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Texas Manufacturing Outlook Survey: Survey Methodology and Performance

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Abstract

The Texas Manufacturing Outlook Survey (TMOS) is a monthly survey of area manufacturers conducted by the Federal Reserve Bank of Dallas. TMOS indexes provide timely information on manufacturing activity in Texas, which is useful for understanding broader changes in regional economic conditions. This paper describes the survey methodology and analyzes the explanatory and predictive power of TMOS indexes with regard to other measures of state economic activity. Regression analysis shows that several TMOS indexes successfully explain monthly changes in Texas employment and quarterly changes in gross state product. Forecasting exercises show that several TMOS indexes, particularly general business activity and growth rate of orders, are useful in predicting changes in Texas employment.

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JEL Numbers: L60, C83, C53

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Overview

Business surveys such as the Dallas Fed's Texas Manufacturing Outlook Survey (TMOS) are used to monitor economic activity and expectations about future growth. They typically also provide timelier information than other data sources. In the U.S., most of these surveys focus on the manufacturing sector since its growth is particularly useful for understanding changes in the general economy. This is because manufacturing is more cyclically sensitive and tends to lead overall economic growth.[1] One such business survey is the Institute for Supply Management's (ISM) Report on Business, which has reported its monthly national manufacturing PMI index since 1948.[2] Other monthly U.S. manufacturing surveys include regional surveys published by a number of the Federal Reserve Banks, including the Philadelphia Fed (started in 1968), the Richmond Fed (started in 1993), the New York Fed (started in 2001), the Kansas City Fed (started in 2001), and the Dallas Fed's TMOS (started in 2004).

These Fed surveys can provide an early look at economic conditions within the Banks' respective regions before official statistics become available. Since its inception in 2004, TMOS has become widely used by analysts and commonly cited by local and global business media outlets, including the *Dallas Morning News*, the *Austin American-Statesman*, *The Wall Street Journal*, *Fortune*, Reuters, and Bloomberg. TMOS provides real-time information on changes in activity in Texas' manufacturing sector, which as noted above has implications for broader economic activity in the region.

[1] See Stock, James H. & Watson, Mark W., 1999. "Business cycle fluctuations in us macroeconomic time series," in: J. B. Taylor & M. Woodford (ed.), Handbook of Macroeconomics, edition 1, vol. 1, chapter 1, pp. 3-64. See also Zarnowitz, Victor, 1992. "Composite Indexes of Leading, Coincident, and Lagging Indicators," in: Zarnowitz, Victor (ed.), Business Cycles: Theory, History, Indicators, and Forecasting, chapter 11, pp. 316-356.

[2] The ISM PMI index has proven a valuable tool in forecasting U.S. gross domestic product growth. See Koenig, Evan F. (2002), "Using the Purchasing Managers' Index to Assess the Economy's Strength and the Likely Direction of Monetary Policy," Federal Reserve Bank of Dallas Economic and Financial Policy Review, vol. 1, no. 6.

The most important gauge of TMOS' value is whether its indexes are correlated with economic activity in Texas. Berger (2010) shows that the TMOS production, employment, and new orders indexes help to explain monthly changes in Texas manufacturing employment, Texas manufacturing industrial production, and the Texas manufacturing business-cycle index. This paper extends this research to explore how well TMOS indexes correlate with changes in overall Texas employment and changes in Texas personal income. In addition, we do a forecast evaluation.

Methodology of the Texas Manufacturing Outlook Survey

TMOS is one of several Dallas Fed surveys that include TMOS's two sister surveys, the Texas Service Sector Outlook Survey and the Texas Retail Outlook Survey, as well as the Beige Book and the Agriculture Survey.[3] The surveys provide information that helps the Dallas Fed fulfill its role as part of the nation's central bank system, providing valuable insight into regional economic conditions and informing monetary policy decisions. The survey data fill a gap in regional economic data, which are scarce and not very timely, and are also subject to large and delayed revisions. State employment data from the Bureau of Labor Statistics is released with a three-week lag and is extensively revised in subsequent months. Annual gross state product data from the Bureau of Economic Analysis is released with a six-month lag and is also subject to revision.[4]

TMOS data are used to construct diffusion indexes, like the well-known PMI index from the ISM. Manufacturing executives report on how business conditions have changed for a number of

[3] These surveys can be found on the Dallas Fed website at http://www.dallasfed.org/research/analysis.cfm.
[4] The Bureau of Economic Analysis began releasing prototype measures of quarterly gross state product on August 20, 2014.

indicators, such as production, new orders, prices, and employment. Respondents are also asked to report on how they perceive that broader economic conditions have changed, such as general business activity. All questions ask whether the indicator has increased, decreased or remained unchanged over the prior month. Survey responses are used to calculate diffusion indexes by subtracting the percentage of respondents reporting a decrease from the percentage reporting an increase.

Survey design and implementation

The Dallas Fed began collecting TMOS data in June 2004. The original sampling frame was drawn from Reference USA, a business database that listed over 45,000 Texas manufacturing firms. Solicitations to participate went out to single-location companies or company headquarters in Texas; branches were excluded to avoid duplicate responses from affiliated operations. We focused on firms with more than 100 employees, although for some industries it was necessary to include smaller entities (Sigalla, et. al 2007).

Letters of invitation were sent to 2,500 randomly selected Texas manufacturing firms meeting the criteria in April 2004, and executives from 130 firms agreed to participate. There were roughly 65 to 80 survey responses each month during the first three years. The survey sample was expanded in January 2007 with a second round of invitation letters, and smaller-scale recruitment efforts have taken place on an ongoing basis since. As of August 2014, nearly 150 firms receive the survey, and 100 to 115 respond each month.[5]

[5] We have found that firms in some industries, such as wood, food, primary metals and paper manufacturing exhibit an above-average response rate overall, while other industries, such as high-tech and printing manufacturing exhibit a below-average response rate overall. The vast majority of firms on the TMOS panel have fewer than 500 employees, and we have found that larger firms (with an employment size of 500-1,000) have an above-average response rate overall, while much larger firms (>1,000 employees) have a below-average response rate overall. We have not yet done an analysis testing for response bias, but will leave this for future work.

TMOS is sent via email mid-month to a panel of roughly 150 executives at Texas manufacturing firms, and participants have seven business days to submit their survey response. Questions ask whether certain indicators of a firm's business activity have increased, decreased or remained unchanged when compared with the prior month.[6] Respondents are also asked about expectations of business activity six months ahead. Responses are collected and assembled in a diffusion index. The indexes are seasonally adjusted in order to discern underlying economic trends. Full results reports along with the number of firms responding are published on the Dallas Fed website on the last Monday of each month. The Dallas Fed began releasing TMOS results to the public in November 2005. Survey results were reported on a seasonally-adjusted basis starting in August 2009.

Seasonal adjustment

The Dallas Fed uses the X12 seasonal-adjustment procedure, developed by the U.S. Census Bureau, to statistically remove seasonal effects. TMOS respondents are explicitly asked to take seasonal variations into account when assessing firm performance each month. However, as of January 2014, the X12 results indicate that 27 of the 34 indexes contained statistically significant seasonality.[7] For these indexes, the increase, decrease and no change components are each adjusted. The indexes are then re-computed using the adjusted components. If the three adjusted component series (increase, decrease, and no change) do not sum to 100 percent, they are normalized to add up to 100. In January each year, the Dallas Fed revises historical data for TMOS by recalculating the seasonal adjustments to account for an additional year of data.

[6] See Appendix for sample survey form.
[7] A current list of the seasonal indexes is found at http://www.dallasfed.org/microsites/research/surveys/tmos/seasonal.cfm.

Representativeness of the TMOS sample

In order for the data received from TMOS to be generally representative of the Texas manufacturing sector, it is important that the industry composition of the survey panel be in line with the industry composition of Texas manufacturing. The Dallas Fed uses employment shares by manufacturing industry (using three-digit North American Industry Classification System (NAICS) codes) within the Texas manufacturing sector to set a target composition for the panel of TMOS participants. For example, if food manufacturing (NAICS 311) accounts for 10 percent of Texas manufacturing employment, ideally 10 percent of TMOS participants would be food manufacturers. A breakout of the desired (i.e. perfect match) and actual industry distributions are shown in Figures 1a and 1b. While not perfect, the industry composition of the TMOS sample very closely mirrors that of manufacturing in Texas, and efforts are always ongoing by Dallas Fed staff to better hone the representativeness of the TMOS sample by adding participants in underrepresented industries.

Figure 1a. Desired Industry Distribution of TMOS Sample

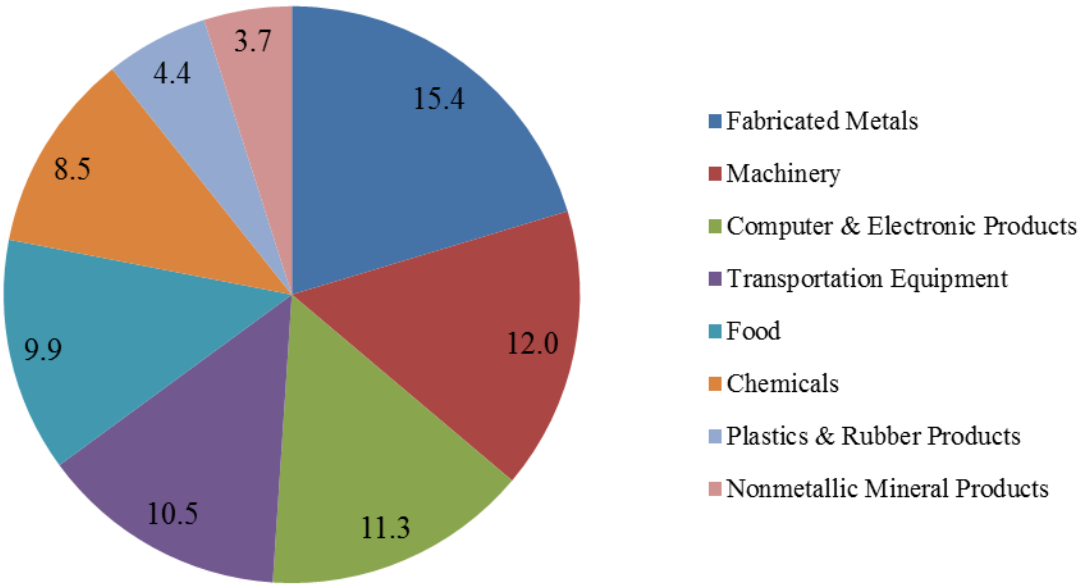
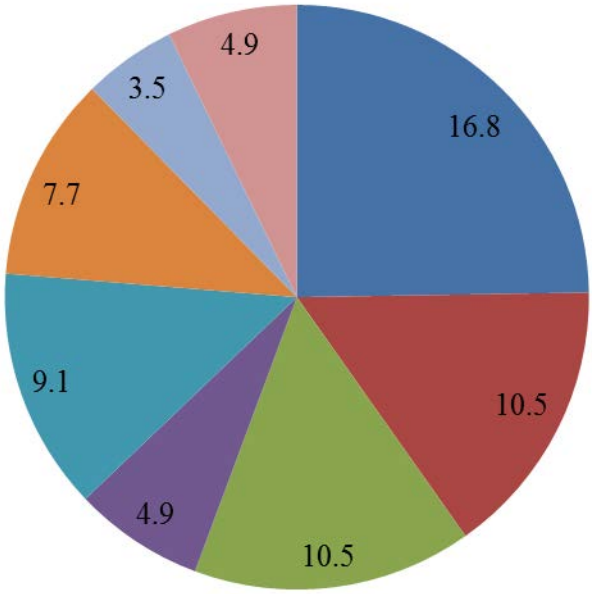


Figure 1b. Actual Industry Distribution of TMOS Sample



NOTE: Shown in Figure 1a are Texas manufacturing employment shares for the top eight NAICS industries, which account for more than 80 percent of total Texas manufacturing employment.
SOURCES: Bureau of Labor Statistics, 2012 Quarterly Census of Employment and Wages.

