is designed to capture the common element in new orders, production, employment, supplier delivery time, and finished inventory that can be represented by a single unobservable variable that can be thought of as state of the regional economy. The estimates from the previous state space model incorporate the common element in the fluctuations of new orders, production, employment, supplier delivery time, and finished inventory. If the coefficients of the state equations were re-estimated using measurement equations for real growth rates, the estimates would not only capture the co-movements in new orders, production, employment, supplier delivery time, and finished inventory, but also the co-movements of the annual growth rates for Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee. Since data for real gross national product for states in the United States are not available on a timely basis, the estimated values for the coefficients in the state equations should not depend on the real growth rates. This is why all of the coefficients in the state equations are set at their estimated values from the previous model.

The state equations for this state space model are shown by the equations in (5). The autoregressive coefficient for the state variable for the unobserved state of the economy with a lag of one, ϕ_1, is set equal to 0.76225, the autoregressive coefficient for the state variable for the unobserved state of the economy with a lag of 12, ϕ_{12}, is set equal to 0.45094, the autoregressive coefficient for the state variable for the unobserved state of the economy with a lag of 13, ϕ_{13}, is set equal to -0.39675, and the variance of the stochastic shock for the state variable for the unobserved state of the economy, w_t, is set equal to one. The coefficients for the moving average terms in the state variables created for the measurement errors for new orders, production, employment, supplier delivery time, and finished inventory are set equal to their estimated values shown in Table 3. The variances of the stochastic shocks, σ_j^2, for the measurement error terms, $w_{j,t}$, for new orders, production, employment, supplier delivery time, and finished inventory are also set equal to their estimated values from the previous state space model.

For the previous state space model, the models for the measurement equations for the observed variables are shown by the equations in (6). α_j is set equal to its estimated value from the previous state space model. γ_j is the regression coefficient for the unobserved state of the economy at time t for the deviation of the diffusion index for measure j and is set equal to its estimated value from the previous state space model. $v_{j,t}$ is the measurement error term for measure j at time t and its time series structure determined by its state equation. Additional measurement equations for observable real growth rates for Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee are added to this model. The specifications for the relationships between the real growth rates and the state variable for the unobservable state of the economy for the measurement equations for real growth rates used in this study are

$$\begin{aligned}
dg_{i,t} &= g_{i,t} - \bar{g}_i \\
dg_{1,t} &= \beta_1 + \lambda_{1,4} x_{t-4} + \omega_{1,t} \\
dg_{2,t} &= \beta_2 + \lambda_{2,3} x_{t-3} + \omega_{2,t} \\
dg_{3,t} &= \beta_3 + \lambda_{3,0} x_t + \lambda_{3,12} x_{t-12} + \omega_{3,t} \\
dg_{4,t} &= \beta_4 + \lambda_{4,3} x_{t-3} + \lambda_{4,12} x_{t-12} + \omega_{4,t} \\
dg_{5,t} &= \beta_5 + \lambda_{5,0} x_t + \omega_{5,t} \\
dg_{6,t} &= \beta_6 + \lambda_{6,0} x_t + \omega_{6,t}
\end{aligned} \tag{8}$$

where $dg_{i,t}$ is the deviation of the real growth rate for southeastern state i at time t from its mean, β_i is a constant for the deviation of the real growth rate for southeastern state i. $\lambda_{i,k}$ is the regression coefficient for the unobserved state of the economy at time t-k

for the deviation of the real growth rate for southeastern state *i*. Statistically significant cross correlations between the economic indicator derived from the five components of the Georgia Purchasing Managers' survey and the real growth rates for the different states are used to identify the different lag structures for the state space models used to estimate the real growth rates for Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee. The measurement equation for the real growth rate for Alabama has a lag of 4. The measurement equation for the real growth rate for Florida has a lag of 3. The measurement equations for Georgia and North Carolina have two lags and the measurement equations for South Carolina and Tennessee have no lags. $\omega_{i,t}$ is the measurement error term for real growth rate for southeastern state *i* at time *t*. The unknown variance of $\omega_{i,t}$ is s_i^2, which is a hyperparameter for this state space model.

The state space model uses estimates of the unobservable states from the previous state space model, estimates of the measurement equations from the previous state space model, and decompositions of observable variables into unobservable measures from the previous state space model to produce estimates of parameters and hyperparameters of the new measurement equations for real growth rates, forecasts the state variable for the state of the economy, and forecasts the observable diffusion indices and real growth rates. This state space model is estimated using monthly observations for the diffusion indices for new orders, production, employment, supplier delivery time, and finished inventory from November 1990 to December 2009 and annual observations for real growth rates for Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee from 1991 to 2008. The estimates for this state space model are shown in Table 5. All of the coefficients for the new measurement equations are significant at the 0.05 level except for four of the constants. Table 4 presents pseudo R-squares and pseudo adjusted R-squares for this state space model. The actual real GDP numbers are positioned at the end of December of the appropriate year. Real growth rates based on actual real GDP numbers are used to calculate the pseudo R-squares. The 11 observations per year produced by the Kalman filter to fill in the missing observations are not used in the calculation of the pseudo R-squares. About 51 percent of the variation in the real growth rate for Alabama, 38 percent of the variation in the real growth rate for Florida, 75 percent of the variation in the real growth rate for Georgia, 63 percent of the variation in the real growth rate for North Carolina, 44 percent of the variation in the real growth rate for South Carolina, and 46 percent of the variation in real growth rate for Tennessee are explained by this state space model. The state variable for the unobserved state of the economy that incorporates the common variation in new orders, production, employment, supplier delivery time, and finished inventory from the purchasing managers' survey for Georgia explains much of the variation in real growth rates for Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee.

