



UNIVERSITÄT  
LEIPZIG

Wirtschaftswissenschaftliche  
Fakultät  
Faculty of Economics and  
Management Science

Working Paper, No. 152

Pablo Duarte / Bernd Süßmuth

**Implementing an approximate dynamic  
factor model to nowcast GDP using  
sensitivity analysis**

Februar 2018

ISSN 1437-9384

# Implementing an approximate dynamic factor model to nowcast GDP using sensitivity analysis

Pablo Duarte<sup>a</sup> and Bernd Süßmuth<sup>a,b</sup>

<sup>a</sup>*University of Leipzig*<sup>\*†</sup>

<sup>b</sup>*CESifo*

## Abstract

Dynamic factor models based on Kalman Filter techniques are frequently used to nowcast GDP. This study deals with the selection of indicators for this practice. We propose a two-tiered mechanism which is shown in a case study to produce more accurate nowcasts than a benchmark stochastic process and a standard model including extreme bounds fragile indicators. Nowcasting accuracy nearly measures up to the one of real-time forecasts by an institution with an interest in high-quality nowcasts.

JEL classification: C38, C53

Keywords: Dynamic factor, Kalman Filter, extreme bounds analysis

---

\*Correspondence: University of Leipzig, Grimmaische Str. 12, D-04109 Leipzig, Germany  
Email contact: [suessmuth@wifa.uni-leipzig.de](mailto:suessmuth@wifa.uni-leipzig.de), [duarte@wifa.uni-leipzig.de](mailto:duarte@wifa.uni-leipzig.de)

†We thank the editor, Michael Graff, two anonymous referees, Katja Heinisch, Esther Ruiz, Domenico Giannone, Massimiliano Marcellino, Rolf Scheufele, Christian Schuhmacher, and participants of seminars at the University of Leipzig, the IWH-CIREQ Macroeconometric Workshop on Forecasting and Big Data, and the IWH-IEW Workshop on Nowcasting and Forecasting for many comments and suggestions that markedly improved our paper.

## 1 Introduction

GDP data is published quarterly with a lag of several weeks. Relying on relevant variables which are available earlier and at higher frequency, an “approximate” dynamic factor model (ADFM) can be used to deduce a common indicator to nowcast GDP. The outcome is a GDP series of higher frequency than its actual one (Aruoba et al., 2009, Camacho and Perez-Quiros, 2010, Camacho and Doménech, 2012, and Camacho and Garcia-Serrador, 2014).<sup>1</sup>

A central aspect of this class of small-scale nowcasting models is the pre-selection of indicators for the ADFM.<sup>2</sup> For example, Camacho and Perez-Quiros (2010, p. 672-674) suggest a selection procedure based on “successive enlargements.” Due to ordering in their screening out, they do not treat candidate variables symmetrically. Our contribution is to overcome this deficiency by proposing to subject the selection of indicators to an extreme bounds analysis (EBA); see e.g. Levine and Renelt (1992). The selection of indicators is illustrated for a sample case in two steps. First, we reduce a set of 258 monthly time series related to Spanish GDP to 27 (14) by keeping only the series showing a reasonable correlation with GDP, both contemporaneously and at its quarterly and yearly lags. In a second step, we apply an EBA procedure to drop “non-robust” indicators. To identify robust indicators, the strategy is to consider all possible regressions with quarterly GDP as dependent that can be estimated by taking combinations of a parsimonious subset (*micro-scale*) of pre-selected series (*small-scale*). The sensitivity analysis then consists in checking for each series whether the resulting distribution of parameter estimates has only positive or negative support, that is, whether the respective coefficient estimate does not change its sign in all regression runs. The latter should, at least, hold in an interval of so-called “extreme bounds” (Levine and Renelt, 1992).

We interpret and apply EBA as shrinkage device. Moreover, we prefer EBA to other more timely shrinkage devices such as the least absolute shrinkage and selection operator (LASSO) and ridge regressions or subset regressions based methods (see, e.g., Elliott et al., 2013) as for the latter the focus is on forecast performance, whereas it is on qualitative characteristics of series in the EBA case. EBA selects more economically meaningful indicator series into the micro-scale ADFM by assuring that they do not change, for instance, from procyclical to countercyclical (or from coinciding to either leading or lagging) indicators depending on covariate subset compositions

---

<sup>1</sup>In practice, an ADFM modifies the exact dynamic factor model by Stock and Watson (1991) to account for problems of different frequency and asynchronous publication of series underlying the real-time forecast in applying a Kalman Filter strategy to fill up the series. For a more exact distinction see, e.g., Luciani (2014). Notably, Giannone et al. (2008), technically, were the first to develop the nowcasting methodology in large scale nowcasting models.

<sup>2</sup>We refer to small-scale as diffusion index forecasts (Stock and Watson, 2002) based on rather small two-digit numbers sets of indicators.

during shrinkage.

Against this backdrop, our central research questions can be summarized as follows:

1. Does it pay to consider a symmetric shrinkage device in the pre-selection process?
2. Does *robust* parsimony improve nowcasts, even if we rely on a rather ad hoc pre-selection device and a shrinkage device with focus on selecting economically meaningful indicators rather than on pure forecast performance in going from small-scale to micro-scale ADFM?

## 2 Approximate Dynamic Factor Model

The general idea behind an ADFM is that each series of a set can be written as sum of two stochastic components: a *common* factor  $f_t$ , which e.g. reflects the overall business cycle and an *idiosyncratic* component  $u_t$  which captures specific characteristics of each series. In general it reads

$$y_t = \mathbb{L}f_t + u_t, \quad (1)$$

where  $y_t$  is a  $K \times 1$  vector of variables,  $f_t$  an  $N \times 1$  vector of common factors with  $N < K$ , and  $\mathbb{L}$  a  $K \times N$  matrix of *factor loadings*. Furthermore,

$$f_t = A_1 f_{t-1} + \dots + A_p f_{t-p} + \eta_t; \quad u_t = C_1 u_{t-1} + \dots + C_q u_{t-q} + \varepsilon_t, \quad (2)$$

where  $\eta_t$  and  $\varepsilon_t$  represent white noise processes. To be estimated are matrices  $\mathbb{L}$ ,  $A_i$ , and  $C_i$  for  $i = 1, \dots, p$ . Growth rate  $\gamma$  then is forecasted by

$$\gamma_{t+h} = \mu + a(L)\gamma_t + b(L)\hat{f}_t + e_{t+h}, \quad (3)$$

where  $a(L)$  and  $b(L)$  denote lag polynomials in  $L$  of order  $p_a$  and  $p_b$ , i.e.  $a_0 + a_1 L + \dots + a_{p_a} L^{p_a}$  and  $b_0 + b_1 L + \dots + a_{p_b} L^{p_b}$  (Breitung and Eickmeier, 2006). An ADFM comprises three steps: (i) computation of the Gaussian likelihood using the Kalman Filter, (ii) estimation of  $\mathbb{L}$ ,  $A_i$  and  $C_i$ , and (iii) use of the Kalman Filter smoother to obtain estimates of  $f_t$ .

## 3 Implementation and in-sample analysis

Spanish GDP growth is stationary and available in quarterly frequency between 1975 and 2011 (solid line in Figure 1). A group of indicators ( $y_t$ ) driven by the same common factor as the growth rates of GDP must be selected to calculate the factor  $\hat{f}_t$ .

### 3.1 Implementation

Initially, we consider 258 variables related to Spanish GDP. All variables are available in monthly frequency and cover, at least, 10 years during the period at stake. All non-deseasonalized series were seasonally adjusted. Time series which were not stationary in levels were log first differenced. All monthly rates are tested stationary.

**Choice of core-set of indicators.** We first consider the correlation coefficients ( $\rho$ ) of each series and its quarterly and yearly lags with GDP growth (henceforth, denoted by  $\gamma_t$  representing first differences of the natural log of real GDP). To qualify it is required that  $|\rho| > .5$ . In our sample 27 series meet the requirement.