Maintaining the TMOS panel

Ongoing recruitment efforts are required to maintain a robust and representative survey panel. Firms discontinue involvement over time due to companies merging, changing the nature of their operations or going out of business, or due to participating executives changing roles, leaving the company or electing to no longer participate.

In the first quarter of each year, Dallas Fed economists analyze the representativeness of the existing TMOS panel. They identify target industries (by three-digit NAICS codes) where the survey panel is underrepresented. Recruitment efforts for the year focus on these industries, as well as bolstering the overall sample size. Methods of recruitment have included mailed letters of invitation, invitation emails, handouts, phone calls, and personal interactions. New participants are enrolled for the next monthly survey on a rolling basis.

In addition to adding new participants, it is also important to hold on to existing ones. Dallas Fed staff enacted a procedure in 2012 to systematically follow-up with non-responding survey participants in an effort to minimize attrition and boost response rates.[8]

Contribution of TMOS

The Dallas Fed's TMOS adds considerable additional value and advantages to the existing body of U.S. business surveys, including other Fed manufacturing surveys.

[8] Staff members call participants who do not respond to three consecutive monthly surveys to resolve any issues and encourage a resumption of participation. A similar follow-up call is placed to participants after six months in a row of non-response, and then an email is sent after nine months, followed by a letter after 11 months. These correspondences usually incite participation to resume, but if a participant were to not respond to a survey for 12 consecutive months, they would be removed from the panel. Participants are also removed from the panel at the request of the company or participant.

TMOS covers an area with a large and growing manufacturing presence.

TMOS covers a geographical area that produces the highest share of U.S. manufactured goods among the areas covered by Fed manufacturing surveys. Additionally, Texas accounts for more than 10 percent of U.S. manufacturing output, the highest share among the regions that Fed surveys cover, as shown in Table 1. Manufacturing is also growing considerably faster in Texas—real (inflation adjusted) manufacturing gross domestic product (GDP) in Texas grew 26 percent over the past five years, compared with 4 percent for the U.S. as a whole. Manufacturing GDP has actually declined over the past five years in New York and the states covered by the Philadelphia Fed's survey. Indeed, the disparity of manufacturing growth rates is sizeable over the most-recent 10-year period: 69 percent for Texas versus 18 percent for the U.S.

Table 1. Comparison of Manufacturing GDP across Fed Survey Geographies

Region	**Mfg GDP, 2013** $2005 millions	**Share of U.S. Mfg GDP, 2013** percent	**Mfg GDP growth, 2008-2013** percent	**Mfg GDP growth, 2003-2013** Percent
Texas	205,736	10.6	25.8	69.1
New York	64,350	3.3	-9.8	-5.7
Third District*	118,480	6.1	-14.6	-19.0
Fifth District**	188,862	9.7	6.7	12.6
Tenth District***	114,337	5.9	1.2	18.5
U.S.	1,939,672	-	4.1	18.2

*Third District numbers include PA, NJ, and DE. These figures are not a perfect measure of the area represented by the Philadelphia Fed survey since the Third District includes only parts of PA and NJ. **Fifth District numbers include MD, WV, VA, NC, SC, and DC. These figures are not a perfect measure of the area represented by the Richmond Fed survey since the Fifth District does not include all of WV. ***Tenth District numbers include MO, NE, KS, OK, WY, CO, and NM. These figures are not a perfect measure of the area represented by the Kansas City Fed survey since the Tenth District includes parts of MO and NM.
SOURCE: Bureau of Economic Analysis.

The TMOS collection period allows for more informed survey responses.

TMOS data are collected in the latter half of the month to allow responding companies to get a real sense of business activity for that month. This adds unique value to the TMOS data, as most of the other Fed manufacturing surveys collect data early in the month (Table 2). Because of TMOS's later collection period, it is typically the last of the Fed manufacturing survey reports released. For about half of the Federal Open Market Committee meetings, TMOS is the most recent Fed manufacturing survey data available.

Table 2. Collection Periods and Release Dates for Manufacturing Surveys, June 2014*

	May 2014			June 2014																											
	Th	F	S	Su	M	T	W	Th	F	S	Su	M	T	W	Th	F	S	Su	M	T	W	Th	F	S	Su	M	T	W	Th	F	S	Su	M
New York Fed	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Philadelphia Fed	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Richmond Fed	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Kansas City Fed	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Dallas Fed	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

*June 2014 is used as an example of a typical month. Collection periods and release dates may vary from month to month.
NOTE: Shaded areas mark survey collection periods. Boxed dates mark survey release dates.

TMOS has unique measures of manufacturing activity.

TMOS includes data on production—a well-defined, quantifiable measure of manufacturing output that is not collected by most other Fed surveys. This adds value alongside measures of general business conditions, which tend to reflect perceptions of broad economic activity rather than actual output. While each of the Fed surveys asks about employment numbers, only TMOS and one other inquire about wages. Also, TMOS has three unique survey variables not available in the other Fed surveys: growth rate of orders, capital expenditures and company outlook. Interestingly, the growth rate of orders index performs very well in regression analysis against

measures of Texas economic activity, and the company outlook index is a top performer in out-of-sample forecasting for Texas employment growth.

TMOS has a large sample with an industry distribution representative of Texas manufacturing.

TMOS receives more than 100 survey responses each month and publishes this number monthly with the release.[9] In addition to a survey sample that is robust in number, it is also imperative that the composition of the sample be roughly in line with the composition of the sector it is intending to measure. The industry distribution of the TMOS sample is closely aligned with the industry distribution within Texas' manufacturing sector, as shown in Figures 1a and 1b.

TMOS Correlation with Regional Indicators

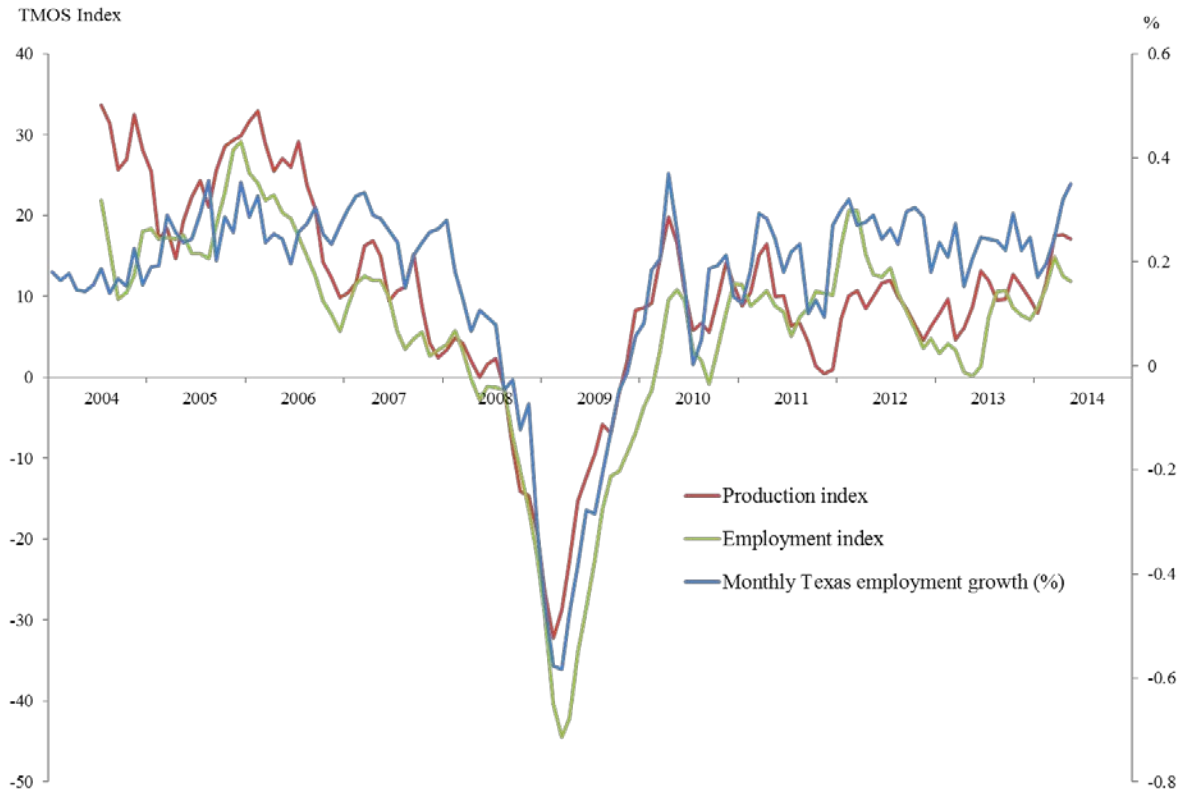
Monthly surveys of regional manufacturing activity can provide an early look of current economic conditions before official statistics become available. The most important gauge of their value, however, is whether the indexes are correlated with the economic activity they are intended to measure; that is, economic activity in their respective regions.

Chart 1 plots the monthly change in Texas employment against TMOS production and employment indexes. The TMOS diffusion indexes are centered at zero, meaning that values greater than zero are consistent with a rising indicator (in this case production or employment). In general, TMOS indexes track fairly well changes in Texas employment growth, the timeliest and most comprehensive official indicator of regional activity.[10] The employment index's behavior around the recession and recovery is consistent with the historical pattern of jobs

[9] TMOS typically has the highest number of monthly responses among the Fed manufacturing surveys.
[10] Texas employment data are released with a lag and heavily revised in subsequent months.

responding more slowly than output at business-cycle turning points; the production index went back to positive territory four months before the employment index.

