Filters or Holt Winters Technique to Improve the Forecasts for USA Inflation Rate?

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Abstract: In this study, transformations of SPF inflation forecasts were made in order to get more accurate predictions. The filters application and Holt Winters technique were chosen as possible strategies of improving the predictions accuracy. The quarterly inflation rate forecasts (1975 Q1-2012 Q3) of USA made by SPF were transformed using an exponential smoothing technique- Holt Winters- and these new predictions are better than the initial ones for all forecasting horizons of 4 quarters. Some filters were applied to SPF forecasts (Hodrick- Prescott, Band-Pass and Christiano-Fitzegerald filters), but Holt Winters method was superior. Full sample asymmetric (Christiano-Fitzegerald) and Band-Pass filter smoothed values are more accurate than the SPF expectations only for some forecast horizons.

Keywords: forecasts accuracy; prediction; Hodrick-Prescott filter; Band-Pass filter; Christiano-Fitzegerald filter

JEL Classification: E31; C81

1 Introduction

By assessing the forecasts accuracy, we have a mirror of forecasting process efficiency. If alternative predictions are made for the same variable, the interest is to choose the most accurate one. But starting only from the prediction made by one institution, new forecasts can be provided that could be better than the initial one.

Some techniques of transforming the forecasts were proposed and the accuracy of the new predictions was evaluated. An exponential smoothing technique and some filters were chosen for the inflation rate forecasts made by SPF.

Bratu (2012) utilized other strategies to improve the forecasts accuracy (combined predictions, regressions models, historical errors method).

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2 Methods of Transforming the Initial Predictions of SPF and the Accuracy Assessment of Forecasts

In this article some filters are proposed to extract the data trend. Holt Winters method is also used to smooth the data series of SPF predictions.

The Hodrick–Prescott (HP) filter is very used in macroeconomics to extract the trend of the data series and separate the cyclical component of the time series. The smoothed data gotten are more sensitive to long term changes.

The initial data series is composed of trend and cyclical component:

Equation 1 Formula for initial data

$inf_t = tr_t + c_t.$

(Hodrick & Prescott, 1997) suggest the solve of the minimization problem:

Equation 2 Formula for minimization problem

$$\min_{\{tr_t\}t=1,T} \sum_{t=1}^{T} (inf_t - tr_t)^2 + \gamma \sum_{t=2}^{T-1} (\nabla^2 tr_{t+1})^2$$

γ- penalty parameter

The solution to the above equation can be written, according to Hyeongwoo as:

Equation 3 Formula for the solution of the minimization problem

$$inf_t = (\gamma F + I_T) \cdot tr_T$$

inf_t- vector of the initial data series of the inflation rate

Equation 4 Formula for F matrix

$$F=\begin{bmatrix} 1 & -2 & 1 & 0 & \dots & & & & & & & & \\ -2 & 5 & -4 & 1 & 0 & \dots & \cdots & & & & & & 0 \\ 1 & -4 & 6 & -4 & 1 & 0 & & & & & & & \\ & & \vdots & & & & \ddots & & \vdots & & & & \\ & & & & & & & & & & & & \dots \\ & & & & & & \cdots & 0 & 1 & -4 & 6 & -4 & 1 & 0 \\ & & & & & & & 0 & 0 & 1 & -4 & 6 & -4 & 1 \\ 0 & & 0 & & & & \dots & 0 & 0 & 1 & -4 & 5 & -2 \\ & & & & & & & & & & & & \end{bmatrix}$$

Equation 5 Formula for trend

The trend is calculated as: $tr_T = [(\gamma \cdot F + I_T \quad)]^{-1} \cdot inf_T$.

Razzak **(**1997) proved that the Hodrick-Prescott filter acts as true `filter' at the end of the sample and as a "smoother" over the sample. The output gap from the true filter generates better out-of-sample predictions of inflation.