Although some of the adjusted pseudo R-squares appear to be low for time series models with lagged variables, they are for rates of change (real growth rates), and not for levels of real GDPs. In fact, the adjusted pseudo R-squares for the levels of real GDPs are quite high. The dependent variables in this study are continuously compounded annual growth rates for the real gross domestic products of Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee. Growth rates are used as the dependent variables instead of levels of real gross domestic products to avoid the spurious regression problem (Granger and Newbold, 1974; Enders, 2004). When time series variables are nonstationary with strong trends, a spurious regression employing one such variable as the dependent variable and another such variable as the independent variable will have a deceptively high adjusted R-square that is at least partially due to the nonstationary. For this study, the adjusted pseudo R-squares for the levels of the real gross domestic products of Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee are 0.99875, 0.99631, 0.99792, 0.99801, 0.99797, and 0.99727, respectively.

Forecasted values for the state variable for the unobservable state of the economy are produced by the model for December 1990 through December 2012 and are used to forecast values for the real growth rates for 1991 through 2012. The forecasted values for real growth rates for 1991 through 2009 are one-year-ahead forecasts and the forecasted values for real growth rates for 2010 through 2012 are multiple-year forecasts. Table 6 gives actual real growth rates, forecasted real growth rates, lower limits (LL) for 95 percent confidence intervals for the forecasted values, upper limits (UL) for 95 percent confidence intervals for the forecasted values, forecast errors, t-statistics for forecast errors, and significance levels for forecast errors for Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee for 1991 through 2008. Forecasted real growth rates, lower limits (LL) for 95 percent confidence intervals for the forecasted values, and upper limits (UL) for 95 percent confidence intervals for the forecasted values are also given for 2009 through 2012. Figures 3 through 8 show actual real growth rates, forecasted real growth rates, lower limits (LL) for 95 percent confidence intervals for the forecasted values, and upper limits (UL) for 95 percent confidence intervals for the forecasted values for Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee.

Table 5. Estimates for state space model for growth rates.

Num	Coefficient	Estimate	Std Error	t-statistic	P-value
1	$\lambda_{1,4}$	1.19831	0.24216	4.94844	0.00000
2	$\lambda_{2,3}$	0.94438	0.25814	3.65839	0.00025
3	$\lambda_{3,0}$	0.76503	0.13159	5.81387	0.00000
4	$\lambda_{3,12}$	0.66198	0.15898	4.16380	0.00003
5	$\lambda_{4,3}$	0.87900	0.20867	4.21230	0.00003
6	$\lambda_{4,12}$	0.64101	0.18185	3.52499	0.00042
7	$\lambda_{5,0}$	0.55260	0.11687	4.72832	0.00000
8	$\lambda_{6,0}$	0.64506	0.14980	4.30623	0.00002
9	β_1	0.08639	0.22106	0.39080	0.69594
10	β_2	-0.23946	0.37073	-0.64591	0.51834
11	β_3	1.15154	0.29366	3.92134	0.00009
12	β_4	0.23698	0.30590	0.77471	0.43851
13	β_5	0.48862	0.24056	2.03119	0.04224
14	β_6	0.57036	0.30921	1.84459	0.06510
15	s_1^2	0.46372	0.19041	2.43531	0.01535
16	s_2^2	2.08867	0.87716	2.38119	0.01791
17	s_3^2	1.00473	0.40360	2.48944	0.01279
18	s_4^2	1.33636	0.58165	2.29755	0.02159
19	s_5^2	0.94052	0.37073	2.53696	0.01118
20	s_6^2	1.50736	0.66318	2.27293	0.02303

Monthly data for November 1990 through December 2009.

Annual data for 1991 through 2008.

Table 6. Forecasts of real growth rates from the state space model.