Chart 1. TMOS Production and Employment Indexes Track Monthly Changes in Texas Employment (three-month moving average)



Several studies have explored how well surveys of business activity correlate with regional economic indicators. Trebing (1998) finds that Philadelphia Fed's Business Outlook Survey (BOS) employment index was positively correlated with month-over-month changes in manufacturing district employment as well as with average manufacturing workweeks in the Third Federal Reserve District. Harris et al (2004) show that the Richmond Fed's Fifth District Survey of Manufacturing Activity headline index highly correlates with Fifth District personal

income. In addition, the authors find that the survey's employment index leads changes in manufacturing employment by one quarter. Keeton and Verba (2004) show the Kansas City Fed's employment indexes from the Survey of Tenth District Manufacturers provide substantial information about current and future growth in Tenth District manufacturing employment.

In order to explore further the relationship between the TMOS indexes and regional data, we used regression analysis.[11] The equation used was of the following form:

$$\Delta TXEMP_t = \beta_0 + \beta_1 TMOS_t + u \qquad (1)$$

Where Δ*TXEMP* is the log difference in Texas employment and *TMOS* is the index variable in levels. The expected sign of the *TMOS* variable is positive and β_1 should be seen as the change in the job growth rate that corresponds to a one-point increase in the value of the index. Regression results show that TMOS output variables as well as TMOS labor market variables are successful in explaining monthly changes in Texas employment (Table 3). The TMOS indexes explain up to 50 percent of month-to-month variation in Texas employment, as evidenced by the adjusted R^2 values noted in the table. All coefficients are statistically significant and with the expected sign. According to the regression results, each one-point increase in the TMOS employment index, for instance, implies a 0.011 percentage point increase in the monthly change of Texas employment. As expected TMOS employment index shows the best fit, followed by capacity utilization and growth of new orders.

[11] Trebing (1998), Schiller and Trebing (2003), and Keeton and Verba (2004) all used similar approaches to explore the relationship between diffusion indexes and regional and national indicators.

Table 3. Monthly Changes in Texas Employment against TMOS Indexes

Regression Results: Log Change in Texas Employment against TMOS Indexes				
Variable	**Constant** (t statistic)	**TMOS Coefficients** (t statistic)	**Adjusted R^2**	**Breakeven Point***
Output				
Production	0.06 (2.74)	0.01 (8.84)	0.39	-5.41
Volume of New Orders	0.11 (5.89)	0.01 (8.69)	0.39	-11.40
Capacity Utilization	0.08 (4.25)	0.01 (9.85)	0.45	-6.64
Volume of Shipments	0.08 (4.00)	0.01 (8.30)	0.36	-8.33
Labor Market Indicators				
Employment	0.09 (5.71)	0.01 (10.88)	0.50	-8.16
Average Employee Workweek	0.14 (8.79)	0.01 (9.31)	0.42	-11.46
General Business Conditions				
Company Outlook	0.10 (5.66)	0.01 (8.55)	0.38	-12.24
General Business Activity	0.15 (8.54)	0.01 (7.16)	0.30	-26.02

*The break-even point is defined as the level of the diffusion index consistent with no change in the underlying official statistic according to the regression model. It is equivalent to the negative of the ratio of the estimated intercept and slope coefficient.
NOTE: Regressions are based on the estimation period 2004:06 to 2014:05
Texas employment and CPI were in log difference.

Table 3 also shows the breakeven point, a value for the TMOS index that is consistent with no change in the regional indicator (dependent variable). The breakeven point is equal to the negative of the ratio of the estimated intercept and slope coefficient. For example, if in equation (1) $\Delta TXEMP$ is zero—that is, no change in employment from the previous month—and β_0 is 5

and β_1 is 2, then *TMOS* breakeven point should be -2.5 in order to be consistent with employment showing no change. Only values above the breakeven point suggest growth for the current month, and only values below the breakeven point suggest a decline. TMOS breakeven points range from -5.4 for the production index to -26 for the general business activity index.

Another factor to consider is whether survey indexes can provide any additional information about regional indicators beyond that contained in their past values. Trebing (1998) regressed monthly changes in U.S. manufacturing production index against 12 lagged values of change in manufacturing production index plus Philadelphia's BOS index and finds that the model was able to account for 14 percentage points more of the monthly variation in U.S. manufacturing production when the BOS diffusion index was added to the regression. Similarly, Keeton and Verba (2004) regressed monthly changes in Tenth Federal Reserve District employment on lagged values of changes in district employment plus the Kansas City Fed survey's manufacturing composite index and find that explanatory power substantially increases after including the survey index in the regression. Following on the steps of previous studies, we regressed monthly changes in Texas employment on its lagged values plus TMOS indexes to test if TMOS survey indexes provide any information about current employment growth beyond that contained in past values of employment growth. The specification used was as follows:

$$\Delta TXEMPL_t = \beta_0 + \beta_1 TMOS_t + \sum_{j=1}^{k} \alpha_j \ \Delta TXEMPL_{t-j} + u_t. \qquad (2)$$

The lag length of k=3 was chosen following the Akaike Information Criterion (AIC). We also included k=6 as a robustness check. Table 4 shows the goodness of fit (adjusted R^2) based on regression results of three lagged values of employment growth—the predictive powers of past

performance—absent the TMOS indexes. In addition, Table 4 also shows adjusted R^2 after adding the TMOS index in both the specifications. When survey indexes are added to the model, the adjusted R^2 rises in all cases, signifying that the TMOS indexes provide additional explanatory power for Texas employment growth beyond that contained in its past values.[12] Growth rate of orders performs the best after accounting for lagged values of employment growth. Capacity utilization and new orders followed.

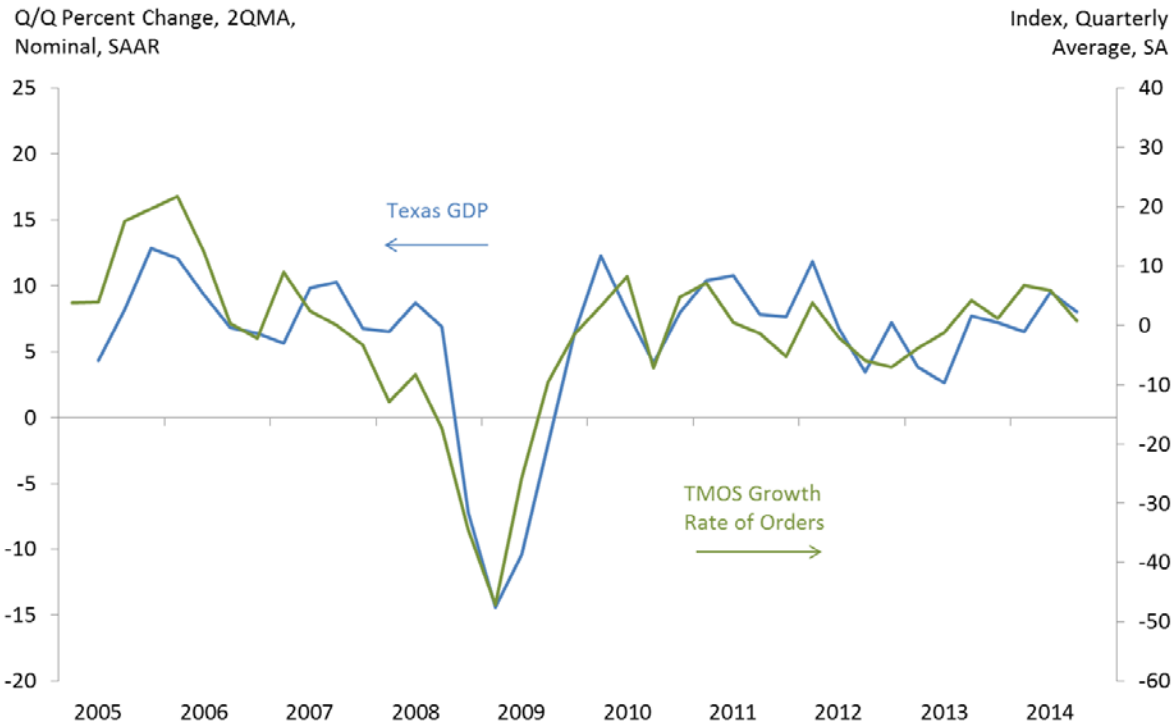
Table 4
Monthly Changes in Texas Employment against TMOS Indexes

Regression Results (2004:06 to 2014:05)	**TMOS Coefficients** (t statistic)	**Adjusted R^2**
With only 3 lags of Texas employment growth *plus TMOS variable*		0.44
Output		
Production	0.01 (4.71)	0.52
Volume of New Orders	0.01 (5.49)	0.55
Capacity Utilization	0.01 (5.55)	0.55
Growth Rate of Orders	0.01 (6.35)	0.58
Volume of Shipments	0.01 (3.99)	0.50
Labor Market Indicators		
Employment	0.01 (5.16)	0.54
Average Employee Workweek	0.01 (4.57)	0.53
General Business Conditions		
Company Outlook	0.01 (5.24)	0.54
General Business Activity	0.00 (4.57)	0.52

[12] The increase in R^2 was on average 10 basis points.

The Bureau of Economic Analysis (BEA) recently published prototype quarterly estimates of state GDP, a supplement to its annual state GDP estimates. The quarterly estimates, which cover Q1 2005 through Q4 2013, provide an opportunity to see how our TMOS indexes correlate with this official measure of Texas output. We ran a series of regression models and found that the headline production TMOS index, as well as several other survey indexes, provided statistically significant explanatory power for Texas quarterly GDP growth at a 1 percent level, confirming TMOS indexes correlate well with variations in the overall regional economy. Growth rate of orders index performed best, with an R-squared of 0.62. Chart 2 shows that growth rate of new orders index tracked the last Texas recession quite well.

Chart 2. Growth Rates of Orders Correlates Well with Changes in Texas Gross State Product



NOTES: Dashed lined represents estimates for Q1-Q3 2014 based on regression. Last data point is Q4 2013 for Texas GDP, Q3 2014 for TMOS.
SOURCES: Bureau of Economic Analysis; Federal Reserve Bank of Dallas.

TMOS was designed to obtain meaningful information about the pace of growth in Texas' manufacturing sector. However, TMOS could also reflect conditions in the national manufacturing sector as well. Several factors may explain correlations with national data. For example, TMOS participants may have plants operating in other parts of the country, or goods produced by some of the firms in the survey could represent inputs for other firms that operate in national markets. Kerr et al. (2014) find that TMOS performs well, better than other Federal Reserve Bank surveys in some cases, predicting changes in U.S. employment growth, manufacturing production growth and the ISM manufacturing index.