(Christiano &Fitzgerald, 2003) explained that Band-Pass filter is used to determine that component of the chronological series that is situated within a specific band of frequencies. (Baxter & King, 1995) built a bandpass filter of order K, where K-finite. If the analyzed time series is a random walk, its spectrum of a Band- Pass filter is:

Equation 6 Formula for the spectrum of random walk Band-Pass filter

$$f(\omega) = \left|\alpha^{I(1)}(\omega)\right|^2 \cdot \frac{\sigma^2}{2\pi}\ , where\ \omega\epsilon[-\pi;\pi]$$

$$\left|\alpha^{I(1)}(\omega)\right|^2 = \left(2 \cdot \sin\left(\frac{\omega}{2}\right) \cdot \sum_{j=1}^{K} a_j \cdot \sum_{h=-(j-1)}^{j-1} (j - |h|) \cdot \cos(\omega h)\right)^2$$

The peak that shows a spurious cycle is smaller in case of a Band Pass filter in comparison with the Hodrick-Prescott one.

$\left|\alpha^{I(1)}(\omega)\right|^2$ is the ptf of the filter.

Christiano-Fitzegerald filter (CF filter) is an asymmetric one and it converges on long run to an optimal filter. It has a steep frequency response function at the limits of the band. The CF filter is computed, according to (Christiano &Fitzgerald, 2003), as:

Equation 7 Formula for CF filter

$$c_t = B_0 \cdot inf_t + B_1 \cdot inf_{t+1} + \cdots + B_{T-l-t} \cdot inf_{T-1} + B_1 \cdot inf_{t-1} + \cdots + B_{t-2} \cdot inf_2 + B_{t-1} \cdot inf_1$$

$B_0 = \frac{b-a}{\pi}$, a=$\frac{2\pi}{p_u}$, b=$\frac{2\pi}{p_l}$

p_u, p_l- parameters that are cut-off cycle length in month

c- cycle term

Equation 8 Formula for coefficients of CF filter

$$B_j = \sin(jb) - \sin(ja)\ , j \geq 1$$

$$B_k = -\frac{1}{2} \cdot B_0 - \sum_{j=1}^{k-1} B_j$$

Holt-Winters Simple exponential smoothing method is recommended for data series with linear trend and without seasonal variations, the forecast being determined as:

Equation 9 Formula for the forecast based on Holt-Winters method

$$\inf_{n+k} = a + b \times k\ .$$

$$a_n = \alpha \times \inf_n + (1-\alpha) \times (a_{n-1} + b_{n-1})$$

$$b_n = \beta \cdot (a_n - a_{n-1}) + (1-\beta) \cdot b_{n-1}$$

Finally, the prediction value on horizon k is:

Equation 10 Formula for the predicted value

$$\hat{\inf}_{n+k} = \hat{a}_n + \hat{b}_n \times k$$

3 The Assessment of Forecasts Accuracy

The most utilized measures of forecasts accuracy, recalled by (Fildes &Steckler, 2000), are:

- Mean error (ME)

Equation 11 Formula for mean error

$$ME = \frac{1}{n}\sum_{j=1}^{n} e_X(T_0 + j, k)$$

- Mean absolute error (MAE)

Equation 12 Formula for mean absolute error

$$MAE = \frac{1}{n}\sum_{j=1}^{n} \left| \ e_X(T_0 + j, k) \ \right|$$

- Root Mean Squared Error (RMSE)

Equation 13 Formula for root mean squared error

$$RMSE = \sqrt{\frac{1}{n}\sum_{j=1}^{n} e_X^2(T_0 + j, k)}$$

U Theil's statistic is calculated as U1 and U2 and it is used to make comparisons between forecasts.

Notations used:

r- the registered results;

f- the forecasted results;

t- reference time;

e- the error (e=r-f);

n- number of time periods.

Equation 14 Formula for U1

$$U_1 = \frac{\sqrt{\sum_{t=1}^{n}(r_t - f_t)^2}}{\sqrt{\sum_{t=1}^{n} r_t^2} + \sqrt{\sum_{t=1}^{n} f_t^2}}$$

A value of U_1 closer to zero implies a higher accuracy.