Year	Region	Actual	Forecasted	LL	UL	Error	t-statistic	P-value
1991	AL	2.51371	2.39627	0.49446	4.29808	0.11744	0.12426	0.45133
1992	AL	4.23301	3.84937	1.98201	5.71673	0.38364	0.40887	0.34403
1993	AL	1.17739	3.11406	1.24725	4.98087	-1.93667	-2.06424	0.02780
1994	AL	3.56144	3.34374	1.47695	5.21053	0.21770	0.23204	0.40972
1995	AL	3.12708	1.95119	0.08440	3.81798	1.17589	1.25335	0.11404
1996	AL	2.97705	3.56624	1.69945	5.43303	-0.58919	-0.62800	0.26943
1997	AL	3.36135	2.84997	0.98318	4.71676	0.51138	0.54507	0.29661
1998	AL	2.87742	1.72039	-0.14640	3.58718	1.15703	1.23325	0.11765
1999	AL	3.31124	3.31052	1.44373	5.17731	0.00072	0.00077	0.49970
2000	AL	0.12751	1.77317	-0.09362	3.63996	-1.64566	-1.75407	0.04927
2001	AL	0.88890	1.18739	-0.67940	3.05418	-0.29849	-0.31815	0.37724
2002	AL	2.21239	2.14447	0.27768	4.01126	0.06792	0.07239	0.47159
2003	AL	2.81897	1.90209	0.03530	3.76888	0.91688	0.97728	0.17149
2004	AL	5.04012	4.17717	2.31038	6.04396	0.86295	0.91980	0.18567
2005	AL	3.38596	3.18707	1.32028	5.05386	0.19889	0.21199	0.41740
2006	AL	2.01064	2.61886	0.75207	4.48565	-0.60822	-0.64829	0.26300
2007	AL	0.89052	2.19429	0.32750	4.06108	-1.30377	-1.38966	0.09183
2008	AL	0.70850	0.44765	-1.41914	2.31444	0.26085	0.27803	0.39227
2009	AL		0.61514	-1.25165	2.48193			
2010	AL		2.20392	-1.97494	6.38278			
2011	AL		2.49206	-1.99577	6.97989			
2012	AL		2.52700	-1.99059	7.04459			
1991	FL	0.34978	2.70226	-0.51020	5.91472	-2.35248	-1.91219	0.03696
1992	FL	3.22578	4.65929	1.45671	7.86187	-1.43351	-1.16627	0.13030
1993	FL	3.36832	4.09176	0.88931	7.29421	-0.72344	-0.58859	0.28218
1994	FL	3.94423	4.94999	1.74756	8.15242	-1.00576	-0.81828	0.21261
1995	FL	3.35336	3.00501	-0.19742	6.20744	0.34835	0.28342	0.39025
1996	FL	4.79943	4.45626	1.25383	7.65869	0.34317	0.27920	0.39183
1997	FL	3.96201	4.62685	1.42442	7.82928	-0.66484	-0.54091	0.29801
1998	FL	4.91472	2.36573	-0.83670	5.56816	2.54899	2.07384	0.02730
1999	FL	3.97768	4.45627	1.25384	7.65870	-0.47859	-0.38938	0.35107
2000	FL	3.90254	2.37317	-0.82926	5.57560	1.52937	1.24429	0.11566
2001	FL	2.83851	2.07618	-1.12625	5.27861	0.76233	0.62023	0.27192
2002	FL	2.53661	2.27481	-0.92762	5.47724	0.26180	0.21300	0.41701
2003	FL	4.53428	3.70640	0.50397	6.90883	0.82788	0.67356	0.25510
2004	FL	5.26849	2.84467	-0.35776	6.04710	2.42382	1.97201	0.03308
2005	FL	7.17110	4.98380	1.78137	8.18623	2.18730	1.77958	0.04707
2006	FL	4.02449	3.30035	0.09792	6.50278	0.72414	0.58916	0.28199
2007	FL	-0.03260	3.26872	0.06629	6.47115	-3.30132	-2.68594	0.00812
2008	FL	-1.62543	-0.58063	-3.78306	2.62180	-1.04480	-0.85004	0.20392
2009	FL		1.10274	-2.09969	4.30517			
2010	FL		2.59469	-1.76636	6.95574			
2011	FL		2.94378	-1.59516	7.48272			
2012	FL		3.03209	-1.52542	7.58960			

Table 6 (continued). Forecasts of real growth rates from the state space model.