Using TMOS Indexes to Forecast Texas Employment Growth

In addition to regression analysis, business survey indexes can be evaluated based on their ability to forecast economic indicators. Schiller and Trebing (2003) find the Philadelphia Fed's Business Outlook Survey is as accurate as national surveys in predicting the monthly change in the U.S. industrial production index for manufacturing. Harris et al (2004) find that the Richmond Survey of Manufacturing Activity adds to the ability to forecast the PMI component of the ISM index, especially when combined with the results of the Philadelphia Fed's Survey results.

In order to evaluate the contribution of TMOS indexes in forecasting Texas job growth, we regressed monthly growth in Texas employment on TMOS indexes and three lags of Texas employment growth. The forecast evaluation period ran from July 2011 to June 2014. Each month during this period, individual TMOS indexes were used to forecast employment growth

for that same month. We utilized the root mean squared forecast error (RMSFE), which is based on average squared difference between forecast and actual results, for accuracy comparisons. To make the forecast comparisons easier, the forecasting performance of the various TMOS indexes was benchmarked against the RMSFE of a model with only lags of Texas employment growth and no TMOS index. Relative RMSFEs are presented in Table 5. Values less than 1 mean that TMOS index variables help improve the accuracy of the forecasts; the lower the RMSFE, the more accurate the forecast.

Table 5
Forecasting Changes in Texas Employment

Texas Employment Growth	
TMOS Variable	**RMSFE**
General Business Activity	0.961
Growth Rate of Orders	0.986
Employment	0.986
Capacity Utilization	0.999
Baseline Model	1
Company Outlook	1.013
Volume of New Orders	1.026
Production	1.032
Volume of Shipments	1.089

NOTES: A lower relative root mean squared forecast error (RMSFE) indicates better forecasting performance. The baseline model is one with three lags of Texas employment growth and no TMOS index. The sample period is June 2004 to May 2014; forecasts run from July 2011 to June 2014. Each entry represents a separate regression and all include three lags of the dependent variable (Texas employment growth).

Four of the eight TMOS variables used in the forecast exercise helped improve the forecast, contributing to outperformance relative to the baseline model. General business activity is the TMOS variable that contributed the most to improved accuracy of the forecast. Growth rate of orders and employment followed.

Summary

The Texas Manufacturing Outlook Survey, a monthly survey of the state's manufacturing sector conducted by the Dallas Fed, tracks economic activity in Texas in a more timely and comprehensive manner than other data available. TMOS output indexes as well as TMOS labor market indexes explain up to 50 percent of monthly changes in Texas total nonfarm employment, which is the best official measure of state economic conditions but is released with a three-week lag and subject to revision. TMOS indexes are available for any given month three to four weeks in advance of Texas employment data, which makes them particularly valuable for a timely analysis of current economic conditions. TMOS indexes are valuable indicators of the Texas business cycle, as they tracked the latest Texas recession very well and were available in real time. In addition, TMOS's growth rate of orders index was able to explain up to 62 percent of the quarterly variation in Texas gross state product. Forecasting exercises show that several TMOS indexes, particularly general business activity and growth rate of orders, are useful in predicting changes in Texas employment.

References

Harris, Matthew, Owens, Raymond E., and Pierre-Daniel G. Sarte. 2004. “Using Manufacturing Surveys to Assess Economic Conditions.“ Federal Reserve Bank of Richmond *Economic Quarterly* 90 (Fall 2004): 65-92.

Keeton, William R., and Michael Verba. 2004. "What Can Regional Manufacturing Surveys Tell Us? Lessons from the Tenth District." Federal Reserve Bank of Kansas City Economic Review 89, no. 3 (third quarter): 39-70.

Kerr, Emily, Orrenius, Pia, Wang, Jack and Jesús Cañas. 2014. “Regional Feds’ Manufacturing Surveys Provide National Economy Insight.” Federal Reserve Bank of Dallas *Economic Letter*…

Nakumura, Leonard, and Michael Trebing. 2008. “What Does the Philadelphia Fed’s Business Outlook Survey Say About Local Activity?” Federal Reserve Bank of Philadelphia Research Rap Special Report (December 2008).

Schiller, Timothy, and Michael Trebing. 2003. “Taking the Measure of Manufacturing.” Federal Reserve Bank of Philadelphia *Business Review* (Q4 2003): 24-37.

Sigalla, Fiona, Berger, Frank, Fomby, Tom, Phillips, Keith, and Mine Yucel. 2007. “Evaluating Alternative Index Designs for the Texas Manufacturing Outlook Survey.” Paper prepared for the Third Joint European Commission-OECD Workshop on International Development of Business and Consumer Tendency Surveys (November 2007).

Trebing, Michael. 1998. ‘What’s Happening in Manufacturing: “Survey Says…’” 1998. Federal Reserve Bank of Philadelphia *Business Review* (September/October 1998): 15-29.

Appendix 1
Electronic survey form sent to survey participants every month

Texas Manufacturing Outlook Survey

Federal Reserve Bank of Dallas

CONFIDENTIAL: Individual responses are kept confidential except for survey comments which may be anonymously published with prior consent of the respondent.

Please complete this survey by marking the circles that best describe your business's activity.

	June vs. May Other than the normal seasonal change			Six months from now Other than the normal seasonal change		
Business Indicators Relating to Your Company's Facilities and Products in Texas:						
	Increase	**No Change**	**Decrease**	Increase	No Change	Decrease
Production	○	○	○	○	○	○
Capacity utilization	○	○	○	○	○	○
Volume of new orders	○	○	○	○	○	○
Growth rate of orders	○	○	○	○	○	○
Unfilled orders	○	○	○	○	○	○
Volume of shipments	○	○	○	○	○	○
Delivery time	○	○	○	○	○	○
Materials inventories	○	○	○	○	○	○
Finished goods inventories	○	○	○	○	○	○
Prices paid for raw materials	○	○	○	○	○	○
Prices received for finished goods	○	○	○	○	○	○
Wages and benefits	○	○	○	○	○	○
Number of employees	○	○	○	○	○	○
Average employee workweek	○	○	○	○	○	○
Capital expenditures	○	○	○	○	○	○
General Business Conditions:						
	Improved	**Remained the Same**	**Worsened**	Improved	Remained the Same	Worsened
How has the outlook for your company changed?	○	○	○	○	○	○
What is your evaluation of the level of general business activity?	○	○	○	○	○	○

Please feel free to comment on any issues that may be affecting your business. Your comments may be published anonymously.

☐ **Check this box if you prefer we not publish your comments.**

Appendix 2
Table A1. Monthly Texas Employment against TMOS Indexes

Regression Results					**3-Lag**			**6-Lag**		
Indicator	Constant (t statistic)	TMOS Coefficient (t statistic)	Adjusted R^2	Break-even Point*	Adjusted R^2 of model	TMOS Coefficient (t statistic)	Adjusted R^2	Adjusted R^2 of model	TMOS Coefficient (t statistic)	Adjusted R^2
CE	0.10	0.01				0.01			0.01	
	(5.55)	(9.55)	0.43	-8.35	0.43	(4.07)	0.502	0.43	(4.09)	0.10
CU	0.08	0.01				0.01			0.01	
	(4.25)	(9.85)	0.45	-6.64	0.43	(5.55)	0.550	0.43	(5.49)	0.55
EMP	0.09	0.01				0.01			0.01	
	(5.71)	(10.88)	0.50	-8.16	0.43	(5.16)	0.537	0.43	(5.29)	0.54
GBA	0.15	0.01				0.00			0.00	
	(8.54)	(7.16)	0.30	26.02	0.43	(4.57)	0.517	0.43	(4.83)	0.52
GO	0.17	0.01				0.01			0.01	
	(10.64)	(9.71)	0.44	15.78	0.43	(6.35)	0.578	0.43	(6.43)	0.58
MINV	0.17	0.01				0.01			0.01	
	(10.52)	(9.83)	0.45	12.25	0.43	(4.29)	0.509	0.43	(4.28)	0.50
NO	0.11	0.01				0.01			0.01	
	(5.89)	(8.69)	0.39	11.40	0.43	(5.49)	0.548	0.43	(5.52)	0.55
PPRM	0.03	0.01				0.00			0.00	
	(0.98)	(6.28)	0.24	-5.82	0.43	(2.85)	0.468	0.43	(2.88)	0.46
PRFG	0.10	0.01				0.00			0.00	
	(5.02)	(7.24)	0.30	11.57	0.43	(2.52)	0.460	0.43	(2.32)	0.45
PRO	0.06	0.01				0.01			0.01	
	(2.74)	(8.84)	0.39	-5.41	0.43	(4.71)	0.522	0.43	(4.70)	0.52
UO	0.21	0.01				0.01			0.01	
	(11.17)	(7.37)	0.31	16.17	0.43	(3.54)	0.486	0.43	(3.65)	0.48
VS	0.08	0.01				0.01			0.01	
	(4.00)	(8.30)	0.36	-8.33	0.43	(3.99)	0.499	0.43	(3.89)	0.49
WS	-0.08	0.01				0.00			0.00	
	(-1.99)	(6.90)	0.28	5.51	0.43	(1.49)	0.441	0.43	(1.42)	0.43
WWK	0.14	0.01				0.01			0.01	
	(8.79)	(9.31)	0.42	11.46	0.43	(4.92)	0.529	0.43	(5.01)	0.53

*The break-even point is defined as the level of the diffusion index consistent with no change in the underlying official statistic according to the regression model. It is equivalent to the negative of the ratio of the estimated intercept and slope coefficient.