Equation 15 Formula for U2

$$U_2 = \sqrt{\frac{\sum_{t=1}^{n-1}(\frac{f_{t+1} - r_{t+1}}{a_t})^2}{\sum_{t=1}^{n-1}(\frac{r_{t+1} - r_t}{r_t})^2}}$$

If U_2 =1=> the same accuracy for the two predictions.
If U_2 <1=> the prediction to compare more accurate than the naive one.
If U_2 >1=> the prediction to compare more accurate than the naive one.

One-year-ahead quarterly forecasts of the inflation rate made by the Survey of Professional Forecasters are utilized in this study, the predictions horizon being 1975 Q1-2012 Q3.

The main accuracy indicators were computed and the results are presented in **Appendices**. In most cases the simple SPF forecasts for a horizon of one year are more accurate than those based on econometric filters, according to U1 statistic. Full sample asymmetric (Christiano-Fitzegerald) smoothed values are more accurate for some forecast horizons. Only few values based on Band-Pass filter gave the better forecasts than the original ones. The application of a filter could give better results only in some cases. All the Holt Winters smoothed values are the most accurate ones for each forecast horizon. So, this exponential smoothing technique is the best strategy to be applied. Most of the SPF forecasts are better than the naïve ones.

The results for the last five years are presented in the following tables. The mean errors presented in **Table 1** show that full sample asymmetric values provided the most accurate predictions. These forecasts are overestimated for the entire horizon while all the other forecasts are underestimated.

Table 1. The values of mean errors for the SPF quarterly inflation rate forecasts and the SPF smoothed predictions (forecasts horizon 2007-2011)

	Mean Errors (ME) of:					
Forecast horizon	SPF forecasts	Hodrick-Prescott smoothed values	Baxter-King smoothed values	Band-Pass smoothed values	Full sample asymmetric (Christiano-Fitzegerald) smoothed values	Holt Winters smoothed values
2007	1.0217	1.2561	1.0218	1.0222	-0.8514	1.00561
2008	0.8550	0.8837	0.8546	0.8526	-0.3657	0.78837
2009	-1.2351	-1.5658	-1.2346	-1.2319	-0.4238	-1.15658
2010	0.0291	-0.1697	0.0284	0.0241	-0.3241	-0.01697
2011	1.6476	1.7961	1.6505	1.6680	-0.3700	1.37961

Source: Own calculations using EViews and Excel

The values of U1 Theil's statistic from **Table 2** show that the predictions smoothed by Holt Winters technique are the most accurate. This conclusion implies the fact that USA inflation rate forecasts depend mostly on recent values of the indicator and less on the inflation registered in the far past.

Table 2. The values of U1 for the SPF quarterly inflation rate forecasts and the SPF smoothed predictions (forecasts horizon 2007-2011)

	U1 Theil's statistic of:					
Forecast horizon	SPF forecasts	Hodrick-Prescott smoothed values	Baxter-King smoothed values	Band-Pass smoothed values	Full sample asymmetric (Christiano-Fitzegerald) smoothed values	Holt Winters smoothed values
2007	0.9231	1.2304	1.0511	1.0472	1.1394	**0.341019**
2008	0.9129	1.5169	1.3397	1.3455	1.4665	**0.079623**
2009	0.8555	2.7806	2.4199	2.3954	2.8334	**0.016668**
2010	1.0307	0.8615	0.8288	0.8269	0.8045	**0.059355**
2011	0.9246	1.2148	1.2157	1.2138	1.3154	**0.018942**

Source: Own calculations using EViews and Excel

In **Table 3** the values of U2 are displayed in order to compare the mentioned predictions with the naïve ones. Excepting 2010, all the predictions based on Holt Winters technique are better than the naïve ones while the SPF forecasts are better than those based on random walk model.