Year	Region	Actual	Forecasted	LL	UL	Error	t-statistic	P-value
1991	GA	1.09204	1.95369	-0.43471	4.34209	-0.86165	-0.81347	0.21434
1992	GA	5.35956	4.23583	1.85919	6.61247	1.12373	1.06742	0.15133
1993	GA	4.00169	5.57559	3.20068	7.95050	-1.57390	-1.49511	0.07781
1994	GA	6.60455	5.43074	3.05587	7.80561	1.17381	1.11505	0.14119
1995	GA	5.42753	4.56604	2.19119	6.94089	0.86149	0.81836	0.21298
1996	GA	6.36226	4.96851	2.59366	7.34336	1.39375	1.32398	0.10267
1997	GA	5.36907	6.23238	3.85753	8.60723	-0.86331	-0.82009	0.21250
1998	GA	5.90832	4.69239	2.31754	7.06724	1.21593	1.15506	0.13307
1999	GA	6.13417	4.85567	2.48082	7.23052	1.27850	1.21450	0.12167
2000	GA	2.80217	2.98249	0.60764	5.35734	-0.18032	-0.17129	0.43314
2001	GA	0.66642	0.19427	-2.18058	2.56912	0.47215	0.44851	0.33010
2002	GA	0.43378	0.68115	-1.69370	3.05600	-0.24737	-0.23499	0.40870
2003	GA	1.87150	3.76246	1.38761	6.13731	-1.89096	-1.79630	0.04631
2004	GA	3.62983	4.16814	1.79329	6.54299	-0.53831	-0.51136	0.30827
2005	GA	3.75406	3.18344	0.80859	5.55829	0.57062	0.54206	0.29787
2006	GA	1.18443	2.92117	0.54632	5.29602	-1.73674	-1.64980	0.05988
2007	GA	1.48070	2.28872	-0.08613	4.66357	-0.80802	-0.76757	0.22733
2008	GA	-0.56203	-1.44545	-3.82030	0.92940	0.88342	0.83920	0.20727
2009	GA		-0.48943	-2.86428	1.88542			
2010	GA		3.14538	-0.30454	6.59530			
2011	GA		4.23840	-0.37095	8.84775			
2012	GA		4.47194	-0.28405	9.22793			
1991	NC	-0.17239	1.69119	-1.03084	4.41322	-1.86358	-1.65371	0.05948
1992	NC	5.25713	4.12284	1.43105	6.81463	1.13429	1.01213	0.16376
1993	NC	2.74174	5.19950	2.50918	7.88982	-2.45776	-2.19319	0.02223
1994	NC	6.72964	5.51910	2.82882	8.20938	1.21054	1.08023	0.14855
1995	NC	4.80659	4.27113	1.58085	6.96141	0.53546	0.47782	0.31983
1996	NC	3.59146	4.29715	1.60687	6.98743	-0.70569	-0.62973	0.26917
1997	NC	6.70213	5.80642	3.11614	8.49670	0.89571	0.79929	0.21830
1998	NC	4.61608	3.67332	0.98304	6.36360	0.94276	0.84128	0.20670
1999	NC	6.17118	4.53491	1.84463	7.22519	1.63627	1.46013	0.08244
2000	NC	2.47729	3.43802	0.74774	6.12830	-0.96073	-0.85731	0.20238
2001	NC	1.65917	0.96027	-1.73001	3.65055	0.69890	0.62367	0.27111
2002	NC	1.46686	0.63454	-2.05574	3.32482	0.83232	0.74273	0.23456
2003	NC	1.41039	2.88413	0.19385	5.57441	-1.47374	-1.31510	0.10411
2004	NC	3.16313	3.81622	1.12594	6.50650	-0.65309	-0.58279	0.28435
2005	NC	4.67222	4.66145	1.97117	7.35173	0.01077	0.00961	0.49623
2006	NC	5.38288	3.36849	0.67821	6.05877	2.01439	1.79755	0.04620
2007	NC	0.67626	2.74373	0.05345	5.43401	-2.06747	-1.84492	0.04244
2008	NC	0.09932	-1.10914	-3.79942	1.58114	1.20846	1.07838	0.14895
2009	NC		-1.86152	-4.55180	0.82876			
2010	NC		2.06444	-1.80081	5.92969			
2011	NC		3.23938	-1.59756	8.07632			
2012	NC		3.50188	-1.43166	8.43542			

Table 6 (continued). Forecasts of real growth rates from the state space model.

Year	Region	Actual	Forecasted	LL	UL	Error	t-statistic	P-value
1991	SC	0.59588	2.15679	0.02801	4.28557	-1.56091	-1.55560	0.06968
1992	SC	2.33880	3.35011	1.22248	5.47774	-1.01131	-1.00795	0.16424
1993	SC	3.12549	3.12066	0.99305	5.24827	0.00483	0.00481	0.49811
1994	SC	4.96133	3.37351	1.24590	5.50112	1.58782	1.58255	0.06654
1995	SC	3.50675	2.32942	0.20181	4.45703	1.17733	1.17342	0.12890
1996	SC	2.69112	3.60834	1.48073	5.73595	-0.91722	-0.91418	0.18710
1997	SC	5.07602	3.51386	1.38625	5.64147	1.56216	1.55698	0.06952
1998	SC	3.60683	2.42277	0.29516	4.55038	1.18406	1.18013	0.12760
1999	SC	3.46413	3.34949	1.22188	5.47710	0.11464	0.11426	0.45523
2000	SC	1.44308	1.36835	-0.75926	3.49596	0.07473	0.07448	0.47078
2001	SC	1.36032	0.99646	-1.13115	3.12407	0.36386	0.36265	0.36081
2002	SC	1.44322	1.72903	-0.39858	3.85664	-0.28581	-0.28486	0.38970
2003	SC	3.32991	3.27060	1.14299	5.39821	0.05931	0.05911	0.47680
2004	SC	0.19542	2.27003	0.14242	4.39764	-2.07461	-2.06773	0.02762
2005	SC	2.40607	2.41348	0.28587	4.54109	-0.00741	-0.00739	0.49710
2006	SC	1.97014	2.01968	-0.10793	4.14729	-0.04954	-0.04938	0.48062
2007	SC	0.86587	2.00694	-0.12067	4.13455	-1.14107	-1.13728	0.13608
2008	SC	0.59121	-0.48891	-2.61652	1.63870	1.08012	1.07654	0.14883
2009	SC		1.93168	-0.19593	4.05929			
2010	SC		2.66446	-0.08486	5.41378			
2011	SC		2.81990	-0.02041	5.66021			
2012	SC		2.85408	0.00344	5.70472			
1991	TN	3.19814	2.86530	0.18392	5.54668	0.33284	0.29561	0.38566
1992	TN	7.04723	4.25829	1.57816	6.93842	2.78894	2.47718	0.01239
1993	TN	3.91930	3.99045	1.31035	6.67055	-0.07115	-0.06320	0.47520
1994	TN	5.74861	4.28560	1.60550	6.96570	1.46301	1.29948	0.10610
1995	TN	3.00900	3.06682	0.38672	5.74692	-0.05782	-0.05136	0.47984
1996	TN	2.85956	4.55973	1.87963	7.23983	-1.70017	-1.51013	0.07525
1997	TN	5.22233	4.44943	1.76933	7.12953	0.77290	0.68651	0.25111
1998	TN	3.10753	3.17578	0.49568	5.85588	-0.06825	-0.06062	0.47621
1999	TN	3.15454	4.25756	1.57746	6.93766	-1.10302	-0.97973	0.17090
2000	TN	0.73301	1.94494	-0.73516	4.62504	-1.21193	-1.07646	0.14884
2001	TN	0.79863	1.51083	-1.16927	4.19093	-0.71220	-0.63259	0.26797
2002	TN	3.84014	2.36597	-0.31413	5.04607	1.47417	1.30939	0.10445
2003	TN	2.88663	4.16547	1.48537	6.84557	-1.27884	-1.13589	0.13637
2004	TN	4.52432	2.99749	0.31739	5.67759	1.52683	1.35616	0.09694
2005	TN	1.85252	3.16494	0.48484	5.84504	-1.31242	-1.16572	0.13041
2006	TN	2.67383	2.70525	0.02515	5.38535	-0.03142	-0.02791	0.48904
2007	TN	1.33281	2.69037	0.01027	5.37047	-1.35756	-1.20581	0.12271
2008	TN	0.51125	-0.22308	-2.90318	2.45702	0.73433	0.65225	0.26175
2009	TN		2.60252	-0.07758	5.28262			
2010	TN		3.45791	0.09419	6.82163			
2011	TN		3.63936	0.17418	7.10454			
2012	TN		3.67926	0.20254	7.15598			