**Dynamic extreme bounds analysis.** In a second step we apply a non-standard EBA<sup>3</sup> to check if the remaining  $K = 27$  candidate indicators are “robust” in explaining GDP growth, i.e. if they are stable in their relationship with GDP growth. To this end, for each of the  $K$  candidate variables  $c$  a total number of  $J$  of the following regressions are estimated

$$\gamma_t = \delta_j + \beta_{c_j} c_t + \sum_{i=1}^k \beta_{x_{i,j}}(L) x_{t,i,j} + \varepsilon_{t,j}, \quad (4)$$

where  $x_{i,j}$  denotes a vector of up to three ( $k = 3$ ) additional indicator candidates, acting as randomly assigned conditioners in each of the  $J$  regression models. The order  $p_{x_\beta}$  of the polynomial  $\beta_{x_{i,j}}(L)$  in  $L$  is chosen on the basis of information criteria AIC and BIC for each  $k$ , respectively. The maximum lag order is set to 12. Note, if a variable is chosen in  $\geq 1$  lagged expression for the  $x$ -set, it is also considered both in contemporaneous form and in all approved lagged expressions for  $c_t$ . This is why we refer to our EBA version as “dynamic” EBA (DEBA). Hence, the minimum number of models to be checked  $J^{\min}$  is

$$J^{\min} = \binom{K-1}{k} = \frac{(K-1)!}{k!(K-1-k)!} \quad (5)$$

In our case ( $K - 1 = 26$ ;  $k = 3$ ),  $J^{\min} = 2,600$  and a total number  $K \times J^{\min} = 27 \times 2,600 = 70,200$  is to be estimated disregarding  $L$ . Considering  $L$ , we actually estimate a total of  $K \times J = 309,960$  models. For each model  $j$ , we obtain estimates  $\hat{\beta}_{c_j}$  and  $\hat{\sigma}_{\hat{\beta}_{c_j}}$  distributed across regressions  $j = 1, \dots, J$ . Next an upper and lower extreme

---

<sup>3</sup>If standard EBA is defined by the seminal approaches advocated in Levine and Renelt (1992), in Sala-i-Martin (1997), sometimes referred to as “modified EBA”, and in Hoover and Perez (2004, p. 774-775), our approach is a hybrid version of all three of them. Following Levine and Renelt (1992), we consider one focus variable (in our notation  $c$ ). Like Sala-i-Martin (1997) we take into account *exactly* (and not *at most* as in Levine and Renelt, 1992) three “doubtful” variables in the conditioning set. And, as in Hoover and Perez (2004), we abstract from any other fixed subset of series (or, in general, variables) that we always include as covariates. However, we stick with the “strict” robustness definition of Levine and Renelt (1992) and also do not likelihood weight estimates.

bound ( $EB$ ) for each candidate indicator  $c$  and for each model  $j$  is defined:

$$\widehat{\beta}_{c_j} \pm 2\widehat{\sigma}_{\widehat{\beta}_{c_j}}. \quad (6)$$

A candidate indicator is said to be robust if for all models  $J$

$$\text{sign}(EB_L) = \text{sign}\left(\widehat{\beta}_{c_j} - 2\widehat{\sigma}_{\widehat{\beta}_{c_j}}\right) = \text{sign}(EB_U) = \text{sign}\left(\widehat{\beta}_{c_j} + 2\widehat{\sigma}_{\widehat{\beta}_{c_j}}\right); \quad (7)$$

in contrast, it is identified as fragile if

$$\text{sign}(EB_L) = \text{sign}\left(\widehat{\beta}_{c_j} - 2\widehat{\sigma}_{\widehat{\beta}_{c_j}}\right) < 0 < \text{sign}(EB_U) = \text{sign}\left(\widehat{\beta}_{c_j} + 2\widehat{\sigma}_{\widehat{\beta}_{c_j}}\right). \quad (8)$$

The intuition behind applying EBA is straightforward: whether a candidate indicator  $c_t$  behaves procyclically or countercyclically, i.e. is positively or negatively related with  $\gamma_t$ , is a defining property. This property should not change by including other indicator series as covariates, i.e. should not depend on whether  $\gamma_t$  is subjected to a randomly drawn set of further indicators in contemporaneous or contemporaneous and lagged expressions. In our sample case, we identify 14 variables as robust (Table 1).

1. INDUSTRY: MANUFACTURING - PRODUCTION TREND RECENT MONTHS
2. INDUSTRY: MANUFACTURING - ORDER BOOKS
3. INDUSTRY: MANUFACTURING - INDUSTRIAL CONFIDENCE
4. CONSUMER SURVEY: ECONOMIC SITUATION NEXT 12 MTH.
5. CONSUMER SURVEY: FINANCIAL SITUATION NEXT 12 MTH.
6. INDUSTRY SURVEY: PROD.EXPECTATION FOR MTH. AHEAD
7. INDUSTRY SURVEY: ORDER BOOK POSITION
8. INDUSTRIAL CONFIDENCE INDICATOR
9. INDUSTRY SURVEY: PROD. TRENDS IN RECENT MTH.
10. WORKERS ON LABOR REGISTER AFFILIATED TO SOCIAL SECURITY (First Differences)
11. INDUSTRIAL PRODUCTION - CONSUMER GOODS (First Differences)
12. INDUSTRIAL PRODUCTION - CAPITAL GOODS (First Differences)
13. INDUSTRIAL PRODUCTION - INTERMEDIATE GOODS (First Differences)
14. MADRID S.E - REAL ESTATE & FINANCE (First Differences)

Table 1: Selected variables to calculate the common leading factor

To sum up and to benchmark EBA against another widely used shrinkage device, consider the general LASSO objective

$$\min_{\beta \in \mathbb{R}^k} \|\gamma_t - X_t \beta\|^2 + \lambda_N \cdot \text{pen}(\beta) \text{ with } \text{pen}(\beta) = \sum_{j=1}^k \frac{|\beta_j|}{|\tilde{\beta}_j|},$$

where  $X_t$  comprises all potential indicator candidates or “target determinants” of  $\gamma_t$ . The LASSO can be interpreted as performing “all-in” penalized least squares (LS) estimations of linear models dropping “seemingly small” target determinants, whereas the EBA routine performs “all-in” LS estimations of linear models dropping “sign switching” target determinants. Economically, sign switching target determinants of  $\gamma_t$  are implausible indicator series that switch from procyclical (coinciding) to countercyclical (leading or lagging) indicators or the other way around depending on the subset composition of conditioners considered in the estimations.

**Statistical and economical properties of EBA.** Sensitivity analysis in the form of EBA has been mainly, although not exclusively (see, e.g. Sturm et al., 2005, and Moosa, 2009, analyzing IMF credit and FDI decisions, respectively), used in the context of model uncertainty with regard to cross-sectional growth regressions. This is also where the Bayesian foundations of this method are rooted (Leamer, 1982, 1983). It has been very rarely applied in the context of time series so far. Indeed, the only exceptions we are aware of are Fowles and Loeb (1995) and, more recently, Gassebner et al. (2016). Both studies are not dynamic in the above defined sense of DEBA, in that both do not consider lagged expressions of variables, neither in the conditioners set nor as focus indicators. In general, following Leamer (1982) and Fowles and Loeb (1995), EBA can be developed as an application of a Bayesian natural conjugate prior on the set of “doubtful” indicator-variables. For the normal linear regression model

$$\mathbf{Y} \sim \mathbf{N}(\mathbf{X}\beta, \sigma^2 \mathbf{I}),$$

the prior mean on the  $p$  doubtful variables is also normal (representing the crucial characteristic of a conjugate prior), centered at zero, with variance matrix  $\mathbf{H}^{*-1}$ . Hence,

$$\mathbf{R}\beta \sim \mathbf{N}(\mathbf{0}, \mathbf{H}^{*-1}),$$

where  $\mathbf{R}$  is a  $p \times k$  matrix of constants,  $\beta$  a  $k \times 1$  column vector of parameters, and  $\mathbf{0}$  a  $p \times 1$  zero vector, and  $\mathbf{H}^*$  is denoting a  $p \times p$  positive definite symmetric precision matrix (i.e. the inverse of the variance covariance matrix). As shown in Leamer (1982), extreme values of linear functions of the posterior mean for the  $k \times 1$  vector  $\tau$ ,

$$\tau \mathbf{b}^{**} = \tau' (\mathbf{H} + \mathbf{R}' \mathbf{H}^* \mathbf{R})^{-1} \mathbf{H} \mathbf{b},$$

are given by

$$\mathbf{a} + \tau^{*'} \mathbf{f} \pm \sqrt{\tau^{*'} \mathbf{A}^{-1} \tau^*} \mathbf{c}$$

when  $\mathbf{H}^*$  is constrained to fall between positive definite matrices  $\mathbf{V}\mathbf{I}$  and  $\mathbf{V}\mathbf{h}$ , and where

