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A note on the model selection risk for ANOVA based adaptive forecasting of the EURIBOR swap term structure

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A note on the model selection risk for ANOVA based adaptive forecasting of the EURIBOR swap term structure. *

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Abstract

The paper proposes a data driven adaptive model selection strategy. The selection criterion measures economic ex–ante forecasting content by means of trading implied cash flows. Empirical evidence suggests that the proposed strategy is neither exposed to selection bias nor to the risk of choosing excessively poor models from a parameterized class of candidate specifications.

Keywords: Model selection, Principal components, Factor analysis, Ex–ante forecasting, EURIBOR swap term structure, Trading strategies.
JEL classification: C32, C53, E43, G29.

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1 Introduction

Quantitative models are formulated to capture regularities governing economic phenomena. As economic relationships are generally complex, models that tempt to describe all aspects of the reality are complicated, too. In order to focus on the essential and to guarantee computational tractability models are formulated which are approximations to real world phenomena. In practice, an analyst frequently encounters a situation in which several candidate models provide reasonable approximations to reality. When selecting a particular model based on a distinct selection criterion, one might be tempted to include as many models as possible into the class of model candidates. Yet, such an approach entails the problem of selection bias. The chance that a model is best in terms of some selection criterion by pure luck increases with the cardinality of the candidate model class (Zucchini 2000). Moreover, with a growing number of models considered the risk of choosing an excessively unfavorable candidate increases.

Within a time series ex–ante forecasting framework we propose a simple method based on an analysis of variance (ANOVA) to select forecasting models out of a parameterized model class. We do not choose a single model for the entire period. Instead, we adaptively select a model in each time instant based on an economic criterion measuring historic ex–ante forecasting performance over a local time window. It is shown that if a forecasting framework is described by a large parameterized model class, the ANOVA based data driven procedure is a suitable tool for model selection which is neither exposed to selection bias nor to the risk of choosing excessively poor models. In the next Section we introduce the class of model candidates, the economic performance criterion and the selection strategy. In Section 3 the empirical results are described using a time series of EURIBOR swap rates. Section 4 concludes.

2 Econometric model and performance measure

The term structure considered is represented by $M = 10$ EURIBOR swap rates with maturities: 3m (3 months), 6m, 1yr (1 year(s)), 2yr, 3yr, 5yr, 7yr, 10yr, 12yr and 15yr. The data is observed over the period from February 22, 1999 to April 25, 2008. To determine rolling

ex–ante forecasts Blaskowitz and Herwartz (2008) employ the model

$$\tilde{y}_t = \Gamma_K F_t + \xi_t, \quad t = T^* - \tau + 1, \ldots, T^*, \tag{2.1}$$

$$\Delta F_t = \nu + \Phi_1 \Delta F_{t-1} + \ldots + \Phi_p \Delta F_{t-p} + \eta_t. \tag{2.2}$$

In (2.1) $\tilde{y}_t = (\tilde{y}_{1t}, \tilde{y}_{2t}, \ldots, \tilde{y}_{Mt})'$ is a vector of swap rates over the $M = 10$ maturities measured in terms of deviations from their local mean, $\tilde{y}_t = y_t - \bar{y}_{T^*}$, $\bar{y}_{T^*} = 1/\tau \sum_{t=T^*-\tau+1}^{T^*} y_t$. F_t is a K–dimensional vector of factors, $F_t = (f_{1t}, ..., f_{Kt})'$, governing the term structure whose changes exhibit vector autoregressive (VAR) dynamics. The M– respectively K–dimensional error terms ξ_t and η_t are treated as white noise processes. The matrix Γ_K is deduced from a principal components analysis (PCA) by decomposing the estimated covariance matrix $\hat{\Sigma}_{T^*}$ of $\tilde{y}_t$ observed over the period $t = T^* - \tau + 1, \ldots, T^*$. More precisely, Γ_K contains the K eigenvectors corresponding to the K largest eigenvalues of $\hat{\Sigma}_{T^*}$.

Conditioning on the information set $\Omega_{T^*,\tau} = \{y_t \mid t = T^* - \tau + 1, \ldots, T^*\}$ h days ahead ex–ante forecasts of swap rates are formalized by means of conditional expectations implied by (2.1) and (2.2). This gives

$$\hat{y}_{T^*+h} = \Gamma_K \hat{F}_{T^*+h} + \bar{y}_{T^*},$$

where factor implied forecasts are readjusted for the local in–sample mean. To compute factor forecasts $\hat{F}_{T^*+h}$ we estimate a VAR(p) model based on extracted factors $\hat{F}_t = \Gamma_K' \tilde{y}_t$ and iterate forecasts h days ahead.

Model performance is measured by trading implied cash flows. In particular, we consider three strategies based on daily ex–ante forecasts for the 2yr, 5yr and 10yr swap rate. For h days ahead predicted upward (downward) movements in swap rates payer (receiver) swap agreements with a notional of 100 Euros are entered. Cash flows for the swap positions are computed by means of the comparison swap valuation technique (Miron and Swannell 1991) using the realized 2yr, 5yr, 10yr swap rates h days ahead. The bank account starts at zero and contains cumulated cash flows inferred from daily forecasts up to time T^*. Total cash flows are given by cumulated cash flows at the end of the trading period.