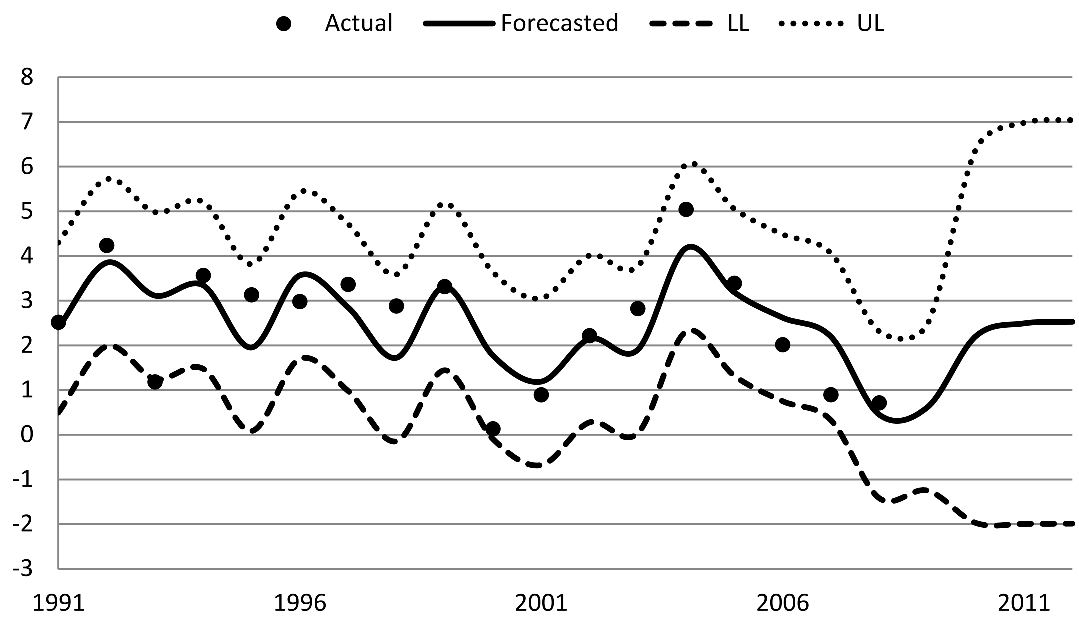

Figure 3. Actual and forecasted real growth rates for Alabama.