$$\begin{aligned}
\mathbf{a} &= \tau' \mathbf{b} - \tau' \mathbf{H}^{-1} \mathbf{R}' (\mathbf{R} \mathbf{H}^{-1} \mathbf{R}')^{-1} \mathbf{R} \mathbf{b}, \\
\tau^{*'} &= \tau' \mathbf{H}^{-1} \mathbf{R}' (\mathbf{R} \mathbf{H}^{-1} \mathbf{R}')^{-1} \\
\mathbf{f} &= (\mathbf{h} + \mathbf{V}\mathbf{I}^{-1})^{-1} \left( \mathbf{h} \mathbf{R} \mathbf{b} + (\mathbf{V}\mathbf{I}^{-1} - \mathbf{V}\mathbf{h}^{-1})^* (\mathbf{h} + \mathbf{V}\mathbf{h}^{-1})^{-1} \mathbf{h} \mathbf{R} \mathbf{b} \frac{1}{2} \right), \\
\mathbf{A} &= (\mathbf{h} + \mathbf{V}\mathbf{h}^{-1}) (\mathbf{V}\mathbf{I}^{-1} - \mathbf{V}\mathbf{h}^{-1})^{-1} (\mathbf{h} + \mathbf{V}\mathbf{h}^{-1}) + (\mathbf{h} + \mathbf{V}\mathbf{h}^{-1}), \\
\mathbf{c} &= (\mathbf{R} \mathbf{b})' \mathbf{h} (\mathbf{h} + \mathbf{V}\mathbf{h}^{-1})^{-1} (\mathbf{V}\mathbf{I}^{-1} - \mathbf{V}\mathbf{h}^{-1}) (\mathbf{h} + \mathbf{V}\mathbf{I}^{-1})^{-1} \mathbf{h} \mathbf{R} \mathbf{b} \frac{1}{4}, \\
\mathbf{h} &= (\mathbf{R} \mathbf{H}^{-1} \mathbf{R}')^{-1}, \mathbf{b} = (\mathbf{X}' \mathbf{X})^{-1} \mathbf{X}' \mathbf{Y}, \mathbf{H} = s^{-2} \mathbf{X}' \mathbf{X}, \text{ and} \\
s &= \sqrt{\frac{1}{n-k} (\mathbf{Y} - \mathbf{X} \mathbf{b})' (\mathbf{Y} - \mathbf{X} \mathbf{b})}.
\end{aligned}$$

As Fowles and Loeb (1995, p. 363) note, the widest possible bounds occur at  $\mathbf{V}\mathbf{I} = \mathbf{0}\mathbf{H}^{*-1}$  and  $\mathbf{V}\mathbf{h} = \infty\mathbf{H}^{*-1}$ . As shown in Chamberlain and Leamer (1976) and Leamer (1982), priors are minimal since  $\mathbf{H}^*$ , i.e. the prior precision matrix, is only required to be positive definite symmetric. Matrix  $\mathbf{R}$  reduces the dimensionality of the prior space from  $k$  to  $p$ .

Apart from these desirable properties, (D)EBA has essentially three drawbacks. First, irrespective of its dynamic (i.e. lag) structure, the model size is quite restrictive (e.g. allowing only triplets of indicators as conditioning set). Secondly, models are equally weighted in the shrinkage procedure. And finally, standard EBA can be assessed as very or even “excessively” conservative; see Durlauf et al. (2009, p. 1132-1134). The standard cross-sectional and non-dynamic version of EBA has been shown in simulation studies by Hoover and Perez (2004) to be of very low empirical size (showing an overly low proportion of type I error), that is, the “algorithm almost never selects a variable that does not belong” (Hoover and Perez, 2004, p. 777), at the cost of a relatively low power. However, this trade-off needs not to apply to the same extent in the context of DEBA<sup>4</sup> and needs to be put into perspective in the context of using sensitivity analysis in the forecasting context as shrinkage device. Relatively high type II errors might hamper the precision of forecasts as “incorrect” indicators might survive the shrinking. On the other hand, the picking-out of economically meaningful (either coinciding or leading/lagging) indicator series is warranted with an extremely high probability. See the discussion in the preceding paragraph on DEBA.

---

<sup>4</sup>It remains for future work to apply the numerical strategy used by Hoover and Perez (2004) in the cross-sectional growth regression context also in the (D)EBA time series context. Similarly, growing computational power will allow to alleviate the first caveat in our list.



### 3.2 In-sample performance

In Figure 1 the estimated common factor is plotted against the Spanish quarterly GDP growth series. The factor loadings are all estimated as significantly different from zero at standard levels. The estimated common factor  $\hat{f}_t$  is the final ingredient to determine the adequate lag structure of the forecast equation

$$\gamma_{t+h} = \mu + \alpha_0 \gamma_t + \alpha_3 \gamma_{t-3} + \beta_0 \hat{f}_t + \beta_1 \hat{f}_{t-1} + \beta_2 \hat{f}_{t-2} + e_{t+h}. \quad (9)$$

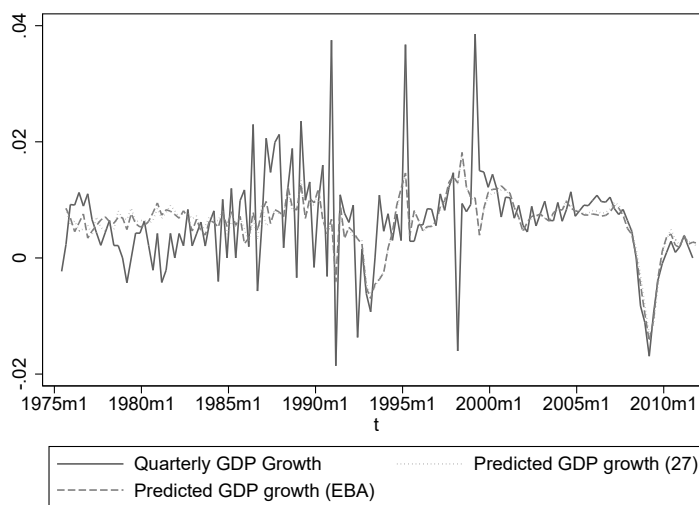


Figure 1: Predicted GDP growth –  $\gamma_{t+h} = \mu + a(L)\gamma_t + b(L)\hat{f}_t + e_{t+h}$

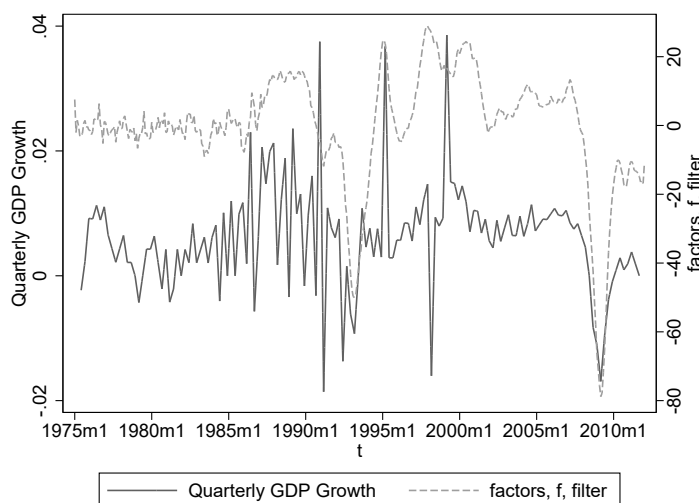


Figure 2: Estimated common factor  $\hat{f}$  and quarterly GDP growth

Our lag choice is based on information criteria.

Figure 2 shows observed and accordingly predicted (dashed line) values of Spanish GDP growth at quarterly frequency since 1975.

#### 4 Out-of-sample performance

To examine and compare the out-of-sample characteristics of the two indices based on the core indicators on the one hand and on the selected candidates from the core set after screening out fragile indicators using EBA techniques on the other, we perform a “pseudo” real-time nowcasting exercise. It is “pseudo” (in contrast to “genuine”) because we are considering a method (ADFM) that was not available at the time of the nowcasts we are simulating. In our exercise, the focus is to see how our method would have performed in case it would have been available.<sup>5</sup>

In our exercise we simulate nowcasts for every quarter starting in 2007:Q1 until 2011:Q3. To simulate our pseudo real-time nowcasting procedure we assume that the information from the first quarter of 2007 onwards is not available at the moment of selecting the variables to be used to calculate the ADFM. This way we overcome a possible hindsight-bias regarding the selection of the variables for our procedure.

Additionally, we use GDP vintage data to simulate the nowcasting procedure with the information that one would have had at the time of the nowcast. Due to multiple data revisions the estimations of GDP are usually revised even some years after the quarter had passed. Figure 3 shows, for example, the GDP growth series nowcasters had access to in the first quarter of 2007 and the actual GDP growth series for the time between December 2000 (2000m12) and December 2006 (2006m12). Even if both series follow a similar pattern, which they obviously should, there are evident misalignments between the time series during the plotted period of time. This makes clear that even past values can change at the time of doing the nowcast and –by this circumstance– also the estimation results. For that reason we estimate our model every quarter anew using the (vintage) GDP growth series that was available at that quarter. The vintage as well as the final series are from the OECD.

Using only the information available until the end of 2006, the core set of indicators includes 14 (plus some lags). After applying the DEBA procedure, 9 variables are identified as robust. Interestingly, without the information from year 2007 afterwards, our selection procedure emphasizes financial variables such as a household consumer credit index –which does not qualify when including the information until 2011– and a real estate index.

