Predicting BIP and HP-BIP

Approach: generalization of classic direct forecast

Simple main idea**: use M-SSA filter outputs as regressors on future BIP** (instead of un-filtered indicators).

* Link to literature: abstract and introduction to paper.
  + List of alternative predictor designs (in applications)
  + Performance of direct forecast (or alternative designs)
    - Short term: nowcast, 1 quarter ahead
* Paper: more `sophisticated’ regressors (than un-filtered indicators)
* Emphasize **mid-term forecast horizons**: 2<==h<=4 quarters
  + Do not need `noisy’ **high-frequency** data
    - Motivation of selected indicators: ip, ESI, ifo, spread
  + Do not need **mixed-frequency** approach
    - Mixed-frequency mostly relevant for short-term (nowcast)
    - Possible extension of paper in future work

Main `ingredients’ of new predictor design(s)

* **Damp** unpredictable high-frequency **noise**: HP(160)
  + Focus attention on components relevant for **mid-term** forecasting.
    - Mitigate overfitting
  + Classic HP(1600) is too smooth (removes information relevant for a 2-4 quarters ahead forecast), see Phillips and Jin (2021).
    - More adaptive designs do not markedly outperform (HP(16) in tutorial 7.4)
* Tracking **two-sided HP: M-SSA**
  + Efficient real-time filtering (predictor) for tracking HP targets: **M-SSA components**
    - New optimization criterion: address MSE and smoothness
  + Outcome: increasing **left-shift** (advancement) of predictor as a function of the forecast horizon (track dips/peaks in a timely fashion).
* Tracking **BIP: WLS regression**
  + One additional optimization step
  + Rely on previous M-SSA components (or M-MSE components) as explanatory variables in regression on future BIP
    - **Left-shift** and **smoothness** of new regressors **facilitate regression**
    - Mitigate overfitting
    - Statistical significance (up to 4 quarters ahead plus publication lag, out-of-sample)
    - Smaller rRMSEs (out-of-sample)
  + Efficiency**: WLS** regression (weight inverse proportional to GARCH-vola)
* **Control smoothness**: rate of zero-crossings (above/below average growth `alarms’)

Two different predictor designs

1.Predicting **HP-BIP**

* M-SSA predictor: tutorial 7.3
* Emphasizes turning-points, dynamic shifts in BIP growth-rate
* Not designed to track future BIP explicitly (standardized series: not calibrated to BIP)
* Maybe less relevant in (this) paper?

2.Predicting **BIP**

* M-SSA component predictor (M-SSA-C): tutorial 7.4
* Emphasizes BIP and MSE forecast performances explicitly
* Difference to M-SSA predictor above**: one additional optimization stage**
  + M-SSA-C are regressed on (future) BIP
    - Weights determined by WLS regression
    - Original M-SSA: equal-weighting of M-SSA components
* Difference to direct forecast: regressors
  + Direct forecasts rely on un-filtered data
  + M-SSA relies on outputs of multivariate filter (which controls smoothness)
  + Link to earlier work
* Motivation: **outperformance at longer forecast horizons** h>=2
  + Link to earlier work (short term: horizons h=0,1?)
  + Benchmarks (see tutorial 7.4):
    - Mean of BIP (expanding window)
    - Direct forecasts
      * Based on ESI, ifo: best combination out-of-sample (plausible?)
      * Based on expanding window, starting in 2007.
      * rRMSE 86% at h=0 (nowcast) and 91% at h=1, without Pandemic (plausible?). Publication lag=2.
    - Direct HP-C forecast
      * Apply univariate concurrent HP to indicators and regress on BIP
      * Performances remarkably similar to direct forecasts (univariate filtering does not work when predicting BIP at h>=1)
    - M-SSA predictor (equal weighting, tutorial 7.3)
      * Outperformed by new M-SSA-C specifically at larger forecast horizons (h>=2)
    - M-MSE component predictor:
      * Does not control smoothness (rate of zero-crossings)
      * Has similar rRMSE (as M-SSA-C) but is noisier: roughly double as many zero-crossings
  + Out-of-sample span for evaluation: starts in 2007; expanding window; includes financial crisis as well as Pandemic.
* **Explainability** part 1: why does new M-SSA-C predictor outperform at **longer** forecast horizons (h>=2)?
  + Outperformance out-of-sample is linked to increasing **left-shift** of predictor (as h increases)
    - MSE is mainly determined by tracking peaks/dips timely: left-shift is crucial.
  + Classic benchmarks (mean, direct forecast) do not generate an explicit left-shift of the corresponding predictors
    - See plots, tutorial 7.4
  + Univariate filters (HP-C) generate a weak unsystematic left-shift (works mainly at zero-crossings but peaks/dips remain more or less unaffected).
* **Explainability** part 2: why does **multivariate** filtering outperform?
  + BIP M-SSA component is the single most important explanatory variable in WLS regression on future BIP (intuitively appealing).
  + Multivariate filter can exploit information of **all indicators** that are leading BIP (BIP is subject to publication lag) when computing BIP M-SSA component.
    - Multivariate filter generates a **larger and more systematic left-shift** (advancement) by exploiting the **leading series** (cross-section)
      * Left-shift is stronger
      * Left-shift operates at **all levels**: not-only at zero-crossings (like univariate filter) but also at peaks and dips
      * The whole series is left-shifted (not only parts of it)
  + In contrast, univariate filtering does not improve performance over direct forecast (additional benchmark in tutorial 7.4)
    - BIP forecast problem is more complex than just `filtering’
* Summary explainability:
  + BIP M-SSA is the single most important explanatory variable (for regression on future BIP).
  + Multivariate filter is particularly efficient when targeting HP-BIP (exploit leading series).
    - Multivariate filter has no advantage when targeting HP-spread, see tutorial 7.4 (in part because all other explanatory variables are lagging).
* **R-package** 
  + All the above points are addressed and detaild in tutorial 7.4: [wiaidp/R-package-SSA-Predictor](https://github.com/wiaidp/R-package-SSA-Predictor)
  + Can generate (and cut/paste) results or plots directly from R-code.