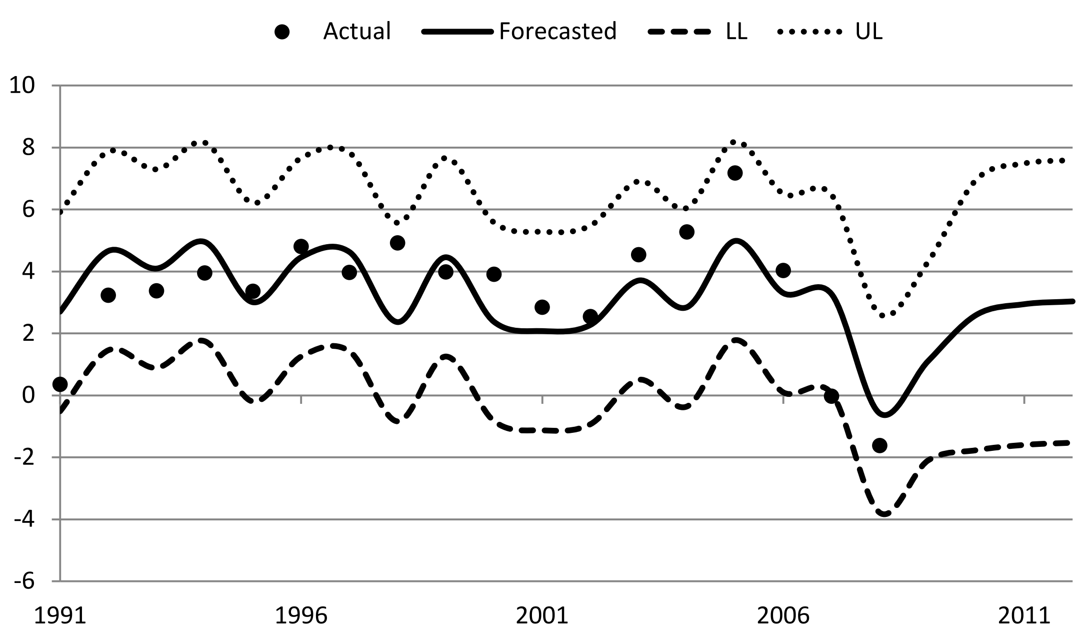

Figure 4. Actual and forecasted real growth rates for Florida.

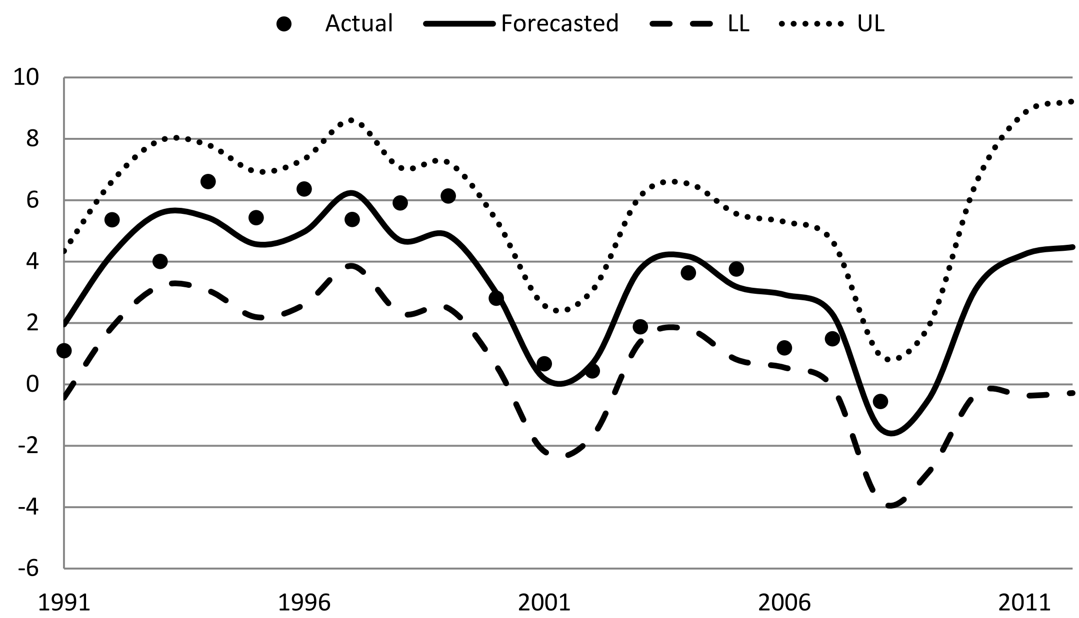

Figure 5. Actual and forecasted real growth rates for Georgia.

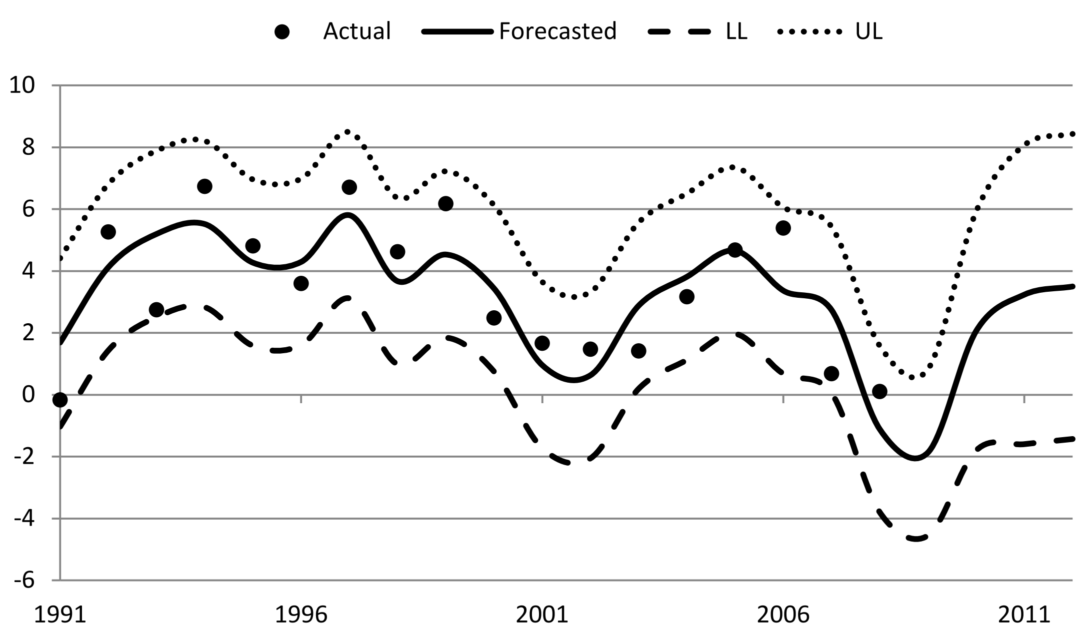

Figure 6. Actual and forecasted real growth rates for North Carolina.