As a benchmark to compare the performance of our nowcasting procedure we use two indicators. The first is a simple AR(2) process. An AR(2) –that is justified on

---

<sup>5</sup>See Müller and Köberl (2012) for a genuine ex-ante nowcasting experiment.

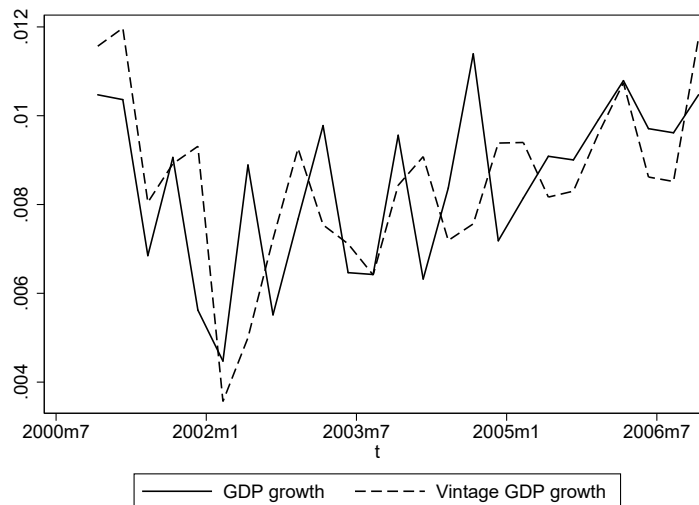


Figure 3: GDP growth vs vintage GDP growth

the basis of information criteria in terms of its order in our case study of Spanish GDP growth as well– is a very frequently used benchmark forecasting process in the context of forecasting real GDP growth. Chauvet and Potter (2013, p. 156) quote an exemplary series of four papers from the 2010s, where an AR(2) is employed in such a way, and state that a “simple linear univariate AR(2) offers an interesting comparison with the more complicated models as it has been shown in several papers to have comparable or better forecasting performance.” In addition, we went through the “Economic Forecast Reports” from the European Commission (EC) and collected the estimation for the current quarter and treated it as its nowcast. For example, if the report was published in April 2007, we treated the therein reported forecast of 2007:Q1 as the nowcast. Since the reports are only published biannually (once in spring and once in autumn), we took the values for the first two quarters of the year from the spring report and the last two quarters from the autumn report. The idea of using the EC official forecasts is to compare our model to a real-time forecast done by an institution with a clear interest in accurately nowcasting Spanish GDP.<sup>6</sup>

We proceed widely in line with the applied literature (see, e.g., Castle et al., 2009) in judging the out-of-sample forecast potential of the derived common factor. In order to assess the one-period ahead forecast properties, we treat the period starting the second quarter of 1975 to the last quarter of 2006 as given and successively extend this window by an additional quarterly observation to make one-quarter ahead projections for each successive step of prolonging the in-sample-“window” up to the penultimate quarter (using the vintage series of each quarter). Hence, our first projection uses equation (9)

<sup>6</sup>We are thankful to one of the anonymous referees to whom we owe this suggestion to referring to actual institutional forecasts as benchmark.

	Without EBA	With EBA	AR(2)	EC
Total period (averaged 1-step FEs)				
SFE	0.00006576	0.00001988	0.00006356	0.00000967
Relative SFE	0.8465	0.8236	–	
FE	-0.00386447	-0.00223941	-0.00484215	-0.00118044
Relative FE	0.798089692	0.462482575	–	
Excl. 2008:Q3 to 2009:Q2				
SFE	0.00004445	0.00001978	0.00002459	0.000005214
Relative SFE	1.807645384	0.804392029	–	
FE	-0.00240069	-0.00194073	-0.00285718	-0.00045629
Relative FE	0.840230577	0.67924667	–	

Table 2: Forecast errors across models

with  $h = 1$ ,  $t = 1$  (1975:Q2), ...,  $T_1$  (2006:Q4), and (justified by information criteria)  $p_a = p_b = 2$  to make a respective forecast of the GDP growth rate  $\gamma_{T_1+1}^F$ . We repeat this procedure for  $T_2$  (2007:Q1) to  $T_{34}$  (2011:Q2) in order to obtain a series of one-step ahead forecasts  $\gamma_{T_1+1}^F, \dots, \gamma_{T_{34}+1}^F$ . For the univariate benchmark AR(2) predictor  $a(L)' = (1 \ 0 \ 0)$ , while  $b(L)' = (0 \ 0 \ 0)$ .

From  $\gamma_{T_1+1}^F, \dots, \gamma_{T_{34}+1}^F$  we can calculate forecast errors (FE) for  $\hat{f}_t$  derived without EBA, i.e. FE (14), and with EBA, i.e. FE (EBA), respectively. Results along with the FE of the benchmark AR(2) are shown in the upper part of Figure 4. The dashed line refers to the EBA-robustly implemented DFM derived index based on 7 constituting indicators, the solid line to the one based on 14 constituting indicators, and the dotted one to the benchmark AR(2) predictor, respectively. Both DFM-based models generate lower forecast errors than the benchmark AR(2). In particular, this holds for times of crises. The error measure spike at the beginning of the great recession and at its onset is the lowest for the EBA-robust DFM index. Putting a stronger weight on larger deviations of forecasts from actual values, we obtain a similar picture for the squared forecast errors (SFE) as shown in the lower part of Figure 4.

Figures of these forecast errors averaged for different periods are summarized in Table 2, where “relative” errors refer to ratios of the respective errors to the corresponding errors of the AR(2) benchmark model. As can be seen from Table 2, while the nowcasting accuracy of the AR(2) measures up to the one of the small-scale ADFM without sensitivity analysis shrinkage (or even tops it in SFE-terms in case of excluding the crisis period), the real-time forecasts of the micro-scale ADFM implemented applying (D)EBA outperform both of them, i.e. AR(2) and small-scale ADFM, throughout and nearly measure up to the ones by the EC.

The common factor extraction including an EBA in the final pre-selection stage

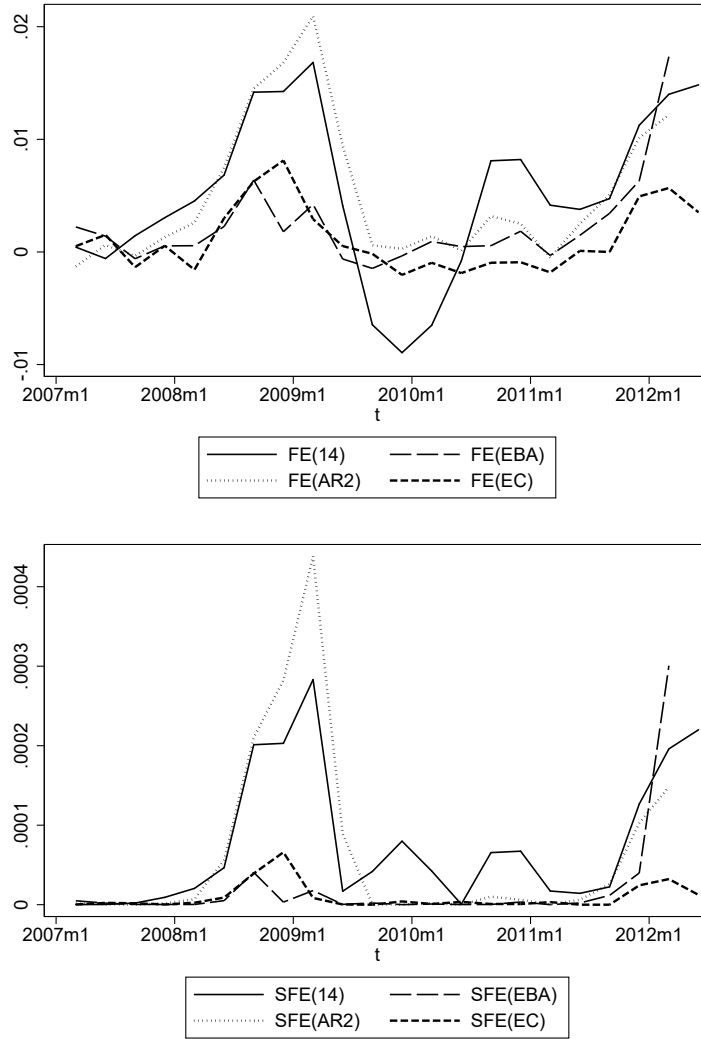


Figure 4: Forecast Error (FE) and Squared Forecast Error (SFE) at each predicted period, based on rolling window starting first quarter 2007

	Diebold-Mariano Test			Modified Diebold-Mariano Test		
	w/o EBA	with EBA	AR(2)	w/o EBA	with EBA	AR(2)
with EBA	-1.94 (0.052)			-1.719 (0.050)		
AR(2)	-0.178 (0.858)	1.13 (0.259)		-0.158 (0.438)	1.001 (0.164)	
EC	-2.879 (0.004)	-0.799 (0.424)	-1.587 (0.112)	-2.551 (0.009)	-0.708 (0.243)	-1.407 (0.087)

Table 3: Forecast accuracy tests between models

outperforms the one excluding it across all considered measures and periods shown in Table 2. We consider for the averaging of forecast errors the total forecast period from  $T_1$  (2007:Q1) to  $T_{34}$  (2011:Q2) as well as a period that leaves out the sub-period from the third quarter of 2008 to the second quarter of 2009, that is, the period when the shock corresponding to the crisis hit the economy.<sup>7</sup> Our results remain mainly untouched. Throughout forecast errors are the lowest for the common factor including the EBA exercise in the final step of its implementation. It is also this factor that throughout outperforms the univariate benchmark model by implying relative forecast errors  $< 1$ .