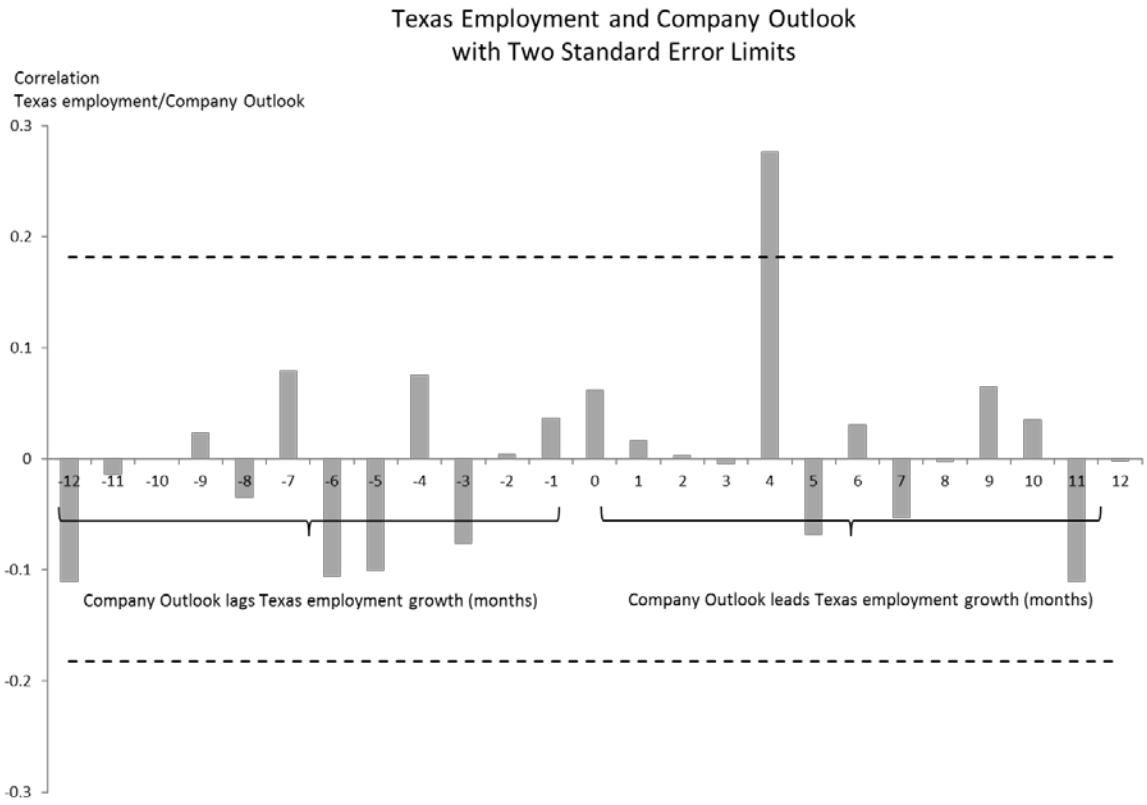
NOTE: Regressions are based on the estimation period 2004:06 to 2014:05
Texas employment and CPI were in log difference.

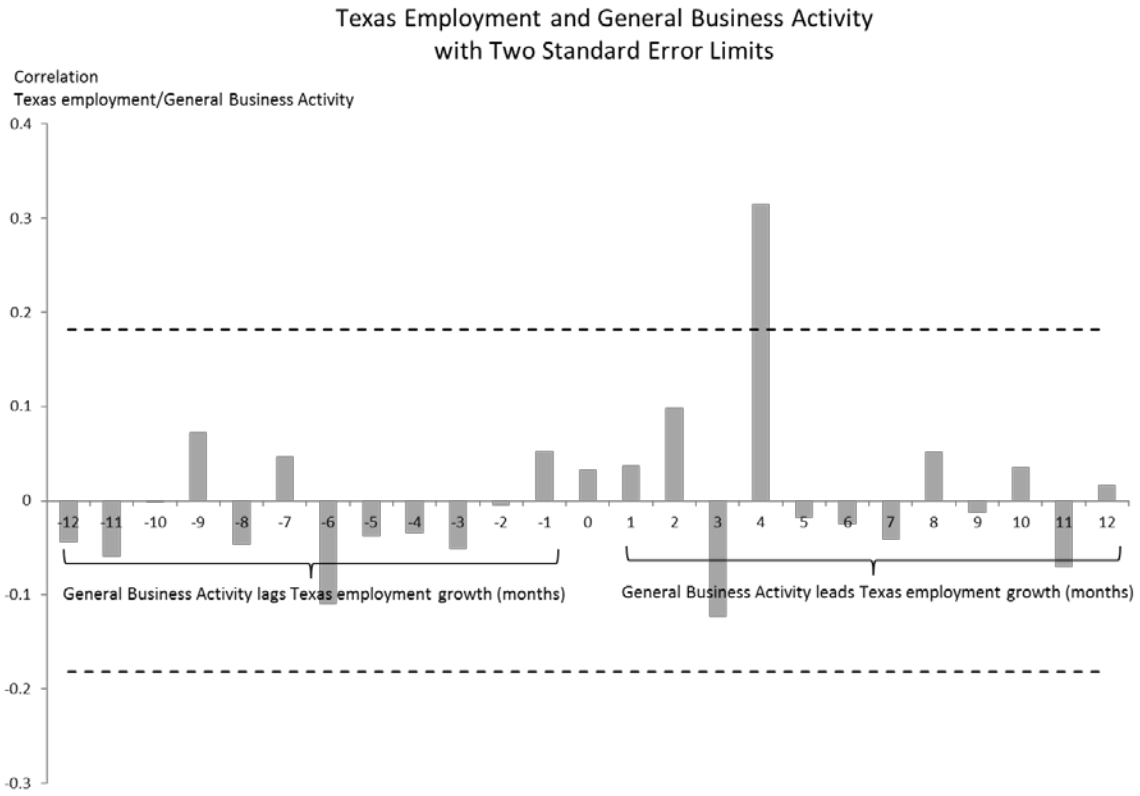
Variable description:

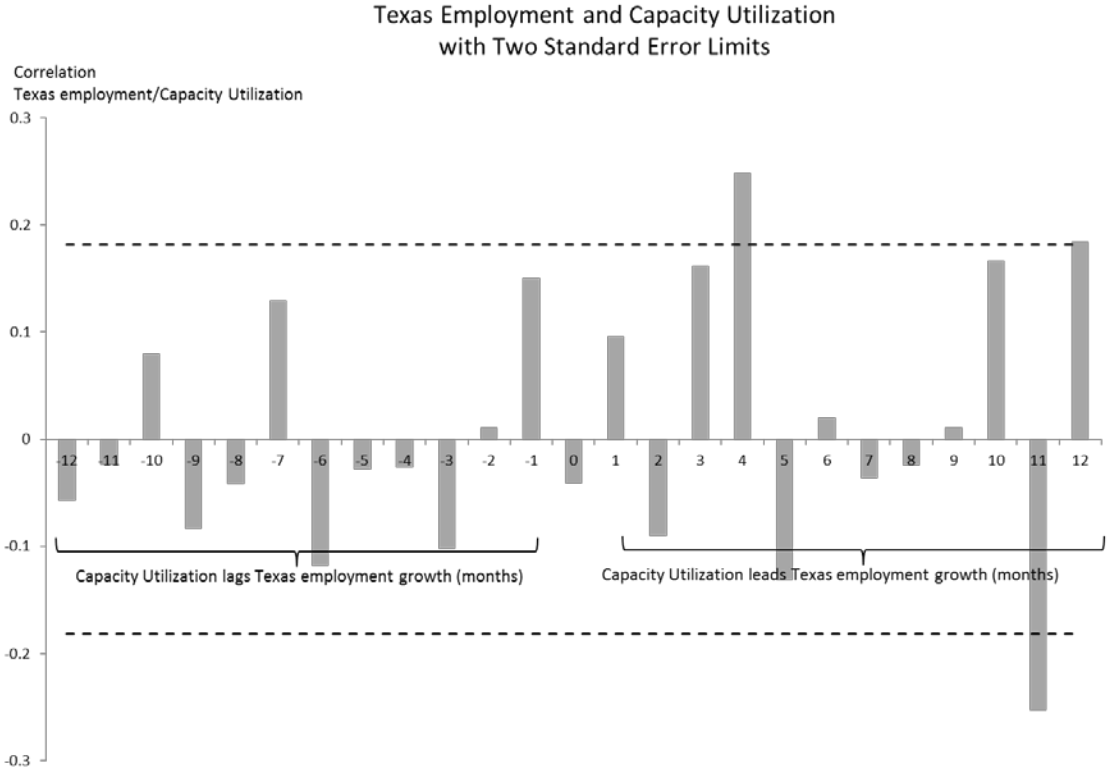
CO	Company Outlook
GBA	General Business Activity
PRO	Production
CU	Capacity Utilization
NO	Volume of New Orders
GO	Growth Rate of Orders
UO	Unfilled Orders
VS	Volume of Shipments
MINV	Materials Inventories
PPRM	Prices Paid for Raw Materials
PRFG	Prices Received for Finished Goods
WS	Wages and Benefits
EMP	Number of Employees
WWK	Average Employee Workweek (Hours Worked)
CE	Capital Expenditures
COMP	TMOS Composite
USEMP	Us employment
BOS	General Business Activity Index
ISM	PMI manufacturing index