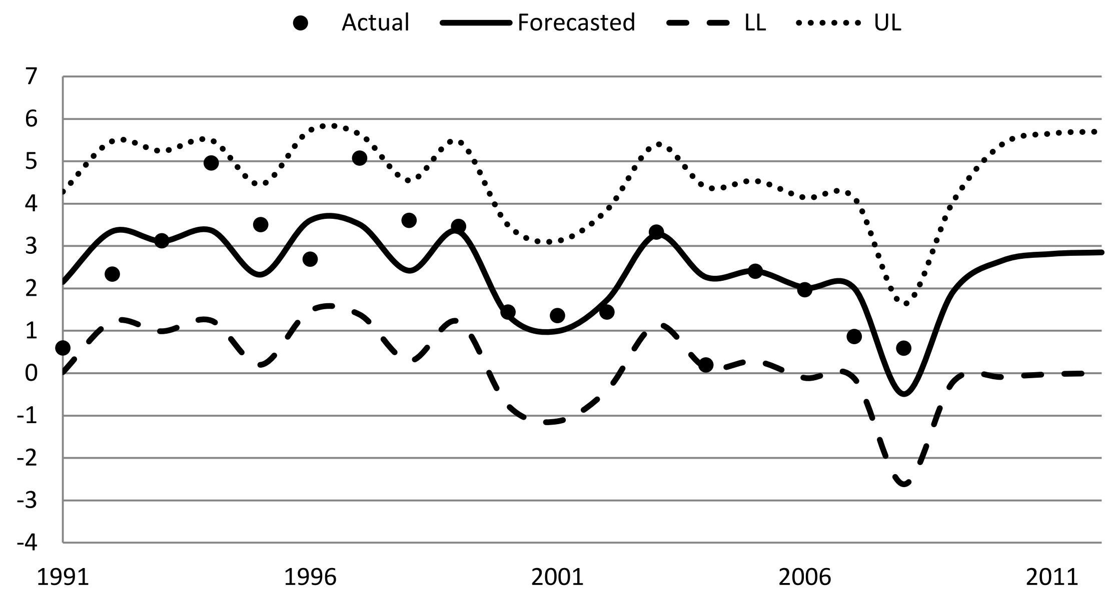

Figure 7. Actual and forecasted real growth rates for South Carolina.

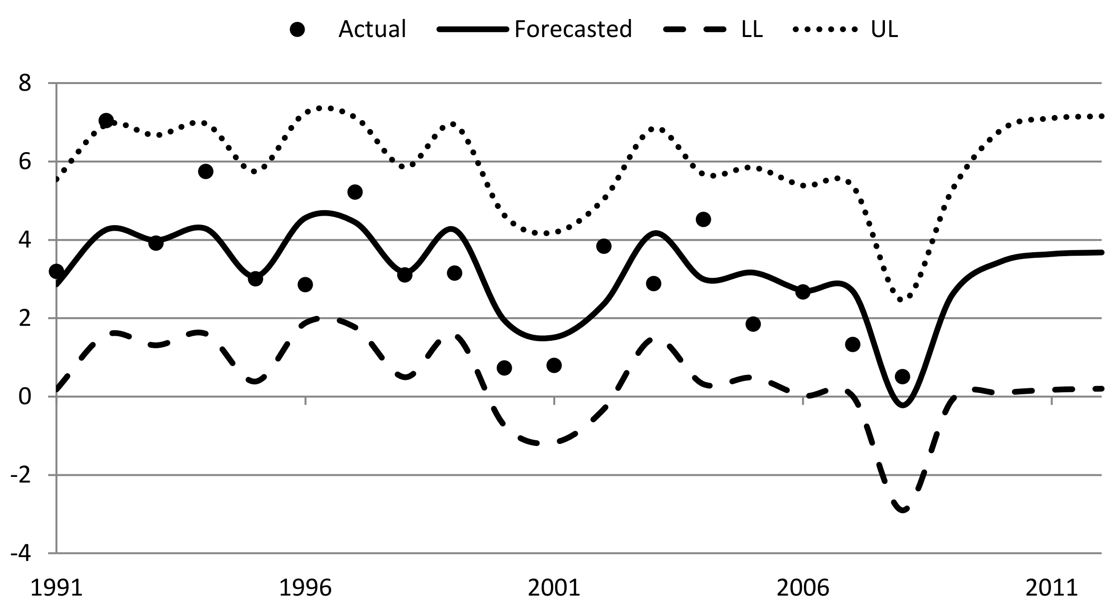

Figure 8. Actual and forecasted real growth rates for Tennessee.

6. Forecasts of real growth rates for the southeastern U.S.

6.1. Forecasts of real growth rates for Alabama

The information for Alabama shown in Table 6 and Figure 3 indicates a close relationship between the actual and forecasted real growth rates for 1991 through 2008. The only large forecast errors occurred in 1993 and 2000. The state space model correctly forecasted the directional changes for 14 of the 18 years when actual values for real growth rates were available. It also correctly identified the downward trend from 2004 through 2008. The state space model forecasts an improvement in the real growth rates for 2010, 2011, and 2012 with the real growth rate returning to its average level in 2012.

