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News-based forecasts of macroeconomic indicators: A semantic path model for interpretable predictions

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ABSTRACT

The macroeconomic climate influences operations with regard to, e.g., raw material prices, financing, supply chain utilization and demand quotas. In order to adapt to the economic environment, decision-makers across the public and private sectors require accurate forecasts of the economic outlook. Existing predictive frameworks base their forecasts primarily on time series analysis, as well as the judgments of experts. As a consequence, current approaches are often biased and prone to error. In order to reduce forecast errors, this paper presents an innovative methodology that extends lag variables with unstructured data in the form of financial news: (1) we apply a variety of models from machine learning to word counts as a high-dimensional input. However, this approach suffers from low interpretability and overfitting, motivating the following remedies. (2) We follow the intuition that the economic climate is driven by general sentiments and suggest a projection of words onto latent semantic structures as a means of feature engineering. (3) We propose a semantic path model, together with estimation technique based on regularization, in order to yield full interpretability of the forecasts. We demonstrate the predictive performance of our approach by utilizing 80,813 ad hoc announcements in order to make long-term forecasts of up to 24 months ahead regarding key macroeconomic indicators. Back-testing reveals a considerable reduction in forecast errors.

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1. Introduction

Macroeconomic developments, such as cyclic downturns or the economic circumstances associated with the U. S. subprime crisis, affect firm operations in multiple ways and represent direct challenges to management (e. g. Demyanyk & Hasan, 2010; Goudie & Meeks, 1982). Examples include changes in the price of goods and raw materials, as well as the impact on overall demand, supply chain utilization and even operational processes (Xu, Pinedo, & Xue, 2017). Therefore, firms are interested in foreseeing the future economic climate in order to manage operations accordingly and hedge potential risks. In this context, operational research (OR) has a long tradition of addressing such risks (Demyanyk & Hasan, 2010). Our discipline has thus contributed to anticipating a variety of developments at a macroeconomic level, including financial distress (Geng, Bose, & Chen, 2015), liquidity risks (Shaik, 2015), credit risks (Akkoç, 2012; Desai, Crook, & Overstreet, 1996), finan-

cial crises (Demyanyk & Hasan, 2010; Huang, Kou, & Peng, 2017), currency crises (Sevim, Oztekin, Bali, Gumus, & Guresen, 2014) and bankruptcy (Du Jardin, 2015; McKee & Lensberg, 2002; Sun & Shenoy, 2007), especially in the financial sector (Tam & Kiang, 1992).

Future expectations regarding the macroeconomic environment play a critical role in the decision-making process for many organizations (Xu et al., 2017). Hence, decision-makers across all sectors must analyze the current economic environment and form accurate expectations about future economic trends in order to support the operational strategy of organization and long-term management. As a result, macroeconomic variables, and the accurate prediction thereof, form the basis for a wide array of OR models (e. g. Calabrese, Degl'Innocenti, & Osmetti, 2017; Fethi & Pasiouras, 2010; Gutiérrez & Lozano, 2012).

The importance of accurate long-term forecasts for firm operations has driven the extensive amount of research conducted with respect to macroeconomic predictions. Specific examples from the OR domain include short-term predictions of asset-related values, including government bonds (Tay & Cao, 2001) and stock

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indices (e. g. Huang, Nakamori, & Wang, 2005; Kung & Yu, 2008; Oztekin, Kizilaslan, Freund, & Iseri, 2016). Further research focuses on forecasting macroeconomic indicators of single countries (e. g. Mahmoud, Motwani, & Rice, 1990) or the relationship between countries (Sermpinis, Theofilatos, Karathanasopoulos, Georgopoulos, & Dunis, 2013). Other works propose agent-based simulations to study the behavior of human forecasters (Bovi & Cerqueti, 2016).

Previous efforts at forecasting macroeconomic indicators have made use of various input features and methodologies. Historic time series data is a staple input for macroeconomic forecasting, and has been applied to make both short- and long-term predictions (e. g. Jansen, Jin, & de Winter, 2016; Mahmoud et al., 1990; Sermpinis et al., 2013). A prevalent alternative is the subjective judgments of professional forecasters (Matsypura, Thompson, & Vasnev, 2018) such as those used by the European Central Bank. However, both time series models and subjective forecasts suffer from severe prediction errors (Jansen et al., 2016), possibly because they cannot benefit from predictors that better measure the state and outlook of the economy.

It is plausible that macroeconomic forecasting could also benefit from the advances of the big data era (Mortenson, Doherty, & Robinson, 2015) and potential improvements in predictive modeling. Especially unstructured data, such as news, promises further insights into global systems and the heterogeneous trends and events that occur within them. Hence, news represents a powerful source of information for financial forecasting and is thus likely to serve as an intriguing – yet currently rare – predictor for macroeconomic forecasts.

