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# Macroeconomic forecasting during the *Great Recession*: The return of non-linearity?

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ABSTRACT

The debate on the forecasting ability of non-linear models has a long history, and the *Great Recession* episode provides an interesting opportunity for a re-assessment of the forecasting performances of several classes of non-linear models. An extensive analysis is performed over a broad cross-country database of the main macroeconomic indicators. The results suggest that, on average, non-linear models cannot outperform standard linear specifications, even during the *Great Recession* episode. However, non-linear models do lead to an improvement in predictive accuracy in almost 40%–45% of cases, and interesting specific patterns arise across models and variables, though in general the gains are limited. Overall, our findings are consistent with the hypothesis that describes this recent recession episode as a sequence of unusually large shocks, rather than as an increase in the degree of non-linearity in the stochastic processes underlying the main macroeconomic time series.


## 1. Introduction

Non-linear models have been used extensively in empirical economics, mainly in attempts to replicate key features of the business cycle, such as phases of recessions and expansions spanning the periods between (swift or smooth) turning points. Much of this body of literature has been built on the Markov-switching models popularized by Hamilton (1989), as well as on the threshold models introduced by Teräsvirta and Anderson (1992) and Tong and Lim (1980). Basically, these models allow for regime-switching parameters, and the underlying dynamics can be driven by either an unobserved or an observed process, such as the past behavior of the variable itself or of other economic variables. Time-varying models have also been implemented successfully in the literature (see Nicholls & Pagan, 1985, for example), since they introduce a flexible modeling of macroeconomic series by allowing parameters to evolve continuously over time, thus representing an optimal approximation of general non-linear processes (Granger, 2008).[1]

Nevertheless, the predictive ability of non-linear models appears less clear-cut. In particular, the empirical evidence on the forecasting performances of non-linear

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[1] Other classes of non-linear models consider changes in the conditional variance of the variables (see for example Clark, 2011, or Cogley & Sargent, 2005, for a VAR approach with stochastic volatility). Since the present paper focuses on quarterly macroeconomic variables, we assume that the conditional variances are constant, possibly after allowing for changes in the conditional means.

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specifications, compared to those of linear or even random-walk processes, is rather mixed. On the one hand, Tiao and Tsay (1994) show that threshold models can outperform linear alternatives when forecasting the US GDP. Similarly, Kilian and Taylor (2003) and Teräsvirta, van Dijk, and Medeiros (2005) find evidence of good predictive performances by smooth-transition models for a small set of monthly variables. Stock and Watson (1999) consider more than 200 real and financial series for the US, and point out that non-linear methods can be used to predict wage, employment and exchange rate series accurately over medium- and long-term horizons. More recently, Bec, Bouabdallah, and Ferrara (2014) show that an extended version of threshold models, allowing for bounce-back effects, is able to forecast GDP growth adequately after recessions.

On the other hand, Clements and Smith (2001) show that forecasts from self-exciting threshold models are not more accurate than those obtained from a random-walk process for a set of exchange rate series. Similar results are reported by Boero and Marrocu (2002), Sarantis (1999) and Teräsvirta and Anderson (1992), who compare smooth-transition models to linear alternatives for forecasting industrial production and exchange rate series, respectively. Clements and Krolzig (1998), Montgomery, Zarnowitz, Tsay, and Tiao (1998) and Sarantis (1999) show that Markov-switching forecasting models perform poorly relative to both linear models and other non-linear models. However, Perez-Quiros and Timmermann (2001) point out that a predictive gain can be obtained when looking at higher moments of the data, asymmetric risks and extreme values. Furthermore, Camacho, Perez-Quiros, and Poncela (2014) compare the accuracy levels of euro area GDP forecasts obtained through linear and Markov-switching models, and show that the main contribution of the latter is to provide valuable and timely insights about the state of the economy. Time-varying models and other non-linear specifications have been implemented by Marcellino (2005) over a large dataset of almost 500 variables for the euro area countries. While linear models broadly dominate the non-linear alternatives, in terms of average performances across variables and forecast horizons, non-linear specifications (especially the time-varying ones) outperform the linear models for a subset of variables (see also Stock & Watson, 1996).

All in all, there is no clear consensus on the predictive performance of non-linear models, compared to that of linear challengers. Indeed, the empirical literature suggests that these results depend crucially on several factors, such as the estimation and forecast evaluation periods, the model implemented, the macroeconomic variables considered, and the forecast horizon. In addition, only few studies consider comparative forecasting exercises with non-linear models in an international perspective. For examples, we refer to Marcellino (2005), Rapach and Wohar (2006) and Teräsvirta et al. (2005) for analyses of G7 and euro area countries.

Against this background, the *Great Recession* that occurred in the years 2008–2009 has been a major and virtually unpredictable macroeconomic event, the magnitude of which extended beyond the expectations of most professional forecasters. Indeed, macroeconomic and financial indicators for the major advanced and emerging OECD economies experienced large and sudden drops, almost simultaneously worldwide. As a result, according to various international organisations, including OECD and IMF, the annual global GDP growth was negative in 2009, for the first time since 1970. In the case of the US, Stock and Watson (2012) argue that the recession was caused by a sequence of unusually large shocks, namely an initial oil shock followed by financial and uncertainty shocks.

In view of the observed strong deterioration in the main macroeconomic indicators, this paper aims to reappraise non-linear models and address the issue of whether a part of those sharp movements could be described adequately by a non-linear specification. For this purpose, we report the predictive ability of non-linear models, compared to benchmark linear specifications, over a window that is centered around the global episode of the *Great Recession*.[2] More specifically, we evaluate the predictive performances of a set of univariate non-linear models over the period from 2004Q1 to 2009Q4. The econometric analysis is carried out extensively over a large cross-country quarterly database, including 19 major real and financial variables and 19 advanced and emerging OECD countries. The empirical results are assessed for various forecast horizons, and the forecast evaluation is based on a battery of the usual loss functions (mean squared forecast error) and tests for predictive ability.

The aggregate results for this broad cross-variable and cross-country analysis of the *Great Recession* episode point to a moderate predictive ability of non-linear models: on average, non-linear specifications outperform the linear benchmark for about 40%–45% of the macroeconomic series analyzed. Furthermore, there is no clear-cut improvement in the predictive accuracy of these models during the *Great Recession* episode, relative to the pre-crisis period. In spite of these findings, the predictions for a group of variables (e.g., interest rates and prices) show interesting outcomes under non-linear specifications. We point out that, during the *Great Recession* episode, time-varying specifications seem to outperform the other non-linear models under analysis, suggesting that a flexible parametrization based on the evolutionary dynamics of the autoregressive coefficients can deal with large macroeconomic shocks efficiently. However, it is worth noticing that the predictive gains from time-varying specifications are quite frequent but small, while threshold models may provide infrequent but larger gains. Overall, our findings tend to corroborate the economic interpretation of the *Great Recession* recently proposed by Stock and Watson (2012), who claim that this episode can be described better as a sequence of unusually large shocks than as an increase in the degree of non-linearity.

The paper is structured as follows. The forecasting models are presented in Section 2, while the design of the experiment is detailed in Section 3. Our empirical results are discussed in Section 4. Section 5 summarizes and concludes.

[2] See also Kock and Teräsvirta (2014) for a recent application around this specific period of time.