6.2. Forecasts of real growth rates for Florida

Table 6 and Figure 4 provide information for Florida indicating that the relationship between the actual and forecasted real growth rates is tight for 1993 through 2003. Large forecast errors occurred in 1991, 1998, 2004, 2005, and 2007. The state space model correctly forecasted the directional changes for 12 of the 18 years when actual values for real growth rates were available. It correctly identified the downward trend from 2004 through 2008. The state space model forecasts an improvement in the real growth rates for 2010, 2011, and 2012 with the real growth rate increasing in 2012 to about 3 percent which is below its average of 3.4 percent.

6.3. Forecasts of real growth rates for Georgia

The information for Georgia in Table 6 and Figure 5 indicates a very close relationship between the actual and forecasted real growth rates for 1991 through 2008. There are no large forecast errors. The state space model correctly forecasted the directional changes for 12 of the 18 years when actual values for real growth rates were available. It also correctly identified the downward trends from 1999 through 2002 and from 2005 through 2008. For 2010, 2011, and 2012, the state space model forecasts an improvement in the real growth rates with the real growth rate moving in 2012 to 4.5 percent, which is about one percent above its average level.

6.4. Forecasts of real growth rates for North Carolina

Figure 6 and Table 6 provide information for North Carolina indicating that the relationship between the actual and forecasted real growth rates is tight for 1994 through 2008. Large forecast errors occurred in 1991, 1993, 2006, and 2007. The directional changes for 14 of the 18 years when actual values for real growth rates were available were correctly forecasted by the state space model. The state space model did correctly identify the downward trends from 1999 through 2002 and from 2006 through 2008. The state space model forecasts an improvement in the real growth rates for 2010, 2011, and 2012 with the real growth rate increasing in 2012 to about 3.5 percent which is slightly above its average of 3.4 percent.

6.5. Forecasts of real growth rates for South Carolina

Table 6 and Figure 7 provide information for South Carolina indicating that the relationship between the actual and forecasted real growth rates is tighter after 1998 than it was before through 1998. The only large forecast error occurred in 2004. For 13 of 18 years when actual values for real growth rates were available, the directional changes were correctly forecasted by the state space model. The state space model correctly identified the downward trend from 2005 through 2008. The state space model forecasts an improvement in the real growth rates for 2010, 2011, and 2012 with the real growth rate increasing in 2012 to about 2.9 percent, which is above its average of 2.4 percent.

6.6. Forecasts of real growth rates for Tennessee

The information for Tennessee shown in Table 6 and Figure 8 indicates a close relationship between the actual and forecasted real growth rates for 1991 through 2008. There is only one large forecast error, occurring in 1992. The state space model correctly forecasted the directional changes for 10 of the 18 years when actual values for real growth rates were available. It also correctly identified the downward trend from 2006 through 2008. For 2010, 2011, and 2012, the state space model forecasts an improvement in the real growth rates with the real growth rate moving in 2012 to 3.7 percent, which is above its average level of 3.1 percent.

7. Summary and conclusions

Monthly information on new orders, production, employment, supplier delivery time, and finished inventory from the purchasing managers' survey on manufacturing activity for the state of Georgia is used in a state space model to estimate and forecast a state variable for the unobservable state of the economy. This state variable is an economic indicator for the southeastern states of Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee. Even though the economic indicator is estimated from information from the purchasing managers' survey on manufacturing activity for just the state of Georgia, it produces reasonable forecasts for the real growth rates for the gross domestic products of Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee for 1991 through 2008. The state of Georgia and Metro Atlanta act as a centralized regional hub for the states in the southeast region. These states have common transportation and distribution systems, regional banks, and manufacturing facilities with interstate supply chains. Foreign automobile plants have located in Chattanooga, Central Georgia, South Carolina, and Alabama. These industries have created other supply-chain related industries that operate in multiple states and attract workers across state boundaries.

Purchasing managers' surveys of manufacturing activity are currently conducted for Austin, Boston, Buffalo, Chicago, Cincinnati, Dallas/Fort Worth, Denver, Houston, Mid-American States, Milwaukee, New York City, Northeast Ohio, Oklahoma, Southeast Michigan, and Western Michigan. The results of this study suggest that these regional purchasing managers' surveys of manufacturing activity are obtaining information on the state of the economy in a much broader geographic area. State space models using information from these surveys could be formulated and used to estimate and forecast state variables which are economic indicators for the unobservable states of these economies. Economic indicators from such state space models could be used to forecast real growth rates for expanded areas in these regions.

This research has found that information from the monthly purchasing managers' survey on manufacturing activity for the state of Georgia can be used as an indicator of the real growth rates for the economies of Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee. Future research should focus on the relationships between information from the monthly purchasing managers' survey on manufacturing activity for the state of Georgia and turning points for the quarterly earnings series of the Bureau of Economic Analysis for the economies of Alabama, Florida, Georgia, North Carolina, South Carolina, and Tennessee to determine whether the purchasing managers' survey on manufacturing activity for the state of Georgia provides information that can serve as an indicator of turning points for earnings for these economies.

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