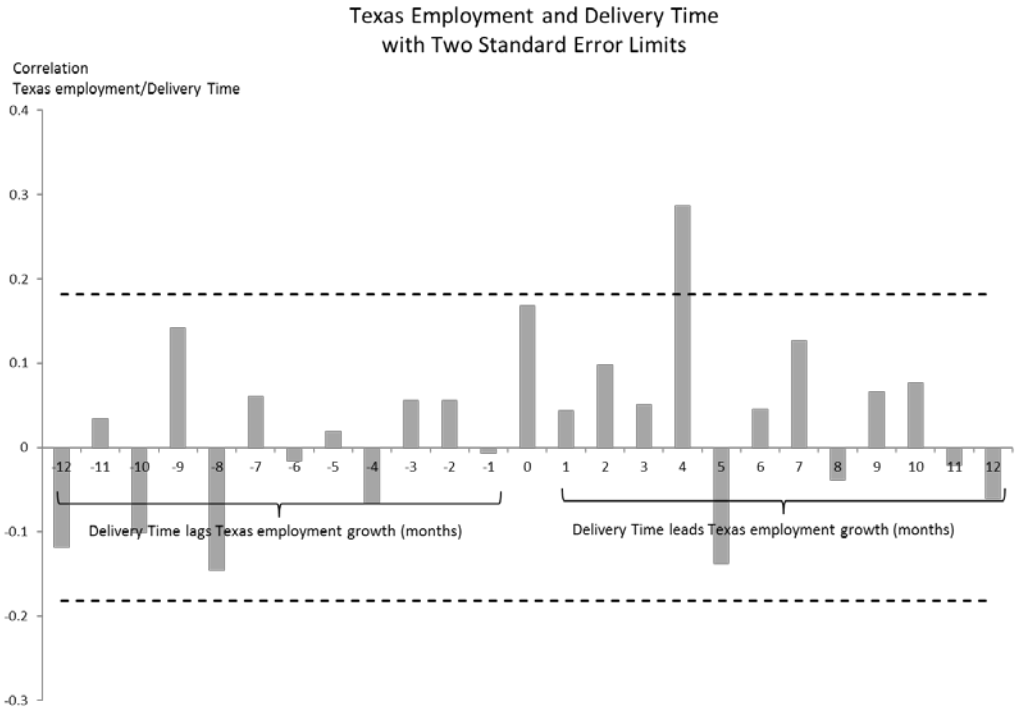
Appendix 3

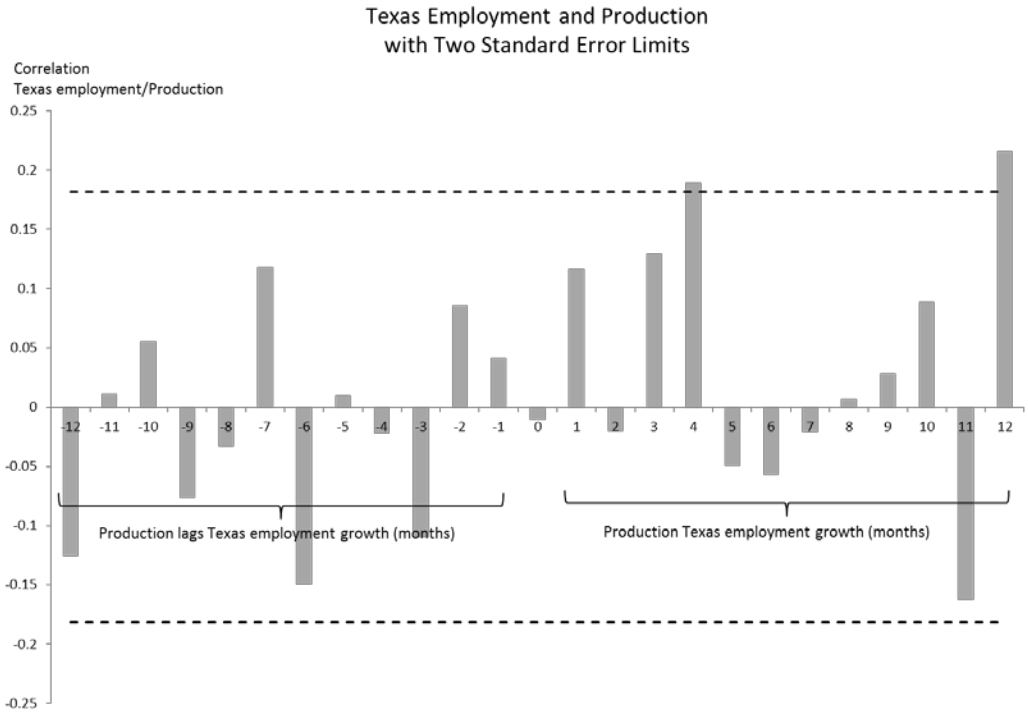
Texas Manufacturing Outlook Survey also includes a set of "looking forward" section where we ask participants about their expectations for production, employment, new orders, etc. six months in advance. In order to test for leading capabilities of TMOS six-month ahead indexes, we used cross-correlation analysis pre-whitening the series to avoid spurious correlations. Production, company outlook, general business activity, capacity utilization, delivery time, and capital expenditures lead Texas employment growth without feedback effects. Generally, the indexes show a four-month lead. The following correlation charts show lag and lead effects for all TMOS six-month ahead indexes.

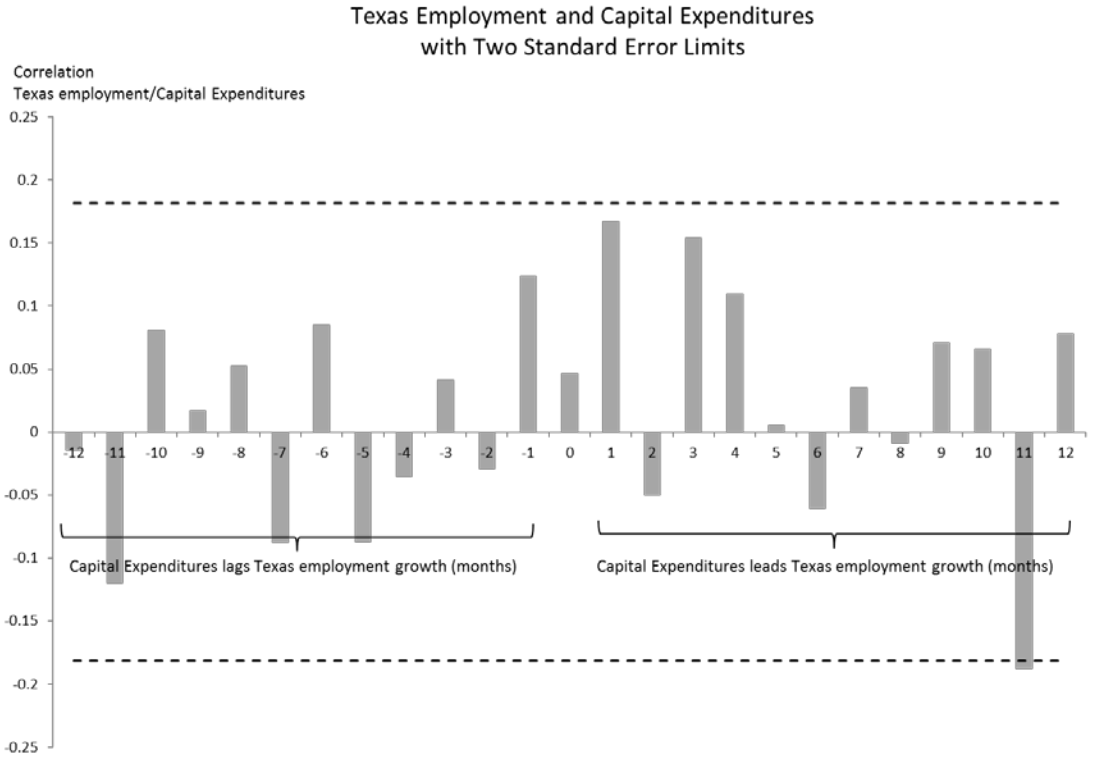


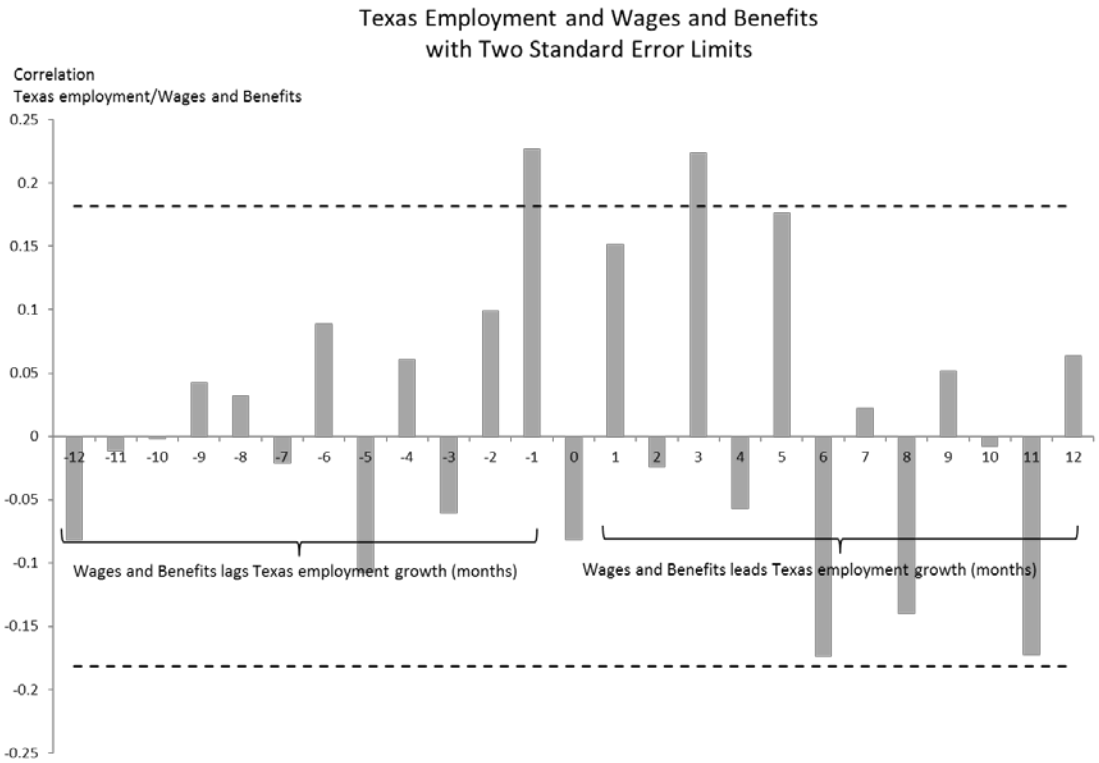

Texas Employment and General Business Activity
with Two Standard Error Limits
Correlation
Texas employment/General Business Activity
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12
General Business Activity lags Texas employment growth (months)
General Business Activity leads Texas employment growth (months)


Texas Employment and Capacity Utilization
with Two Standard Error Limits
Correlation
Texas employment/Capacity Utilization
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12
Capacity Utilization lags Texas employment growth (months)
Capacity Utilization leads Texas employment growth (months)

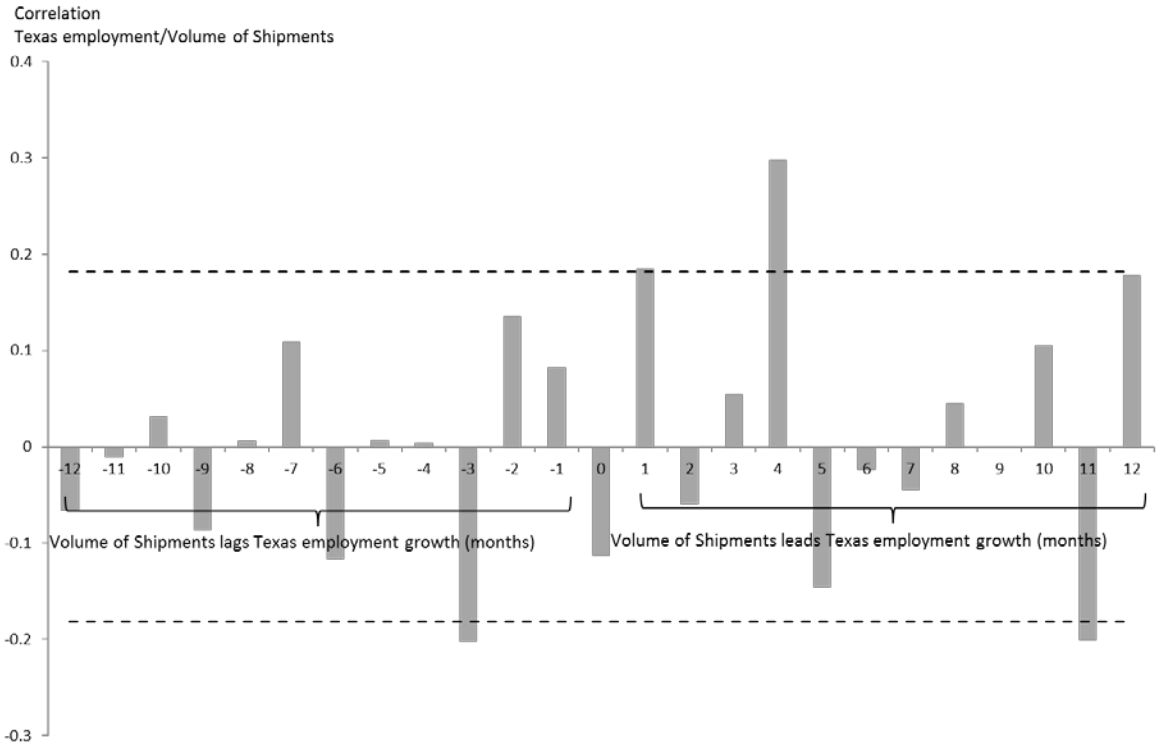

Texas Employment and Delivery Time
with Two Standard Error Limits
Correlation
Texas employment/Delivery Time
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12
Delivery Time lags Texas employment growth (months)
Delivery Time leads Texas employment growth (months)