In Table 3, the first three columns with numerical entries show the test statistics of the pairwise test proposed by Diebold and Mariano (1995) to analyze whether empirical loss differences between competing models are statistically significant. It is generally seen to be the most influential and most widely used test in this context (see Carstensen et al., 2011, p. 87). The second triple-block of columns with numerical entries refers to the test statistics of the modified Diebold-Mariano (MDM) test suggested by Harvey et al. (1997) that corrects for small sample bias. It evaluates whether the average loss difference between a pair of models is significantly different from zero. Under the null the forecast accuracy of two models is identical; see e.g. Carstensen et al. (2011, p. 87) for detail. Note, each entry of Table 3 displays the respective test statistics for the forecasting performance of each model listed in the respective row vis-à-vis its respective competitor model in the header to each column. For instance, the combination of row “with EBA” and column “w/o, i.e. without, EBA” amounting to  $-1.94$  ( $-1.719$ ) for the (modified) Diebold-Mariano test corresponds to the respective test statistics of the MSE of model “with EBA” minus the corresponding MSE of model “w/o EBA.” A negative value implies that the model behind the subtractive MSE-part (here “w/o EBA”) performs worse in terms of forecasting accuracy. Corresponding p-values are given in parentheses. There are two differentials between models that are statistically significant for the standard Diebold-Mariano (SDM) test. Both nowcasts “with EBA” and the EC-one significantly outperform the model without DEBA pre-selection stage (i.e. the small-scale ADFM) at the ten percent and at the one percent level of significance, respectively. This holds also for the MDM test, where the first difference now turns out statistically significant even at a five percent level of significance. Additionally, the EC nowcast is statistically significantly better in terms of accuracy than the AR(2) benchmark, at least, at a ten percent level of significance, when correcting for small sample properties (MDM test). Moreover, neither for the SDM nor the MDM test, we

---

<sup>7</sup>One reason for doing so is that one might be bothered that by merely dropping some indicators in the derivation of the common factor raises the weight of the stock exchange for real estate and finance index in the constitution of the factor and through this channel alone gives the (D)EBA based factor a comparative advantage. However, as can be seen from Table 2, the FE difference between the two factors remains if we leave out the recent crisis which is generally seen to be rooted in Spanish housing price dynamics. Interestingly, the FE for the model with the 14 core variables and the benchmark AR(2) process is almost the same excluding the crisis.

find a statistically significant difference in forecast accuracy between the EC nowcast and the micro-scale ADFM nowcast with DEBA pre-selection of indicators.

## 5 Conclusion

We examined the implementation stage of an ADFM to nowcast GDP growth using Spanish time series. To overcome a common deficiency of the literature, treating candidate indicators for the estimation of the common factor not symmetrically, we propose a two-tiered procedure. First, variables highly correlated with growth are identified as “core.” Secondly, they are checked for robustness according to a dynamic version of EBA standards to nowcast Spanish GDP growth. We find that our implementation clearly improves the accuracy of nowcasts compared to ADFM nowcasts implemented without the help of sensitivity analysis and to a benchmark AR(2) process. It leads to nowcasts almost measuring up to real-time forecasts by an institution with an interest in high-quality nowcasts (i.e. by the EC). Thus, we conclude by answering our central research questions raised in the introductory section: First, it can pay to consider a symmetric shrinkage device in the pre-selection process. Secondly, parsimony can improve nowcasts, even if we rely on a rather ad hoc pre-selection device and a shrinkage device with focus on selecting economically meaningful indicators rather than on pure forecast performance in going from small-scale to micro-scale ADFM.

It remains for future work to check our partially ad hoc framework for its robustness in selecting predictors with regard to the choice of parameters both at the pre-selection (in particular, concerning  $\rho$ ) and at the shrinkage stage (in particular, concerning  $k$ ). A further future task, that is beyond the scope of the present paper, is to scrutinize the trade-off between using all variables and adding more factors on the one hand (see, e.g. Giannone et al., 2008) and selecting variables a-priori and then using only a single factor on the other. Such a check might be based on the quasi maximum likelihood approach proposed in Doz et al. (2012).

## References

- Aruoba, S., Diebold, F.X., and C. Scotti, 2009. Real-time Measurement of Business Conditions, *Journal of Business and Economic Statistics* 27, 417-427.
- Breitung, J. and S. Eickmeier, 2006. Dynamic Factor Models, *Advances in Statistical Analysis* 90, 27-42.

- Camacho, M. and R. Doménech, 2012. MICA-BBVA: A Factor Model of Economic and Financial Indicators for Short-term GDP Forecasting, *Journal of the Spanish Economic Association* 3, 475-497.
- Camacho, M. and A. Garcia-Serrador, 2014. The Euro-STING Revisited: The Usefulness of Financial Indicators to Obtain Euro Area GDP, *Journal of Forecasting* 33, 186-197.
- Camacho, M. and G. Perez-Quiros, 2010. Introducing the Euro-STING: Short-term Indicator of Euro Area Growth, *Journal of Applied Econometrics* 25, 663-694.
- Carstensen, K., Wohlrabe, K., and C. Ziegler, 2011. Predictive Ability of Business Cycle Indicators under Test. *Journal of Economics and Statistics* 231, 82-106.
- Castle, J.L., Fawcett, N.W.P., and D.F. Hendry, 2009. Nowcasting is not just contemporaneous forecasting. *National Institute Economic Review* 210, 71-89.
- Chamberlain, G. and E.E. Leamer, 1976. Matrix Weighted Averages and Posterior Bounds, *Journal of the Royal Statistical Society Series B* 38, 73-84.
- Chauvet, M., and S. Potter, 2013. Forecasting Output, in Elliott, G. and A. Timmermann (eds.), *Handbook of Economic Forecasting, Vol. 2 A*, Elsevier: Amsterdam, 141-194.
- Diebold, F.X., and R.S. Mariano, 1995. Comparing predictive accuracy, *Journal of Business and Economic Statistics* 13, 253-265.
- Doz, C., Giannone, D., and L. Reichlin, 2012. A Quasi Maximum Likelihood Approach for Large Approximate Dynamic Factor Models, *Review of Economics and Statistics* 94, 1014-1024.
- Durlauf, S.N., Johnson, P.A., and J.R.W. Temple, 2009. The Methods of Growth Econometrics, in Mills, T.C. and K. Patterson (eds.), *Palgrave Handbook of Econometrics, Vol. 2 Applied Econometrics*, Palgrave Macmillan: New York, 1119-1179.
- Elliott, G., Gargano, A., and A. Timmermann, 2013. Complete Subset Regressions, *Journal of Econometrics* 177, 357-373.
- Fowles, R. and P.D. Loeb, 1995. Effects of Policy-Related Variables on Traffic Fatalities: An Extreme Bounds Analysis Using Time-Series Data, *Southern Economic Journal* 62, 359-366.
- Gassebner, M., Gutmann, J., and S. Voigt, 2016. When to expect a coup d'état? An extreme bounds analysis of coup determinants, *Public Choice* 169, 293-313.



