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## The Treasury Bill Rate, the Great Recession, and Neural Networks Estimates of Real Business Sales

Anthony Joseph<sup>a,\*</sup>, Maurice Larrain<sup>b</sup>, Claude Turner<sup>c</sup>

<sup>ab</sup>*Pace University, One Pace Plaza, New York, New York 10038, U.S.A.*

<sup>c</sup>*Bowie State University, 14000 Jericho Park Road, Bowie, MD 20715, U.S.A.*

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### Abstract

This paper analyzes out-of-sample forecasts of real total business sales. We study monthly data from January 1970 to June 2012. The predictor variable, 3-month Treasury bill interest rate, was used with both the regression (used as a benchmark) and neural network models. The neural network models, trained in supervised learning with the Levenberg-Marquardt backpropagation through time algorithm, prediction accuracy was confirmed with correlation coefficient and root mean square tests. The activation function used for the focused gamma models of the time-lag recurrent networks in both the hidden and output layers was tanh. The forecast period ranged from January 2006 to June 2012 thus encompassing the past recession. The real business sales variable is one of the indicators used as a coincident index of the U.S. business cycle, and is included among the variables studied by the Federal Reserve to formulate monetary policy. It is thus an important indicator surrogating for real GDP, which is reported quarterly and with a longer time delay. Our analysis shows that recent recessions have increased in duration, so that using a 36-month change to approximate an average cycle in estimating and forecasting is more relevant and accurate than past usage of a 24-month change.

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\* Corresponding author. Tel.: 1212-346-1492; fax: +0-000-000-0000 .  
*E-mail address:* [ajoseph2@pace.edu](mailto:ajoseph2@pace.edu).

## 1. Introduction

The economic and financial crisis of 2007-2009 known as the “Great Recession” is the most severe downturn experienced in the United States since the Depression of the late 1920’s through 1930’s. The recovery from the recent recession is also notable by taking longer than any other post World War II recovery. By June 2012, three years after the trough of the recession was called, indicators such as sales, industrial production and unemployment were performing far below their comparative values in previous upturns. Records made available by the Federal Reserve showed that up to the very start of the Great Recession the Federal Reserve was unaware of the forthcoming crisis and was primarily focused on incipient inflation as a problem<sup>1</sup>.

Post-event analysis revealed that the mainstream academic and financial communities saw the recession as unpredictable. Among the reasons were securitization that promoted advances in financial innovations and changes in banking practices over the late 1990’s and early part of this century as well as the emergence of a shadow banking sector, since both were viewed as fostering unforeseen structural changes in the economy<sup>2</sup>. Nevertheless, some professionals did forecast elements of the crisis well in advance<sup>3</sup>. In addition, the recession was also forecasted by interest rates and the interest rate spread (albeit the spread performed weakly), which are predictors of business cycle recessions. This study seeks to support the latter proposition that the economic downturn itself was predictable and that the predictions were feasible for well over twenty months in advance.

The interest rate and the interest rate spread are used to forecast economic conditions including recessions, real GDP, total real sales, and total inventories. The reason interest rates have predictive ability over aggregate macroeconomic variables is because they reflect the monetary policy of the Federal Reserve. Monetary expansion stimulates the economy with a time lead by lowering interest rates. Monetary contractions have the opposite effect: increased money results in rising interest rates, which over time act to reduce economic growth. Recent work on the predictive ability of the interest rate spread includes Rudebusch<sup>4</sup>, Abdymomunov<sup>5</sup> and Gilchrist et al<sup>6</sup>. A detailed survey of the spread literature as a forecaster is found in Wheelock and Wohar<sup>7</sup>. Seminal studies that focused on interest rate as a predictor includes Zarnowitz<sup>8</sup> and King and Watson<sup>9</sup>. More recent works are attributable to Joseph et al<sup>10</sup> and Stock and Watson<sup>11</sup>.

A lessening of the ability of the spread to forecast recent real GDP and sales<sup>12</sup> appears to be concurrent with a change in the length of business cycles’ durations. The National Bureau of Economic Research (NBER) reported that of the 12 recessions in the U.S. since 1945; the first 9 had an average half-cycle of peak-to-peak and trough-to-trough of 26.6 months durations<sup>13</sup>. When the last 3 recessions from 1990 to date are also included, the duration increases to 35.4 months, thus lending further credence to the Gorton et al<sup>2</sup> observation of possible structural changes in the economy. Several past studies on interest rate forecasting ability have used a 24-month change/cycle in the dependent and independent variables based on the NBER data from 1945 to 1990, but as the NBER’s updated information through 2013 showed, the average length of the cycles has been steadily increasing since the 1990’s, and the average half-cycle reported by the NBER is now closer to 36 months. Some examples of studies using the 24-month cycle included Larrain<sup>14,15</sup> and Joseph et al<sup>2,16</sup>.

The intention of this study is to generate predictions of both the downturn and recovery of the Great Recession. The hypothesis is that models based on the 36-month cycle are statistically more stable, and will outperform those based on 24-month cycle assumptions as they will produce forecasts that more closely conform to the National Bureau of Economic Research’s updated information on business cycles. The forecasts generated from these two types of models under the neural network scheme will be subsequently benchmarked against similar forecasts produced by regression models. The accuracy of the forecasts will be determined using correlation, root mean square error, mean absolute error, mean error, mean absolute percent error, percent of correct direction, and Thiel inequality coefficient statistics.

## 2. Methods and Materials

The data consists of real total business sales (RTBS), which is the aggregate of all manufacturing, wholesale and retail sales in the U.S., reported on a monthly basis by the U.S. Department of Commerce, Bureau of the Census. RTBS is often used as a surrogate for the gross domestic product (GDP) since their correlation is 0.98, and it is available much earlier and more frequently than the GDP. The second time series used is the U.S. 90-day monthly

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