Texas Employment and Production
with Two Standard Error Limits
Correlation
Texas employment/Production
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12
Production lags Texas employment growth (months)
Production Texas employment growth (months)

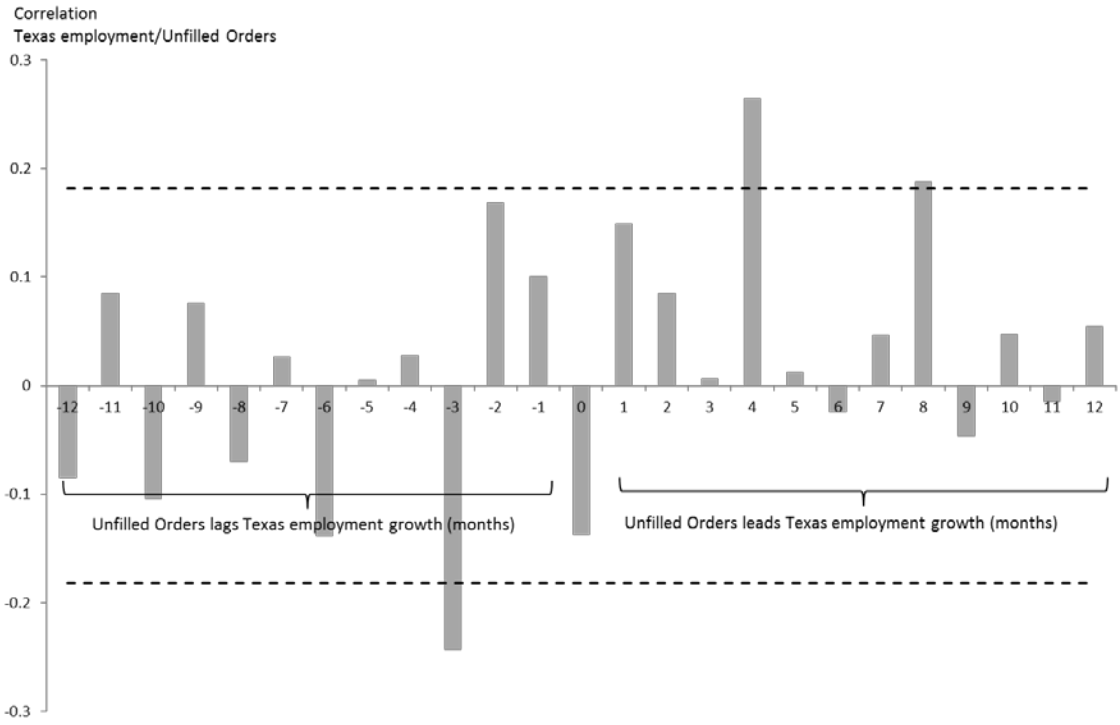

Texas Employment and Capital Expenditures
with Two Standard Error Limits
Correlation
Texas employment/Capital Expenditures
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12
Capital Expenditures lags Texas employment growth (months)
Capital Expenditures leads Texas employment growth (months)


Texas Employment and Wages and Benefits
with Two Standard Error Limits
Correlation
Texas employment/Wages and Benefits
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12
Wages and Benefits lags Texas employment growth (months)
Wages and Benefits leads Texas employment growth (months)

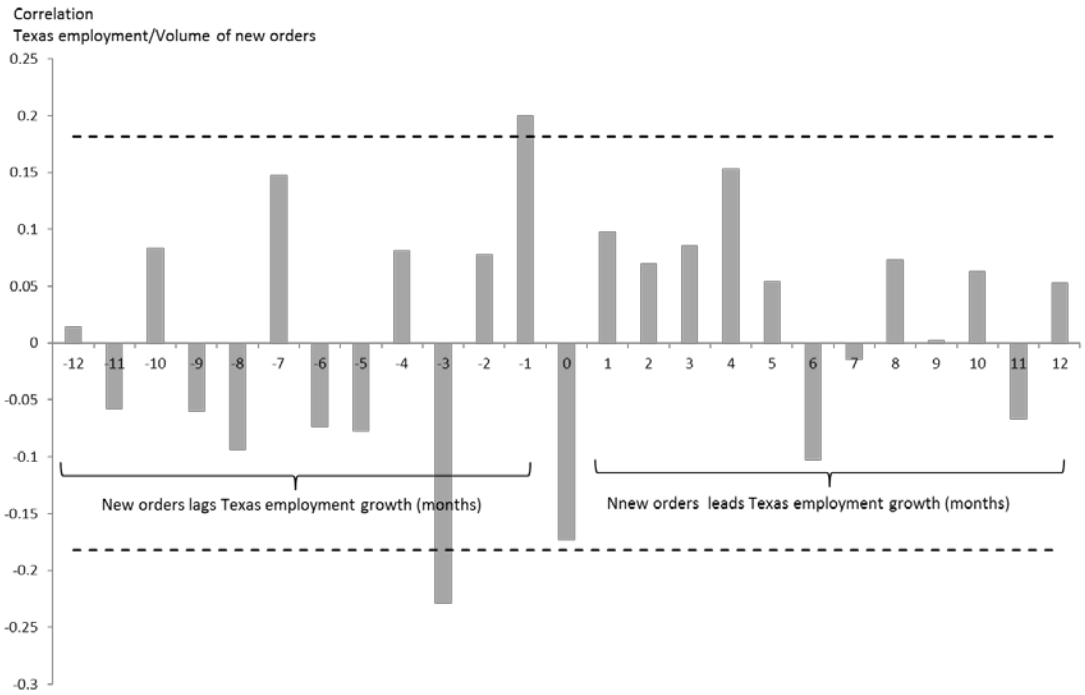
Texas Employment and Volume of Shipments
with Two Standard Error Limits



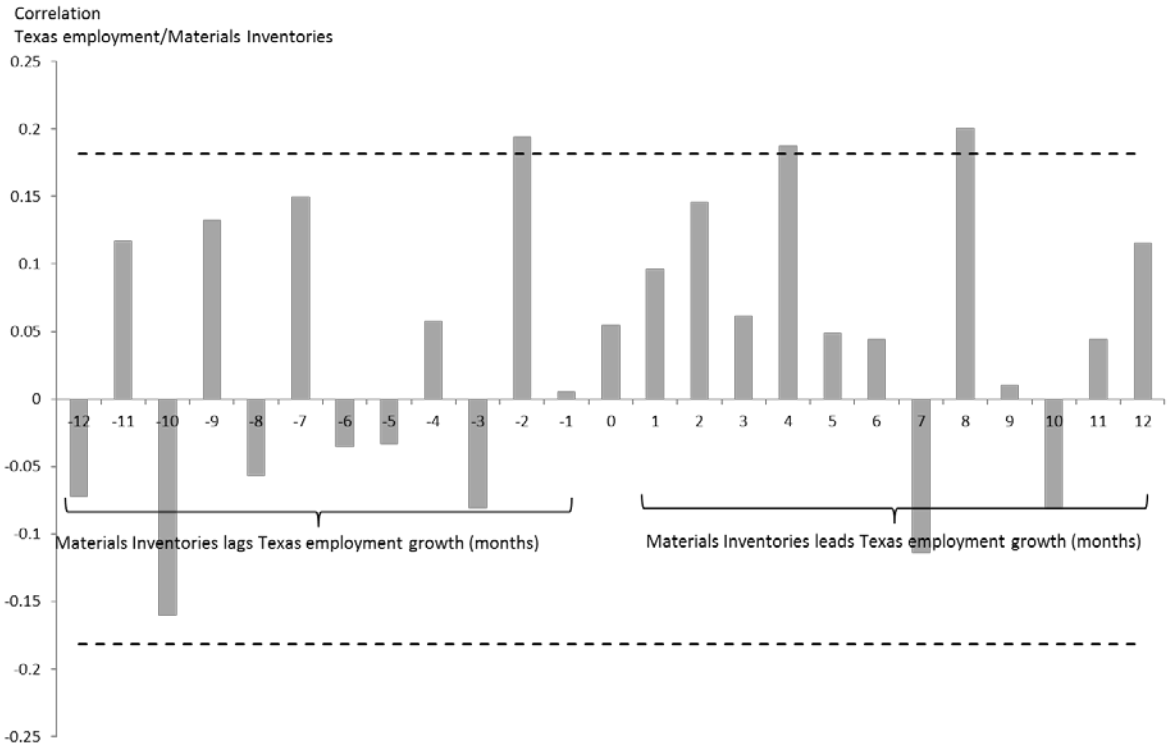
Texas Employment and Unfilled Orders
with Two Standard Error Limits