- Giannone, D., Reichlin, L., and D. Small, 2008. Nowcasting: the real-time informational content of macroeconomic data, *Journal of Monetary Economics* 55, 665-676.
- Harvey, D.I., Leybourne, S.J., and P. Newbold, 1997. Testing the equality of prediction mean square errors, *International Journal of Forecasting* 13, 281-291.
- Hoover, K.D. and S.J. Perez, 2004. Truth and robustness in cross-country growth regressions, *Oxford Bulletin of Economics and Statistics* 66, 765-798.
- Levine, R. and D. Renelt, 1992. A Sensitivity Analysis of Cross-country Growth Regressions, *American Economic Review* 82, 942-963.
- Leamer, E.E., 1982. Sets of Posterior Means with Bounded Variance Priors, *Econometrica* 50, 725-736.
- Leamer, E.E., 1983. Let's take the con out of econometrics, *American Economic Review* 73, 31-43.
- Luciani, M., 2014. Forecasting with Approximate Dynamic Factor Models: The Role of Non-pervasive Shocks, *International Journal of Forecasting* 30, 20-29.
- Müller, C. and E. Köberl, 2012. Catching a floating treasure: A genuine ex-ante forecasting experiment in real time, *KOF Working Papers 12-297*, KOF Swiss Economic Institute, ETH Zurich.
- Moosa, I.A., 2009. The determinants of foreign direct investment in MENA countries: an extreme bounds analysis, *Applied Economics Letters* 16, 1559-1563.
- Sala-i-Martin, X.X., 1997. I have just run two million regressions, *American Economic Review* 87, 178-183.
- Stock, J. and M. Watson, 1991. A Probability Model of the Coincident Economic Indicators, in Lahiri, K. and G. Moore (eds.), *Leading Economic Indicators: New Approaches and Forecasting Records*, Cambridge University Press: Cambridge, 63-89.
- Stock, J. and M. Watson, 2002. Macroeconomic Forecasting Using Diffusion Indexes, *Journal of Business and Economic Statistics* 20, 147-162.
- Sturm, J.-E., Berger, H., and J. De Haan, 2005. Which variables explain decision on IMF credits? An extreme bounds analysis, *Economics and Politics* 17, 177-213.

# Universität Leipzig

## Wirtschaftswissenschaftliche Fakultät

Nr. 1	Wolfgang Bernhardt	Stock Options wegen oder gegen Shareholder Value? Vergütungsmodelle für Vorstände und Führungskräfte 04/1998
Nr. 2	Thomas Lenk / Volkmar Teichmann	Bei der Reform der Finanzverfassung die neuen Bundesländer nicht vergessen! 10/1998
Nr. 3	Wolfgang Bernhardt	Gedanken über Führen – Dienen – Verantworten 11/1998
Nr. 4	Kristin Wellner	Möglichkeiten und Grenzen kooperativer Standortgestaltung zur Revitalisierung von Innenstädten 12/1998
Nr. 5	Gerhardt Wolff	Brauchen wir eine weitere Internationalisierung der Betriebswirtschaftslehre? 01/1999
Nr. 6	Thomas Lenk / Friedrich Schneider	Zurück zu mehr Föderalismus: Ein Vorschlag zur Neugestaltung des Finanzausgleichs in der Bundesrepublik Deutschland unter besonderer Berücksichtigung der neuen Bundesländer 12/1998
Nr. 7	Thomas Lenk	Kooperativer Föderalismus – Wettbewerbsorientierter Föderalismus 03/1999
Nr. 8	Thomas Lenk / Andreas Mathes	EU – Osterweiterung – Finanzierbar? 03/1999
Nr. 9	Thomas Lenk / Volkmar Teichmann	Die fiskalischen Wirkungen verschiedener Forderungen zur Neugestaltung des Länderfinanzausgleichs in der Bundesrepublik Deutschland: Eine empirische Analyse unter Einbeziehung der Normenkontrollanträge der Länder Baden-Württemberg, Bayern und Hessen sowie der Stellungnahmen verschiedener Bundesländer 09/1999
Nr. 10	Kai-Uwe Graw	Gedanken zur Entwicklung der Strukturen im Bereich der Wasserversorgung unter besonderer Berücksichtigung kleiner und mittlerer Unternehmen 10/1999
Nr. 11	Adolf Wagner	Materialien zur Konjunkturforschung 12/1999
Nr. 12	Anja Birke	Die Übertragung westdeutscher Institutionen auf die ostdeutsche Wirklichkeit – ein erfolg-versprechendes Zusammenspiel oder Aufdeckung systematischer Mängel? Ein empirischer Bericht für den kommunalen Finanzausgleich am Beispiel Sachsen 02/2000
Nr. 13	Rolf H. Hasse	Internationaler Kapitalverkehr in den letzten 40 Jahren – Wohlstandsmotor oder Krisenursache? 03/2000
Nr. 14	Wolfgang Bernhardt	Unternehmensführung (Corporate Governance) und Hauptversammlung 04/2000
Nr. 15	Adolf Wagner	Materialien zur Wachstumsforschung 03/2000
Nr. 16	Thomas Lenk / Anja Birke	Determinanten des kommunalen Gebührenaufkommens unter besonderer Berücksichtigung der neuen Bundesländer 04/2000
Nr. 17	Thomas Lenk	Finanzwirtschaftliche Auswirkungen des BundesverfassungsgerichtsUrteils zum Länderfinanzausgleich vom 11.11.1999 04/2000
Nr. 18	Dirk Büttel	Continuous linear utility for preferences on convex sets in normal real vector spaces 05/2000
Nr. 19	Stefan Dierkes / Stephanie Hanrath	Steuerung dezentraler Investitionsentscheidungen bei nutzungsabhängigem und nutzungsunabhängigem Verschleiß des Anlagenvermögens 06/2000
Nr. 20	Thomas Lenk / Andreas Mathes / Olaf Hirschfeld	Zur Trennung von Bundes- und Landeskompetenzen in der Finanzverfassung Deutschlands 07/2000
Nr. 21	Stefan Dierkes	Marktwerte, Kapitalkosten und Betafaktoren bei wertabhängiger Finanzierung 10/2000
Nr. 22	Thomas Lenk	Intergovernmental Fiscal Relationships in Germany: Requirement for New Regulations? 03/2001
Nr. 23	Wolfgang Bernhardt	Stock Options – Aktuelle Fragen Besteuerung, Bewertung, Offenlegung 03/2001
Nr. 24	Thomas Lenk	Die „kleine Reform“ des Länderfinanzausgleichs als Nukleus für die „große Finanzverfassungs-reform“? 10/2001

Nr. 25	Wolfgang Bernhardt	Biotechnologie im Spannungsfeld von Menschenwürde, Forschung, Markt und Moral Wirtschaftsethik zwischen Beredsamkeit und Schweigen 11/2001
Nr. 26	Thomas Lenk	Finanzwirtschaftliche Bedeutung der Neuregelung des bundestaatlichen Finanzausgleichs – Eine allkoative und distributive Wirkungsanalyse für das Jahr 2005 11/2001
Nr. 27	Sören Bär	Grundzüge eines Tourismusmarketing, untersucht für den Südraum Leipzig 05/2002
Nr. 28	Wolfgang Bernhardt	Der Deutsche Corporate Governance Kodex: Zuwahl (comply) oder Abwahl (explain)? 06/2002
Nr. 29	Adolf Wagner	Konjunkturtheorie, Globalisierung und Evolutionsökonomik 08/2002
Nr. 30	Adolf Wagner	Zur Profilbildung der Universitäten 08/2002
Nr. 31	Sabine Klinger / Jens Ulrich / Hans-Joachim Rudolph	Konjunktur als Determinante des Erdgasverbrauchs in der ostdeutschen Industrie? 10/2002
Nr. 32	Thomas Lenk / Anja Birke	The Measurement of Expenditure Needs in the Fiscal Equalization at the Local Level Empirical Evidence from German Municipalities 10/2002
Nr. 33	Wolfgang Bernhardt	Die Lust am Fliegen Eine Parabel auf viel Corporate Governance und wenig Unternehmensführung 11/2002
Nr. 34	Udo Hielscher	Wie reich waren die reichsten Amerikaner wirklich? (US-Vermögensbewertungsindex 1800 – 2000) 12/2002
Nr. 35	Uwe Haubold / Michael Nowak	Risikoanalyse für Langfrist-Investments Eine simulationsbasierte Studie 12/2002
Nr. 36	Thomas Lenk	Die Neuregelung des bundesstaatlichen Finanzausgleichs auf Basis der Steuerschätzung Mai 2002 und einer aktualisierten Bevölkerungsstatistik 12/2002
Nr. 37	Uwe Haubold / Michael Nowak	Auswirkungen der Renditeverteilungsannahme auf Anlageentscheidungen Eine simulationsbasierte Studie 02/2003
Nr. 38	Wolfgang Bernhard	Corporate Governance Kodex für den Mittel-Stand? 06/2003
Nr. 39	Hermut Kormann	Familienunternehmen: Grundfragen mit finanzwirtschaftlichen Bezug 10/2003
Nr. 40	Matthias Folk	Launhardtsche Trichter 11/2003
Nr. 41	Wolfgang Bernhardt	Corporate Governance statt Unternehmensführung 11/2003
Nr. 42	Thomas Lenk / Karolina Kaiser	Das Prämienmodell im Länderfinanzausgleich – Anreiz- und Verteilungsmittwirkungen 11/2003
Nr. 43	Sabine Klinger	Die Volkswirtschaftliche Gesamtrechnung des Haushaltsektors in einer Matrix 03/2004
Nr. 44	Thomas Lenk / Heide Köpping	Strategien zur Armutsbekämpfung und –vermeidung in Ostdeutschland: 05/2004
Nr. 45	Wolfgang Bernhardt	Sommernachtsfantasien Corporate Governance im Land der Träume. 07/2004
Nr. 46	Thomas Lenk / Karolina Kaiser	The Premium Model in the German Fiscal Equalization System 12/2004
Nr. 47	Thomas Lenk / Christine Falken	Komparative Analyse ausgewählter Indikatoren des Kommunalwirtschaftlichen Gesamt-ergebnisses 05/2005
Nr. 48	Michael Nowak / Stephan Barth	Immobilienanlagen im Portfolio institutioneller Investoren am Beispiel von Versicherungsunternehmen Auswirkungen auf die Risikosituation 08/2005
Nr. 49	Wolfgang Bernhardt	Familiengesellschaften – Quo Vadis? Vorsicht vor zu viel „Professionalisierung“ und Ver-Fremdung 11/2005
Nr. 50	Christian Milow	Der Griff des Staates nach dem Währungsgold 12/2005