Our research therefore aims to improve macroeconomic forecasts using financial disclosures. Financial news, in particular, conveys rich information about expected firm performance that often goes beyond pure numeric data (e. g. Tsai & Wang, 2017). Text mining of financial news has been successfully used in conjunction with predictive analytics to infer profitable short-term investment decisions in capital markets (Feuerriegel & Prendinger, 2016; Nassirtoussi, Aghabozorgi, Wah, & Ngo, 2014). However, it is unclear whether financial filings – which should essentially mirror the current health of the firm – also provide long-term prognostic capacity.

To make long-term predictions of macroeconomic indicators, we construct an approach as follows: we use financial news and insert corresponding linguistic features into various machine learning methods. Our specific setting represents a major difference from previous news-based forecasts, in the sense that the outcome variable is reported in monthly or quarterly resolution. This results in fewer observations and thus extremely high-dimensional predictor matrices with severe risks of overfitting. To overcome this challenge, we develop a form of feature engineering based on semantic projections and, on top of that, propose a semantic path model that fulfills the demand of practitioners by being fully interpretable. Afterwards, we conduct an out-of-sample evaluation of the predictive performance. The results demonstrate that our approach is superior in terms of relative performance when compared to common time series models that serve as a benchmark.

The remainder of this paper is structured as follows. Section 2 reviews related research on macroeconomic forecasting in order to outline the aforementioned research gap. As a remedy, Section 3 explains our methodology for making news-based macroeconomic predictions, with a particular focus on the proposed projections to latent semantic structures. Section 4 reports the datasets, based on which Section 5 compares the predictive performance of both traditional time series models and news-based forecasts. A discussion of managerial implications follows in Section 6, while Section 7 concludes with an outlook on future research.

2. Background

2.1. Predictive models for macroeconomic forecasts

Beyond human predictions (Matsypura et al., 2018), common approaches to macroeconomic forecasting include various time series models (Allen & Morzuch, 2006), for instance, auto-regressive moving-average (ARMA) models and their multivariate variations, such as vector autoregression and vector error correction models. However, their use entails certain challenges, since they must be adapted to cope with structural changes in the underlying systems (Litterman, 1986). Nevertheless, time series models still appear to be the standard benchmark against which the predictive performance of alternative approaches is measured (de Gooijer & Hyndman, 2006).

Since vector autoregression and its variants are limited to a few variables, researchers have proposed alternative models, such as Bayesian vector autoregression (BVAR). The BVAR accounts more accurately for uncertainty regarding the structure of the economy and is utilized to handle instances with dozens of relevant variables (Litterman, 1986). Its use for forecasts requires extensive computational resources, especially when dealing with many predictors (Carriero, Clark, & Marcellino, 2015; Litterman, 1986).

Bridge equations have been suggested as an alternative means of incorporating relevant explanatory variables into predictive models. This approach is a form of linear regression that time-aggregates economic time series to bridge the information gap between low and high frequency indicators. It is a widely used method for forecasting macroeconomic variables (Jansen et al., 2016). However, these forecasts are generally limited to one or two periods ahead.

A different concept is represented by leading indicators. These are supposed to provide prognostic capabilities for future changes in the economic outlook. Examples include major stock indices, the Ifo Business Climate Index from Germany, or the University of Michigan Consumer Sentiment Index for the United States. These indices can yield important information regarding future cyclical fluctuations of the general economy (Allen & Morzuch, 2006) and they have thus been used to forecast imminent turning points in the business cycle (Layton & Smith, 2007). Predictive models using leading indicators have been applied, for instance, in single variable ARMA models, multivariate models, diffusion indices and BVAR (Allen & Morzuch, 2006; Stock & Watson, 2002). However, it is not clear whether these indices have a prognostic potential for future developments.

Since previous approaches to macroeconomic forecasting have primarily focused on using various forms of economic data as dynamic predictors, the use of qualitative or unstructured data, such as financial news, deserves the attention of researchers. However, the inclusion of larger numbers of predictors in traditional time series models can prove to be problematic, as such models typically struggle with such settings (Jansen et al., 2016; Litterman, 1986). The above literature review thus motivates our choice of models: we specifically decided to utilize different machine learning models that can cope with non-linear relationships and large numbers of textual features.

2.2. Predictive text mining with financial news

News-based predictions of macroeconomic indicators constitute an innovative area of research. Due to the scarcity of related publications, we decided to extend our literature overview and also include news-based forecasts of stock returns in addition to macroeconomic variables.

Text mining of financial news have been successfully used in conjunction with predictive analytics to infer profitable short-term

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