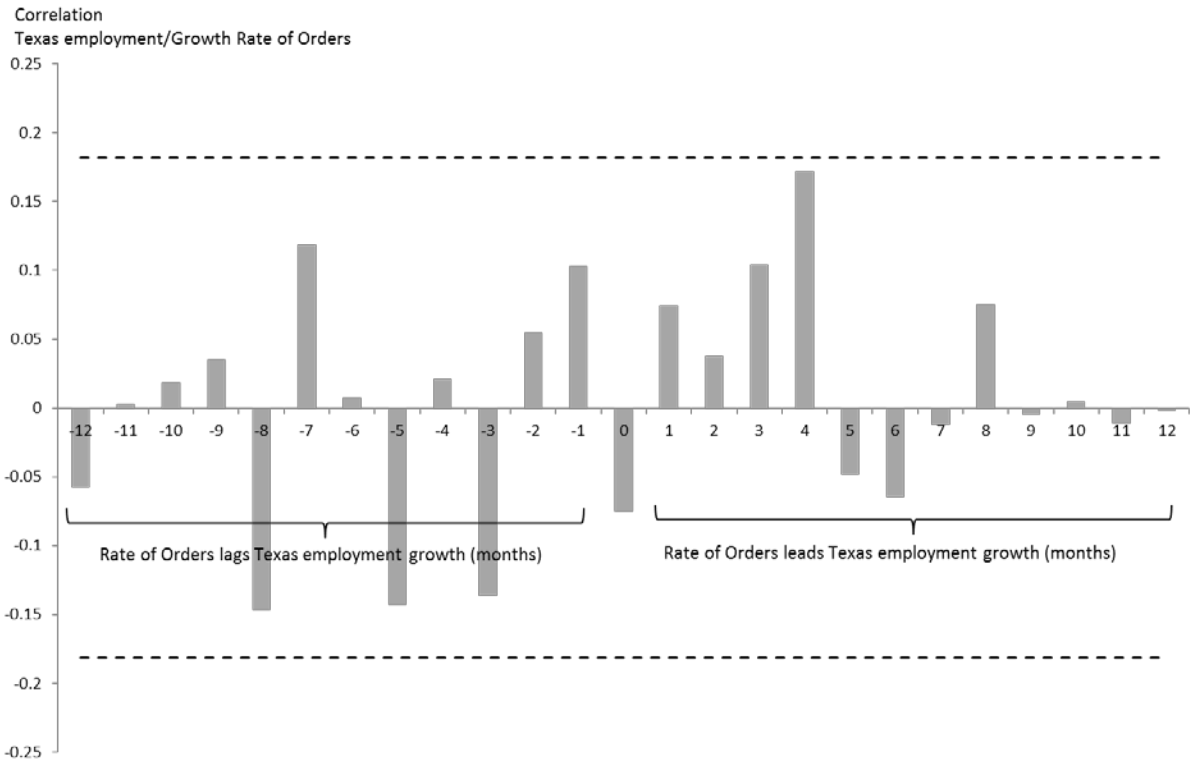
Texas Employment and New Orders
with Two Standard Error Limits



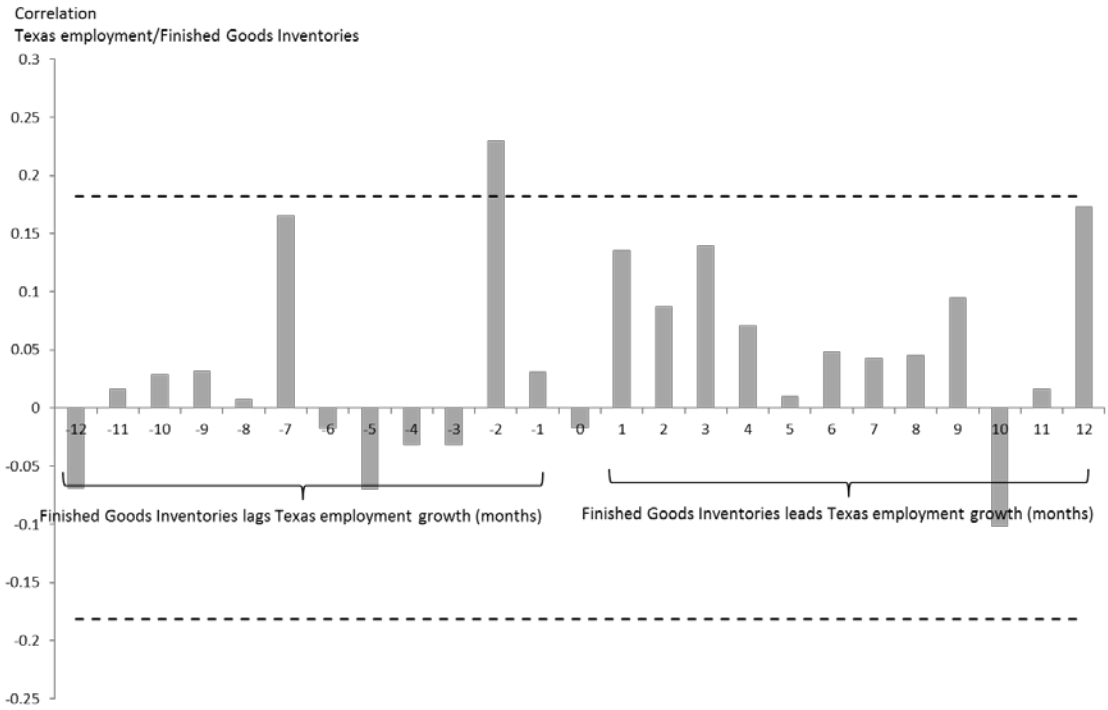
Texas Employment and Materials Inventories
with Two Standard Error Limits

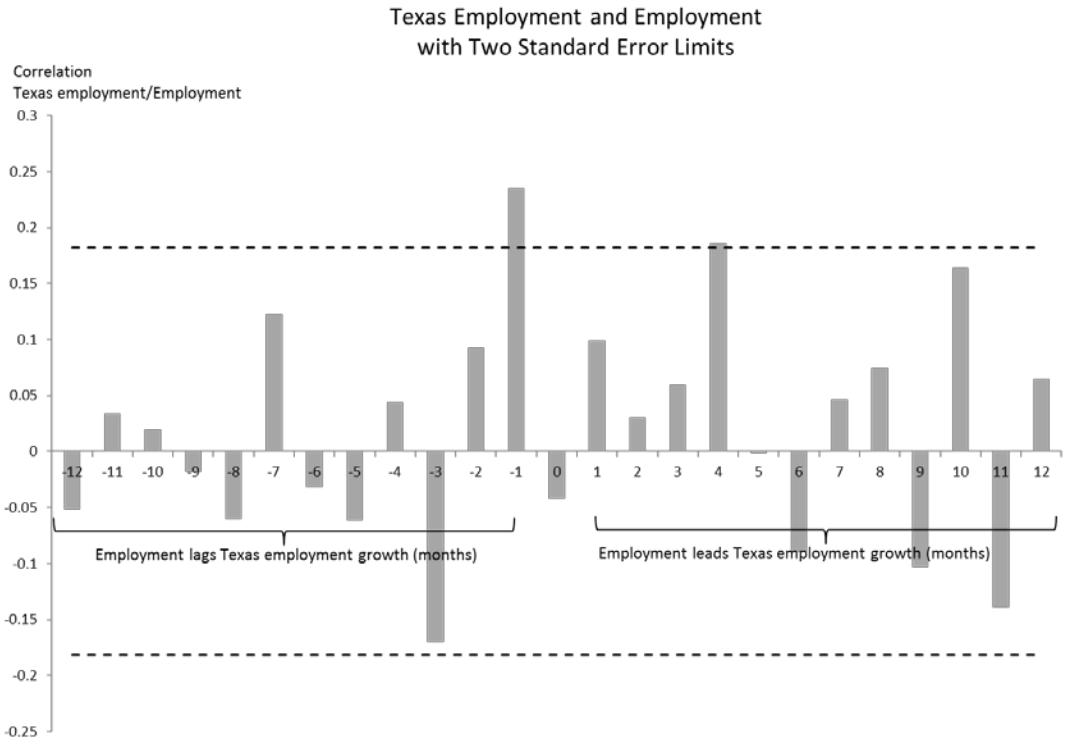


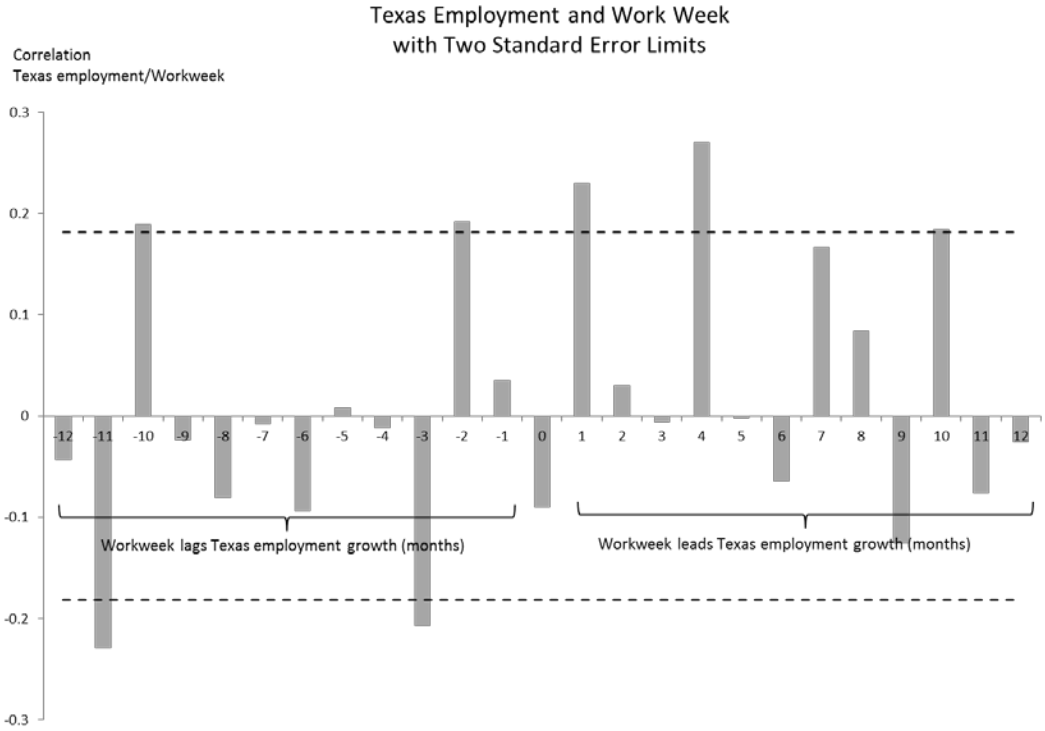
Texas Employment and Growth Rate of Orders
with Two Standard Error Limits



Texas Employment and Finished Goods Inventories
with Two Standard Error Limits




Texas Employment and Employment
with Two Standard Error Limits
Correlation
Texas employment/Employment
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12
Employment lags Texas employment growth (months)
Employment leads Texas employment growth (months)


Texas Employment and Work Week
with Two Standard Error Limits
Correlation
Texas employment/Workweek
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12
Workweek lags Texas employment growth (months)
Workweek leads Texas employment growth (months)