Nr. 51	Anja Eichhorst / Karolina Kaiser	The Institutional Design of Bailouts and Its Role in Hardening Budget Constraints in Federations 03/2006
Nr. 52	Ullrich Heilemann / Nancy Beck	Die Mühen der Ebene – Regionale Wirtschaftsförderung in Leipzig 1991 bis 2004 08/2006
Nr. 53	Gunther Schnabl	Die Grenzen der monetären Integration in Europa 08/2006
Nr. 54	Hermut Kormann	Gibt es so etwas wie typisch mittelständige Strategien? 11/2006
Nr. 55	Wolfgang Bernhardt	(Miss-)Stimmung, Bestimmung und Mitbestimmung Zwischen Juristentag und Biedenkopf-Kommission 11/2006
Nr. 56	Ullrich Heilemann / Annika Blaschzik	Indicators and the German Business Cycle A Multivariate Perspective on Indicators of Ifo, OECD, and ZEW 01/2007
Nr. 57	Ullrich Heilemann	“The Soul of a new Machine” zu den Anfängen des RWI-Konjunkturmodells 12/2006
Nr. 58	Ullrich Heilemann / Roland Schuhr / Annika Blaschzik	Zur Evolution des deutschen Konjunkturzyklus 1958 bis 2004 Ergebnisse einer dynamischen Diskriminanzanalyse 01/2007
Nr. 59	Christine Falken / Mario Schmidt	Kameralistik versus Doppik Zur Informationsfunktion des alten und neuen Rechnungswesens der Kommunen Teil I: Einführende und Erläuternde Betrachtungen zum Systemwechsel im kommunalen Rechnungswesen 01/2007
Nr. 60	Christine Falken / Mario Schmidt	Kameralistik versus Doppik Zur Informationsfunktion des alten und neuen Rechnungswesens der Kommunen Teil II Bewertung der Informationsfunktion im Vergleich 01/2007
Nr. 61	Udo Hielscher	Monti della cita di firenze Innovative Finanzierungen im Zeitalter Der Medici. Wurzeln der modernen Finanzmärkte 03/2007
Nr. 62	Ullrich Heilemann / Stefan Wappler	Sachsen wächst anders Konjunkturelle, sektorale und regionale Bestimmungsgründe der Entwicklung der Bruttowertschöpfung 1992 bis 2006 07/2007
Nr. 63	Adolf Wagner	Regionalökonomik: Konvergierende oder divergierende Regionalentwicklungen 08/2007
Nr. 64	Ullrich Heilemann / Jens Ulrich	Good bye, Professir Phillips? Zum Wandel der Tariflohdeterminanten in der Bundesrepublik 1952 – 2004 08/2007
Nr. 65	Gunther Schnabl / Franziska Schobert	Monetary Policy Operations of Debtor Central Banks in MENA Countries 10/2007
Nr. 66	Andreas Schäfer / Simone Valente	Habit Formation, Dynastic Altruism, and Population Dynamics 11/2007
Nr. 67	Wolfgang Bernhardt	5 Jahre Deutscher Corporate Governance Kodex Eine Erfolgsgeschichte? 01/2008
Nr. 68	Ullrich Heilemann / Jens Ulrich	Viel Lärm um wenig? Zur Empirie von Lohnformeln in der Bundesrepublik 01/2008
Nr. 69	Christian Groth / Karl-Josef Koch / Thomas M. Steger	When economic growth is less than exponential 02/2008
Nr. 70	Andreas Bohne / Linda Kochmann	Ökonomische Umweltbewertung und endogene Entwicklung peripherer Regionen Synthese einer Methodik und einer Theorie 02/2008
Nr. 71	Andreas Bohne / Linda Kochmann / Jan Slavík / Lenka Slavíková	Deutsch-tschechische Bibliographie Studien der kontingenten Bewertung in Mittel- und Osteuropa 06/2008
Nr. 72	Paul Lehmann / Christoph Schröter-Schlaack	Regulating Land Development with Tradable Permits: What Can We Learn from Air Pollution Control? 08/2008
Nr. 73	Ronald McKinnon / Gunther Schnabl	China's Exchange Rate Impasse and the Weak U.S. Dollar 10/2008
Nr. 74	Wolfgang Bernhardt	Managervergütungen in der Finanz- und Wirtschaftskrise Rückkehr zu (guter) Ordnung, (klugem) Maß und (vernünftigem) Ziel? 12/2008

Nr. 75	Moritz Schularick / Thomas M. Steger	Financial Integration, Investment, and Economic Growth: Evidence From Two Eras of Financial Globalization 12/2008
Nr. 76	Gunther Schnabl / Stephan Freitag	An Asymmetry Matrix in Global Current Accounts 01/2009
Nr. 77	Christina Ziegler	Testing Predictive Ability of Business Cycle Indicators for the Euro Area 01/2009
Nr. 78	Thomas Lenk / Oliver Rottmann / Florian F. Woitek	Public Corporate Governance in Public Enterprises Transparency in the Face of Divergent Positions of Interest 02/2009
Nr. 79	Thomas Steger / Lucas Bretschger	Globalization, the Volatility of Intermediate Goods Prices, and Economic Growth 02/2009
Nr. 80	Marcela Munoz Escobar / Robert Holländer	Institutional Sustainability of Payment for Watershed Ecosystem Services. Enabling conditions of institutional arrangement in watersheds 04/2009
Nr. 81	Robert Holländer / WU Chunyou / DUAN Ning	Sustainable Development of Industrial Parks 07/2009
Nr. 82	Georg Quaas	Realgrößen und Preisindizes im alten und im neuen VGR-System 10/2009
Nr. 83	Ullrich Heilemann / Hagen Findeis	Empirical Determination of Aggregate Demand and Supply Curves: The Example of the RWI Business Cycle Model 12/2009
Nr. 84	Gunther Schnabl / Andreas Hoffmann	The Theory of Optimum Currency Areas and Growth in Emerging Markets 03/2010
Nr. 85	Georg Quaas	Does the macroeconomic policy of the global economy's leader cause the worldwide asymmetry in current accounts? 03/2010
Nr. 86	Volker Grossmann / Thomas M. Steger / Timo Trimborn	Quantifying Optimal Growth Policy 06/2010
Nr. 87	Wolfgang Bernhardt	Corporate Governance Kodex für Familienunternehmen? Eine Widerrede 06/2010
Nr. 88	Philipp Mandel / Bernd Süßmuth	A Re-Examination of the Role of Gender in Determining Digital Piracy Behavior 07/2010
Nr. 89	Philipp Mandel / Bernd Süßmuth	Size Matters. The Relevance and Hicksian Surplus of Agreeable College Class Size 07/2010
Nr. 90	Thomas Kohstall / Bernd Süßmuth	Cyclic Dynamics of Prevention Spending and Occupational Injuries in Germany: 1886-2009 07/2010
Nr. 91	Martina Padmanabhan	Gender and Institutional Analysis. A Feminist Approach to Economic and Social Norms 08/2010
Nr. 92	Gunther Schnabl / Ansgar Belke	Finanzkrise, globale Liquidität und makroökonomischer Exit 09/2010
Nr. 93	Ullrich Heilemann / Roland Schuhr / Heinz Josef Münch	A "perfect storm"? The present crisis and German crisis patterns 12/2010
Nr. 94	Gunther Schnabl / Holger Zemanek	Die Deutsche Wiedervereinigung und die europäische Schuldenkrise im Lichte der Theorie optimaler Währungsräume 06/2011
Nr. 95	Andreas Hoffmann / Gunther Schnabl	Symmetrische Regeln und asymmetrisches Handeln in der Geld- und Finanzpolitik 07/2011
Nr. 96	Andreas Schäfer / Maik T. Schneider	Endogenous Enforcement of Intellectual Property, North-South Trade, and Growth 08/2011
Nr. 97	Volker Grossmann / Thomas M. Steger / Timo Trimborn	Dynamically Optimal R&D Subsidization 08/2011
Nr. 98	Erik Gawel	Political drivers of and barriers to Public-Private Partnerships: The role of political involvement 09/2011
Nr. 99	André Casajus	Collusion, symmetry, and the Banzhaf value 09/2011
Nr. 100	Frank Hütner / Marco Sunder	Decomposing $R^2$ with the Owen value 10/2011
Nr. 101	Volker Grossmann / Thomas M. Steger / Timo Trimborn	The Macroeconomics of TANSTAAFL 11/2011