3 Results

When specifying the parameters τ, K and p the analyst faces a model selection problem. Blaskowitz and Herwartz (2008) consider a plentitude of 100 contending PCA/VAR models

implied by alternative parameter selections $\tau \in \{42, 63, 126, 189, 252\}$, $K \in \{1, 2, 3, 4, 5\}$ and $p \in \{0, 1, 2, 3\}$. They propose an adaptive model selection procedure based on an ANOVA of trading implied cash flows. The latter procedure is implemented by regressing total cash flows generated over a second local window of 42 days on dummy variables related to the model characteristics (τ, K, p). In this section we compare the economic forecast performance of $h = 1, 5, 10$ days ahead ex–ante forecasts of the adaptive approach and the set of unconditional models. To ensure that the forecasts of all models are compared over the same period of swap rates the rolling window analysis starts on April 19, 2000. Hence 2083 ex–ante forecasts for the 100 unconditional models and the adaptive strategy are available.

From the top panel of Table 1 it can be seen that all adaptive strategies generate positive total cash flows over the 2083 trading days. In particular, total cash flows increase with the forecast horizon as swap rate movements are likely to be larger over multiple days. The performance of the adaptive model selection strategies compares favorably to the performance of the unconditional modeling approach. In four cases out of nine (2yr and 5yr for $h = 5$ and $h = 10$ resp.) the adaptive strategy outperforms at least 90 out of 100 unconditional models. Moreover, for all forecast exercises the adaptive approach is better than at least 70 unconditional specifications. Furthermore, the total cash flow of the adaptive strategy exceeds the average cash flow over all unconditional PCA/VAR models for all trades considered. The class of unconditional PCA/VAR models considered contains specifications having considerable downside risk. The model specification with the minimum total cash flow (MinCF) always generates negative cash flows. Yet, the adaptive selection procedure seems to filter out unfavorable models as indicated by the corresponding total cash flows.

The above ranking of total cash flows is only a snapshot characterizing the last trading day. Figure 1 shows the ranking of the adaptive strategy with respect to unconditional models in terms of cumulated cash flows over time. The data driven ANOVA selection procedure performs strongly in 6 out of 9 (5yr and 10yr for $h = 1$, 2yr and 5yr for $h = 5$ and $h = 10$ resp.) forecast exercises. In these cases the adaptive strategy cumulates higher cash flows than at least 50 unconditional models. Particularly convincing is the performance of the adaptive procedure for the 2yr and 5yr trades for horizons $h = 5, 10$. It performs better than at least 80 unconditional models. For the three remaining forecast exercises (2yr for $h = 1$, 10yr for $h = 5, 10$) it can be seen that in terms of cumulated cash flows the ranking of the

ANOVA selection procedure is more or less fluctuating around the median of unconditional models. The last line of Table 1 shows that the adaptive strategy's time average of the ranking is larger than the time average of the ranking of 50, 69 and 65 unconditional models resp.

Table 1 also provides an insight into the evolution of the bank account for the adaptive and unconditional strategies over the 2083 trading days. The minimum bank account of the adaptive model selection procedure is negative for all forecast exercises considered as can be seen from the first panel of Table 1. However the adaptive approach is always better than at least 50 of the 100 unconditional models as shown in the third panel of Table 1 (RankMinBank).

	2yr			5yr			10yr		
	$h=1$	$h=5$	$h=10$	$h=1$	$h=5$	$h=10$	$h=1$	$h=5$	$h=10$
CF	12.24	38.84	100.18	33.49	71.00	164.41	36.42	78.94	118.88
MinBank	-1.29	-3.26	-7.74	-1.13	-8.12	-20.42	-1.13	-14.15	-29.30
MinCF	-1.00	-5.98	-24.80	-11.58	-47.13	-53.56	-12.07	-90.05	-106.08
AvCF	9.86	18.38	31.97	18.33	32.42	58.84	26.08	51.01	80.49
RankCF	70	90	100	88	92	98	80	79	78
MaxCF	22.31	46.91	95.33	45.05	96.51	180.49	48.23	138.51	244.49
MinMinBank	-5.35	-21.72	-46.44	-12.41	-55.28	-71.45	-13.69	-105.53	-144.88
RankMinBank	51	77	74	48	68	74	73	54	53
MaxMinBank	0.03	-0.85	-3.16	0.20	-1.36	-10.46	0.15	-0.29	-6.37
AvRankBank	50	87	94	83	91	100	88	69	65

Table 1. Results for the adaptive strategy and some summary measures for the set of unconditional models for each forecast exercise over the period April 19, 2000 to April 11, 2008. CF and MinBank denote the total cash flow and the minimum bank account of the adaptive strategy. MinCF, AvCF and MaxCF give the minimum, average and maximum total cash flow, respectively, over all the unconditional PCA/VAR models. RankCF is the rank of the adaptive strategy within the set of unconditional models when ordered according to total cash flows. MinMinBank and MaxMinBank denote the minimum resp. maximum value of the minimum bank account over the 2083 trading days over all unconditional models. RankMinBank resp. AvRankBank are the ranks of the adaptive strategy within the set of unconditional models when ordered according to the minimum bank account value resp. when ordered according to the time average of ranks (see also Figure 1).