Table 3 The values of U2 for the SPF quarterly inflation rate forecasts and the SPF smoothed predictions (forecasts horizon 2007-2011)

	U2 Theil's statistic of:					
Forecast horizon	SPF forecasts	Hodrick-Prescott smoothed values	Baxter-King smoothed values	Band-Pass smoothed values	Full sample asymmetric (Christiano-Fitzegerald) smoothed values	Holt Winters smoothed values
2007	0.9231	1.2304	1.0511	1.0472	1.1394	1.0943
2008	0.9129	1.5169	1.3397	1.3455	1.4665	1.3659
2009	0.8555	2.7806	2.4199	2.3954	2.8334	2.1695
2010	1.0307	0.8615	0.8288	0.8269	0.8045	0.9278
2011	0.9246	1.2148	1.2157	1.2138	1.3154	1.3811

Source: Own calculations using EViews and Excel

The predictions based on Holt Winters smoothing technique are recommended for the USA inflation rate. A good strategy of improving the SPF forecasts is to smooth the original predictions using this method that gives a higher weight to recent values than to the older ones.

4. Conclusions

The results of this empirical research highlight that for the USA quarterly inflation rate predictions made by SPF for a horizon of one year in 1975-2011 a good strategy of improving the forecasts accuracy is the smoothing of the values using Holt Winters technique, an exponential smoothing method that considers exponentially decreasing weights over time.

Applying a certain filter to the initial predictions of SPF is not always the best method of improving the accuracy. Starting from the results of this study we recommend the use of exponential techniques to smooth the SPF predictions in order to improve the forecasts accuracy of USA inflation rate.

It is important to choose the best prediction in order to improve the decision process or to establish a better government policy. Choosing the best inflation rate will improve the monetary policy and the best solutions to control the inflation will be taken in time.

6. References

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Appendix 1

The values of mean errors for the SPF quarterly inflation rate forecasts and the SPF smoothed predictions (forecasts horizon= 4 quarters)

	Mean Errors (ME) of:					
Forecast horizon	SPF forecasts	Hodrick-Prescott smoothed values	Baxter-King smoothed values	Band-Pass smoothed values	Full sample asymmetric (Christiano-Fitzegerald) smoothed values	Holt Winters smoothed values
1976	-0.2002	-0.5362	-0.1999	-0.1981	-0.4344	-0.2613
1977	0.5501	-0.2068	0.5499	0.5489	-0.5440	0.6655
1978	0.9995	0.4768	0.9982	0.9899	-0.5833	1.3425
1979	3.3751	3.7658	3.3738	3.3658	-0.3979	3.7075
1980	4.6141	6.0347	4.6180	4.6418	-0.1716	4.9692
1981	2.0928	3.1570	2.0937	2.0992	-0.0858	1.6881
1982	-0.0220	-0.3686	-0.0215	-0.0189	-0.1241	-0.4454
1983	-1.8434	-2.4956	-1.8436	-1.8445	-0.0108	-1.7989
1984	-0.5711	-0.6771	-0.5717	-0.5756	0.3961	-0.6972
1985	-0.5857	-0.8526	-0.5847	-0.5782	1.0064	-0.8526
1986	-1.1282	-2.0933	-1.1341	-1.1699	1.8265	-2.0933
1987	-0.1792	-0.1942	-0.1771	-0.1639	2.7248	-0.1942
1988	-0.0060	0.2303	-0.0062	-0.0075	3.5724	0.2303
1989	0.4736	1.0373	0.4743	0.4787	4.5271	1.0373

