

TECHNICAL APPENDIX

NORTH DAKOTA FORECAST MODEL

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Overview

The methodology used in the North Dakota Forecast Model is a nested Vector Autoregression (VAR) system.

VAR is a regression methodology that uses lagged values of endogenous variables (variables that the model predicts and determines) and lagged values of exogenous variables (variables that are determined outside of the model and that the model takes as given) in a system of equations whereby the future values of each endogenous variable are predicted based on its own lagged values and the lagged values of other endogenous and exogenous variables.

VAR has been demonstrated in the literature to be an effective method for forecasting variables that follow certain dynamic patterns. VAR models are data driven and do not rely on theoretical assumptions regarding empirical relationships among the data. VAR has also been found to be effective for forecast models that are relatively small.

The North Dakota Forecast Model is nested, meaning that it starts with a minimal model of the U.S. economy. This model of the U.S. economy has a set of endogenous variables (GDP, unemployment, etc.) and takes oil prices as exogenous. The relationships among these variables are econometrically measured separately from other components of the larger model.

A separate model of the North Dakota economy uses a set of North Dakota endogenous variables (GSP, total tax collections, etc.) and takes as exogenous the variables from the U.S. model and commodity prices. This North Dakota VAR model is econometrically measured separately from the other components.

Lastly, there are three models for each of the major metro areas inside North Dakota: Fargo, ND-MN; Bismarck, ND; and Grand Forks, ND-MN. Each metro VAR model has a set of endogenous variables and takes variables from the North Dakota model as exogenous. There is also a VAR model that incorporates commodity prices as endogenous variables.

The overall North Dakota Forecast Model is nested because the metro models are nested inside the state model and the state model is nested inside the model of the U.S. economy.

The model uses quarterly data. Some data used is available daily or monthly. Daily and monthly data is converted to quarterly by taking a simple average of all data values in that quarter. All data used is downloaded from the FRED database maintained by the St. Louis Federal Reserve Bank. The VAR method requires that each time series meet a requirement known as stationarity. Most time series economic data do not meet this requirement; however, the differences between the data do meet stationarity requirements. Therefore, when we implement the North Dakota Forecast Model, we first take the natural logarithm of all the data and then take the first difference. For reporting, all data is converted back to original values. All VAR systems inside the model have three lags.

National Variables

Variable	Units	Source
Real Personal Consumption	Billions of Dollars	U.S. Bureau of Economic Analysis
Net Domestic Investment	Billions of Dollars	U.S. Bureau of Economic Analysis
Corporate Profits Before Tax	Billions of Dollars	U.S. Bureau of Economic Analysis
Federal Business Tax Receipts	Billions of Dollar	U.S. Bureau of Economic Analysis
Total Wages and Salaries	Billions of Dollars	U.S. Bureau of Economic Analysis
Government Wages and Salaries	Billions of Dollars	U.S. Bureau of Economic Analysis
Private Industry Wages and Salaries	Billions of Dollars	U.S. Bureau of Economic Analysis
Total Government Expenditures	Billions of Dollars	U.S. Bureau of Economic Analysis
Gross Fixed Capital Formation in United States	Dollars	Organization for Economic Co-operation and Development
Real Gross Domestic Product	Billions of Chained 2012 Dollars, Seasonally Adjusted Annual Rate	U.S. Bureau of Economic Analysis
Unemployment Rate	Percent, Seasonally Adjusted	U.S. Bureau of Labor Statistics

Exogenous Variables

- Crude Oil Prices: West Texas Intermediate (WTI) - Cushing, Oklahoma

State Variables

Variable	Units	Source
Average Hourly Earnings	Dollars per Hour	U.S. Bureau of Labor Statistics
North Dakota Unemployment Rate	Percent	U.S. Bureau of Labor Statistics
Civilian Labor Force in North Dakota	10,000 Individuals	U.S. Bureau of Labor Statistics
Real Gross Domestic Product: North Dakota	100 Millions of Dollars	U.S. Bureau of Economic Analysis
Total Wages and Salaries in North Dakota	100 Millions of Dollars	U.S. Bureau of Economic Analysis
Nonperforming Loans (past due 90+ days plus nonaccrual): North Dakota	Percent	Federal Financial Institutions Examination Council (US)
Total Assets for Commercial Banks in North Dakota	Thousands of Dollars	Federal Financial Institutions Examination Council (US)
Total State Taxes for North Dakota	Millions of Dollars	U.S. Census Bureau