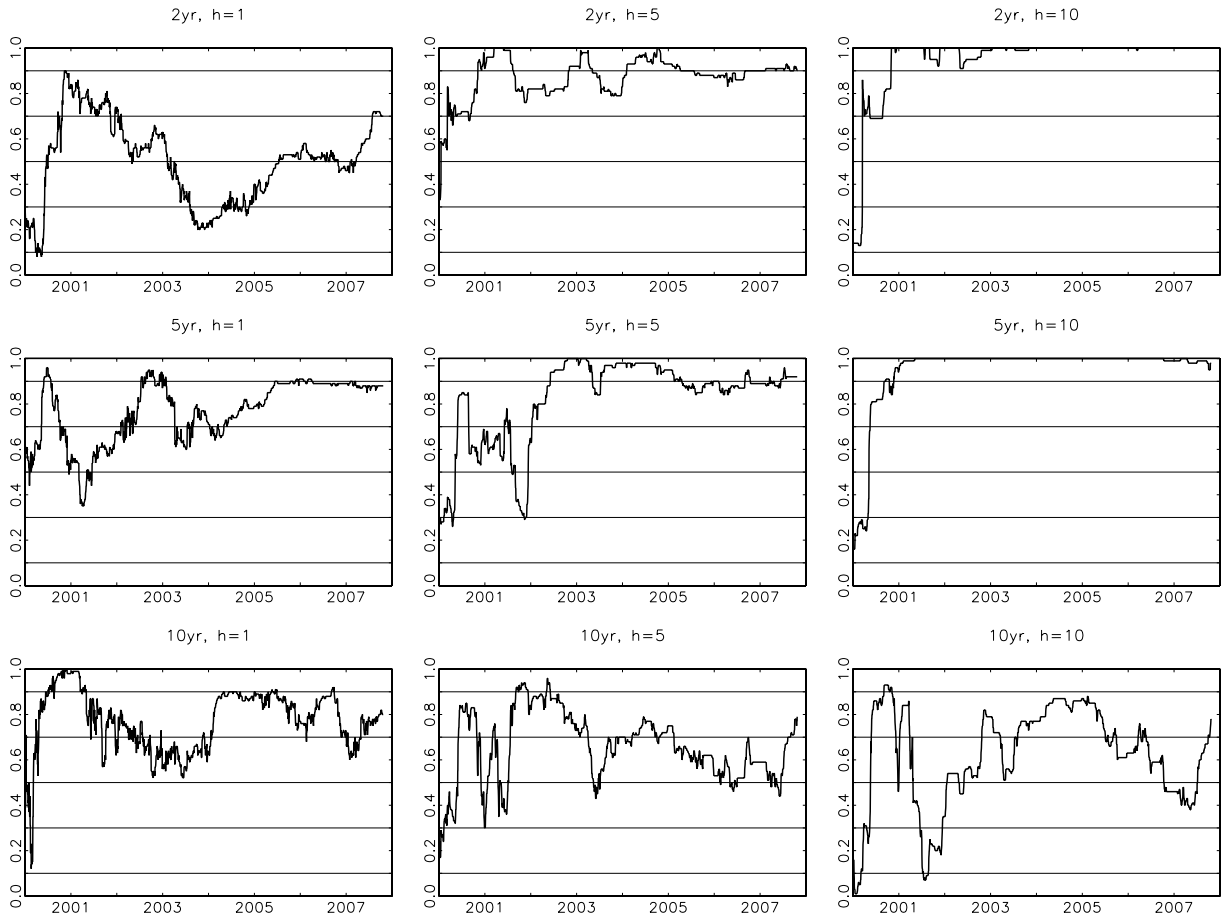

Figure 1. Rankings of the adaptive strategy with respect to the set of 100 unconditional models over the period April 19, 2000 to April 11, 2008. The value of the bank account at time T^* is used as the ranking criterion. Horizontal lines represent the 10th, 30th, ..., 90th quantile of unconditional models in time T^* according to the bank account value.

4 Conclusion

In an empirical application to forecast the EURIBOR swap term structure we show that ANOVA based adaptive model selection performs strongly when compared to a set of 100 candidate models in economic terms. As a conclusion data–driven adaptive model selection based on local ex–ante economic forecasting performance merits consideration to avoid model selection bias.

References

Blaskowitz, O. and H. Herwartz, 'PCA based ex–ante forecasting of swap term structures', *International Journal of Theoretical and Applied Finance*, forthcoming in 2008.

Miron P. and P. Swannell, *Pricing and hedging swaps*, Euromoney Publications PLC, London (1991).

Zucchini, W., 'An introduction to model selection', *Journal of Mathematical Psychology*, **44**, 41–61 (2000).

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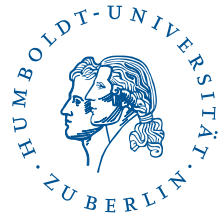

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