1990	1.3539	1.7185	1.3551	1.3620	5.4132	1.7185
1991	0.3555	0.2208	0.3549	0.3515	5.6893	0.2208
1992	0.2621	-0.0857	0.2615	0.2581	5.6312	-0.0857
1993	-0.0677	-0.1963	-0.0685	-0.0729	4.9484	-0.1963
1994	-0.2766	-0.0798	-0.2762	-0.2737	3.8215	-0.0798
1995	0.2208	0.1717	0.2204	0.2176	3.4084	0.1717
1996	0.4540	0.5669	0.4555	0.4640	2.7510	0.5669
1997	-0.3855	-0.2906	-0.3854	-0.3845	1.9616	-0.2906
1998	-0.2700	-0.5147	-0.2718	-0.2829	1.4594	-0.5147
1999	0.7311	0.5639	0.7309	0.7300	0.3703	0.5639
2000	1.1657	1.4409	1.1670	1.1751	-0.6647	1.4409
2001	0.3634	0.3455	0.3625	0.3568	-1.3820	0.3455
2002	0.0969	0.0586	0.0979	0.1038	-2.0159	0.0586
2003	0.2947	0.0387	0.2932	0.2838	-2.5156	0.0387
2004	1.0093	0.9827	1.0094	1.0097	-2.5483	0.9827
2005	1.3279	1.4724	1.3288	1.3341	-1.9404	1.4724
2006	0.6616	0.8460	0.6612	0.6585	-1.4885	0.8460
2007	1.0217	1.2561	1.0218	1.0222	-0.8514	1.2561
2008	0.8550	0.8837	0.8546	0.8526	-0.3657	0.8837
2009	-1.2351	-1.5658	-1.2346	-1.2319	-0.4238	-1.5658
2010	0.0291	-0.1697	0.0284	0.0241	-0.3241	-0.1697
2011	1.6476	1.7961	1.6505	1.6680	-0.3700	1.7961

Source: Own calculations using EViews and Excel

Appendix 2

The values of U1 for the SPF quarterly inflation rate forecasts and the SPF smoothed predictions (forecasts horizon= 4 quarters)

	U1 Theil's statistic of:					
Forecast horizon	SPF forecasts	Hodrick-Prescott smoothed values	Baxter-King smoothed values	Band-Pass smoothed values	Full sample asymmetric (Christiano-Fitzegerald) smoothed values	Holt Winters smoothed values
1976	0.6544	1.6041	0.8413	0.8337	1.2885	0.000898
1977	2.1219	0.6492	0.8014	0.8310	0.3761	8.23E-05
1978	1.4810	1.2315	1.5413	1.5319	1.0419	0.002578
1979	0.9432	3.9720	3.5510	3.5420	3.7664	0.026233
1980	0.8341	5.2174	4.0563	4.0781	4.8589	0.001023
1981	0.7985	2.4827	1.7571	1.7459	2.2030	0.048258
1982	0.5407	0.9317	0.5980	0.5799	1.1116	0.004442
1983	0.7916	3.8381	3.0869	3.0412	3.9097	0.012992
1984	1.5657	0.9287	0.8149	0.8175	0.5213	0.011349
1985	1.6837	2.4449	1.7492	1.7106	1.0434	0.028849
1986	0.7306	4.2584	2.4947	2.5617	3.4001	0.043886
1987	1.0205	1.2985	1.1562	1.1209	1.1386	0.069176
1988	0.3788	0.9997	0.3794	0.3695	1.0060	0.09358
1989	0.5943	2.3639	1.1045	1.1093	1.8576	0.128365
1990	0.9678	2.3975	1.7661	1.8131	1.8172	0.131054
1991	1.1128	1.1456	1.1540	1.1362	1.0397	0.159573
1992	0.6287	1.8868	2.0084	1.8748	3.2302	0.237398
1993	1.7591	0.8861	1.5568	1.4805	0.8931	0.168107
1994	1.8883	0.9941	1.1253	1.1150	0.5970	0.079322
1995	0.3911	0.8593	0.6623	0.6715	1.6953	0.085313
1996	0.8073	3.4008	3.1215	3.1229	3.8666	0.023088
1997	0.8242	0.9054	0.9217	0.9359	1.1158	0.005032
1998	0.6387	3.0903	2.5880	2.5616	4.0595	0.052562
1999	1.2172	1.2149	1.4439	1.4274	1.1893	0.027111
2000	0.8645	3.6724	3.1361	3.1548	3.6242	0.000216
2001	0.8086	1.7281	1.5348	1.5331	1.8988	0.000653
2002	1.1341	1.2574	1.1678	1.1579	1.0312	0.003713
2003	0.9858	1.0542	1.2825	1.2777	1.3018	0.052012
2004	1.0912	1.1006	1.1809	1.1750	1.0833	0.184135
2005	1.0067	2.6362	2.4210	2.4210	2.4049	0.199776
2006	0.9814	1.6117	1.4492	1.4491	1.4767	0.396261
2007	0.9231	1.2304	1.0511	1.0472	1.1394	0.341019
2008	0.9129	1.5169	1.3397	1.3455	1.4665	0.079623
2009	0.8555	2.7806	2.4199	2.3954	2.8334	0.016668
2010	1.0307	0.8615	0.8288	0.8269	0.8045	0.059355
2011	0.9246	1.2148	1.2157	1.2138	1.3154	0.018942