Nr. 102	Andreas Hoffmann	Determinants of Carry Trades in Central and Eastern Europe 11/2011
Nr. 103	Andreas Hoffmann	Did the Fed and ECB react asymmetrically with respect to asset market developments? 01/2012
Nr. 104	Christina Ziegler	Monetary Policy under Alternative Exchange Rate Regimes in Central and Eastern Europe 02/2012
Nr. 105	José Abad / Axel Löffler / Gunther Schnabl / Holger Zemanek	Fiscal Divergence, Current Account and TARGET2 Imbalances in the EMU 03/2012
Nr. 106	Georg Quaas / Robert Köster	Ein Modell für die Wirtschaftszweige der deutschen Volkswirtschaft: Das "MOGBOT" (Model of Germany's Branches of Trade)
Nr. 107	Andreas Schäfer / Thomas Steger	Journey into the Unknown? Economic Consequences of Factor Market Integration under Increasing Returns to Scale 04/2012
Nr. 108	Andreas Hoffmann / Björn Urbansky	Order, Displacements and Recurring Financial Crises 06/2012
Nr. 109	Finn Marten Körner / Holger Zemanek	On the Brink? Intra-euro area imbalances and the sustainability of foreign debt 07/2012
Nr. 110	André Casajus / Frank Hüttner	Nullifying vs. dummifying players or nullified vs. dummified players: The difference between the equal division value and the equal surplus division value 07/2012
Nr. 111	André Casajus	Solidarity and fair taxation in TU games 07/2012
Nr. 112	Georg Quaas	Ein Nelson-Winter-Modell der deutschen Volkswirtschaft 08/2012
Nr. 113	André Casajus / Frank Hüttner	Null players, solidarity, and the egalitarian Shapley values 08/2012
Nr. 114	André Casajus	The Shapley value without efficiency and additivity 11/2012
Nr. 115	Erik Gawel	Neuordnung der W-Besoldung: Ausgestaltung und verfassungsrechtliche Probleme der Konsumtionsregeln zur Anrechnung von Leistungsbezügen 02/2013
Nr. 116	Volker Grossmann / Andreas Schäfer / Thomas M. Steger	Migration, Capital Formation, and House Prices 02/2013
Nr. 117	Volker Grossmann / Thomas M. Steger	Optimal Growth Policy: the Role of Skill Heterogeneity 03/2013
Nr. 118	Guido Heineck / Bernd Süßmuth	A Different Look at Lenin's Legacy: Social Capital and Risk Taking in the Two Germanies 03/2013
Nr. 119	Andreas Hoffmann	The Euro as a Proxy for the Classical Gold Standard? Government Debt Financing and Political Commitment in Historical Perspective 05/2013
Nr. 120	Andreas Hoffmann / Axel Loeffler	Low Interest Rate Policy and the Use of Reserve Requirements in Emerging Markets 05/2013
Nr. 121	Gunther Schnabl	The Global Move into the Zero Interest Rate and High Debt Trap 07/2013
Nr. 122	Axel Loeffler / Gunther Schnabl / Franziska Schobert	Limits of Monetary Policy Autonomy and Exchange Rate Flexibility by East Asian Central Banks 08/2013
Nr. 123	Burkhard Heer / Bernd Süßmuth	Tax Bracket Creep and its Effects on Income Distribution 08/2013
Nr. 124	Hans Fricke / Bernd Süßmuth	Growth and Volatility of Tax Revenues in Latin America 08/2013
Nr. 125	Ulrich Volz	RMB Internationalisation and Currency Co-operation in East Asia 09/2013
Nr. 126	André Casajus / Helfried Labrenz	A property rights based consolidation approach 02/2014
Nr. 127	Pablo Duarte	The Relationship between GDP and the Size of the Informal Economy: Empirical Evidence for Spain 02/2014
Nr. 128	Erik Gawel	Neuordnung der Professorenbesoldung in Sachsen 03/2014
Nr. 129	Friedrun Quaas	Orthodoxer Mainstream und Heterodoxe Alternativen Eine Analyse der ökonomischen Wissenschaftslandschaft 04/2014

Nr. 130	Gene Callahan / Andreas Hoffmann	The Idea of a Social Cycle 05/2014
Nr. 131	Karl Trela	Klimaanpassung als wirtschaftspolitisches Handlungsfeld 06/2014
Nr. 132	Erik Gawel / Miquel Aguado	Neuregelungen der W-Besoldung auf dem verfassungsrechtlichen Prüfstand 08/2014
Nr. 133	Ulf Papenfuß / Matthias Redlich / Lars Steinhauer	Forschend und engagiert lernen im Public Management: Befunde und Gestaltungsanregungen eines Service Learning Lehrforschungsprojektes 10/2014
Nr. 134	Karl Trela	Political climate adaptation decisions in Germany - shortcomings and applications for decision support systems 11/2014
Nr. 135	Ulf Papenfuß / Lars Steinhauer / Benjamin Friedländer	Beteiligungsberichterstattung der öffentlichen Hand im 13-Länder-Vergleich: Erfordernisse für mehr Transparenz über die Governance und Performance öffentlicher Unternehmen 02/2015
Nr. 136	Gunther Schnabl	Japans Lehren für das Schweizer Wechselkursdilemma 02/2015
Nr. 137	Ulf Papenfuß / Christian Schmidt	Determinants of Manager Pay in German State-Owned Enterprises and International Public Policy Implications: 3-Year Study for Sectors, Performance and Gender 02/2015
Nr. 138	Philipp Mandel / Bernd Süßmuth	Public education, accountability, and yardstick competition in a federal system 05/2015
Nr. 139	Gunther Schnabl	Wege zu einer stabilitäts- und wachstumsorientierten Geldpolitik aus österreichischer Perspektive 06/2015
Nr. 140	Ulf Papenfuß / Matthias Redlich / Lars Steinhauer / Benjamin Friedländer	Forschend und engagiert lernen im Public Management: Befunde und Gestaltungsanregungen eines Service Learning Lehrforschungsprojektes – 2. aktualisierte Auflage 08/2015
Nr. 141	Friedrun Quaas / Georg Quaas	Hayeks Überinvestitionstheorie 10/2015
Nr. 142	Bastian Gawellek / Marco Sunder	The German Excellence Initiative and Efficiency Change among Universities, 2001-2011 01/2016
Nr. 143	Benjamin Larin	Bubble-Driven Business Cycles 02/2016
Nr. 144	Friedrun Quaas / Georg Quaas	Effekte des Kapitalmarktzinseszinses auf die Preis- und Produktivitätsentwicklung Eine Analyse der deutschen Volkswirtschaft 1970-2014 02/2016
Nr. 145	Thomas Lenk / Matthias Redlich / Philipp Glinka	Nachhaltige Stadtfinanzen - Akzeptanzsteigerung der bürgerschaftlichen Beteiligung an der Haushaltsplanung 02/2016
Nr. 146	Michael von Prollius / Gunther Schnabl	Geldpolitik, Arabellion, Flüchtlingskrise 10/2016
Nr. 147	David Leuwer / Bernd Süßmuth	The Exchange Rate Susceptibility of European Core Industries, 1995-2010 05/2017
Nr. 148	Gunther Schnabl	Monetary Policy and Wandering Overinvestment Cycles in East Asia and Europe 05/2017
Nr. 149	Ullrich Heilemann / Karsten Müller	Wenig Unterschiede – Zur Treffsicherheit internationaler Prognosen und Prognostiker 07/2017
Nr. 150	Gunther Schnabl / Sebastian Müller	Zur Zukunft der Europäischen Union aus ordnungspolitischer Perspektive 10/2017
Nr. 151	Gunther Schnabl	Ultra-lockere Geldpolitiken, Finanzmarktblasen und marktwirtschaftliche Ordnung 10/2017
Nr. 152	Pablo Duarte / Bernd Süßmuth	Implementing an approximate dynamic factor model to nowcast GDP using sensitivity analysis 02/2018