Exogenous Variables

- Unemployment Rate
- Real Gross Domestic Product
- Crude Oil Prices: West Texas Intermediate (WTI) - Cushing, Oklahoma
- Wheat Producer Price Index
- Corn Producer Price Index
- Soybean Producer Price Index

Metropolitan Area Variables

Fargo MSA

Variable	Units	Source
Unemployment rate in Fargo MSA	Percent	U.S. Bureau of Labor Statistics
Civilian Labor Force in Fargo MSA	10,000 Individuals	U.S. Bureau of Labor Statistics
Average Private Weekly Earnings: Fargo MSA	Dollars per Week	U.S. Bureau of Labor Statistics
All-Transactions House Price Index for Fargo MSA	Current Index Value/100	U.S. Federal Housing Finance Agency
Total Quarterly Wages in Fargo MSA	100 Million Dollars	U.S. Bureau of Labor Statistics

Exogenous Variables

- North Dakota Unemployment Rate
- Civilian Labor Force in North Dakota
- Real Gross Domestic Product : North Dakota
- Total Wages and Salaries in North Dakota
- Nonperforming Loans (past due 90+ days plus nonaccrual): North Dakota
- Total Assets for Commercial Banks in North Dakota
- Total State Taxes for North Dakota
- Crude Oil Prices: West Texas Intermediate (WTI) - Cushing, Oklahoma
- Wheat Producer Price Index
- Corn Producer Price Index
- Soybean Producer Price Index

Bismarck, ND

Variable	Units	Source
Unemployment Rate in Bismarck MSA	Percent	U.S. Bureau of Labor Statistics
Civilian Labor Force in Bismarck MSA	10,000 Individuals	U.S. Bureau of Labor Statistics
Average Private Weekly Earnings in Bismarck MSA	Dollars per Week	U.S. Bureau of Labor Statistics
All-Transactions House Price Index for Bismarck MSA	Current Index Value/100	U.S. Federal Housing Finance Agency
Total Quarterly Wages in Bismarck MSA	100 Million Dollars	U.S. Bureau of Labor Statistics

Exogenous Variables

- North Dakota Unemployment Rate
- Civilian Labor Force in North Dakota
- Real Gross Domestic Product : North Dakota
- Total Wages and Salaries in North Dakota
- Nonperforming Loans (past due 90+ days plus nonaccrual): North Dakota
- Total Assets for Commercial Banks in North Dakota
- Total State Taxes for North Dakota
- Crude Oil Prices: West Texas Intermediate (WTI) - Cushing, Oklahoma
- Wheat Producer Price Index
- Corn Producer Price Index
- Soybean Producer Price Index

Grand Forks MSA

Variable	Units	Source
Unemployment Rate in Grand Forks MSA	Percent	U.S. Bureau of Labor Statistics
Civilian Labor Force in Grand Forks MSA	10,000 Individuals	U.S. Bureau of Labor Statistics
Average Private Weekly Earnings in Grand Forks MSA	Dollars per Week	U.S. Bureau of Labor Statistics
All-Transactions House Price Index for Grand Forks MSA	Current Index Value/100	U.S. Federal Housing Finance Agency
Total Quarterly Wages in Grand Forks MSA	100 Million Dollars	U.S. Bureau of Labor Statistics

Exogenous Variables

- North Dakota Unemployment Rate
- Civilian Labor Force in North Dakota
- Real Gross Domestic Product : North Dakota
- Total Wages and Salaries in North Dakota
- Nonperforming Loans (past due 90+ days plus nonaccrual): North Dakota
- Total Assets for Commercial Banks in North Dakota
- Total State Taxes for North Dakota
- Crude Oil Prices: West Texas Intermediate (WTI) - Cushing, Oklahoma
- Wheat Producer Price Index
- Corn Producer Price Index
- Soybean Producer Price Index

Commodities

Variable	Units	Source
Wheat Producer Price Index	Current Index Value	U.S. Bureau of Labor Statistics
Corn Producer Price Index	Current Index Value	U.S. Bureau of Labor Statistics
Soybean Producer Price Index	Current Index Value	U.S. Bureau of Labor Statistics
Crude Oil Prices: West Texas Intermediate (WTI) - Cushing, Oklahoma	Quarterly Average Price Per Barrel	U.S. Energy Information Administration

Exogenous Variables

- Real Personal Consumption
- Real Gross Domestic Product