Source: Own calculations using EViews and Excel

Appendix 3

The values of U2 for the SPF quarterly inflation rate forecasts and the SPF smoothed predictions (forecasts horizon= 4 quarters)

	U2 Theil's statistic of:					
Forecast horizon	SPF forecasts	Hodrick-Prescott smoothed values	Baxter-King smoothed values	Band-Pass smoothed values	Full sample asymmetric (Christiano-Fitzegerald) smoothed values	Holt Winters smoothed values
1976	0.6544	1.6041	0.8413	0.8337	1.2885	0.9893
1977	2.1219	0.6492	0.8014	0.8310	0.3761	1.1219
1978	1.4810	1.2315	1.5413	1.5319	1.0419	2.0023
1979	0.9432	3.9720	3.5510	3.5420	3.7664	3.9022
1980	0.8341	5.2174	4.0563	4.0781	4.8589	4.3711
1981	0.7985	2.4827	1.7571	1.7459	2.2030	1.3941
1982	0.5407	0.9317	0.5980	0.5799	1.1116	0.6777
1983	0.7916	3.8381	3.0869	3.0412	3.9097	2.7525
1984	1.5657	0.9287	0.8149	0.8175	0.5213	1.1444
1985	1.6837	2.4449	1.7492	1.7106	1.0434	1.9742
1986	0.7306	4.2584	2.4947	2.5617	3.4001	2.4150
1987	1.0205	1.2985	1.1562	1.1209	1.1386	0.6643
1988	0.3788	0.9997	0.3794	0.3695	1.0060	0.9081
1989	0.5943	2.3639	1.1045	1.1093	1.8576	1.1024
1990	0.9678	2.3975	1.7661	1.8131	1.8172	2.0011
1991	1.1128	1.1456	1.1540	1.1362	1.0397	0.9407
1992	0.6287	1.8868	2.0084	1.8748	3.2302	1.4357
1993	1.7591	0.8861	1.5568	1.4805	0.8931	1.8478
1994	1.8883	0.9941	1.1253	1.1150	0.5970	0.8075
1995	0.3911	0.8593	0.6623	0.6715	1.6953	0.7841
1996	0.8073	3.4008	3.1215	3.1229	3.8666	3.8737
1997	0.8242	0.9054	0.9217	0.9359	1.1158	1.0629
1998	0.6387	3.0903	2.5880	2.5616	4.0595	2.8688
1999	1.2172	1.2149	1.4439	1.4274	1.1893	1.8382
2000	0.8645	3.6724	3.1361	3.1548	3.6242	3.6443
2001	0.8086	1.7281	1.5348	1.5331	1.8988	1.5230
2002	1.1341	1.2574	1.1678	1.1579	1.0312	0.9311
2003	0.9858	1.0542	1.2825	1.2777	1.3018	1.2705
2004	1.0912	1.1006	1.1809	1.1750	1.0833	1.4139
2005	1.0067	2.6362	2.4210	2.4210	2.4049	2.5995
2006	0.9814	1.6117	1.4492	1.4491	1.4767	1.5687
2007	0.9231	1.2304	1.0511	1.0472	1.1394	1.0943
2008	0.9129	1.5169	1.3397	1.3455	1.4665	1.3659
2009	0.8555	2.7806	2.4199	2.3954	2.8334	2.1695
2010	1.0307	0.8615	0.8288	0.8269	0.8045	0.9278
2011	0.9246	1.2148	1.2157	1.2138	1.3154	1.3811

Source: Own calculations using EViews and Excel