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A Study in Forecasting CPI

The consumer price index (CPI) is of particular interest to economic researchers and practitioners. In essence, CPI is a measure for inflation. It is a collection, or basket, of market goods representative of consumer goods and services purchased by a typical household that indexes price changes. The change in prices in the basket between periods is a measure of inflation. CPI is an important metric for monetary policy makers. Central banks, for example, seek to maintain healthy inflation in order to maintain price stability. In the US, the target inflation rate is around 2%[1]. Inflation is not only important to policy makers, but it matters to everyone. Times of extreme inflation such as the great depression, the Mexican Peso Crisis, 1920 Weimar republic, ect were very difficult times for the people living under each respective government. The impact of hyperinflation in one country has global repercussions. Too much inflation contributes to financial crisis, so it is naturally an area of great concern for monetary policy makers.

Fabio Canova in his 2002 paper, G-7 *Inflation Forecasts*, published by the European Central Bank, identifies several significant explanatory variables for forecasting CPI in bivariate models, such as the ARDL models used in this study. Canova identified 9 variables for forecasting G-7 inflation: unemployment, employment

[1] Federal Reserve Bank of San Francisco
https://www.frbsf.org/education/publications/doctor-econ/2006/march/inflation/

growth, the labor income share, output gap, output growth, money growth, real money growth, and the slope term for term structure or stock returns[2]. From here, I got the idea to use the M3 growth rate and civilian employment to population ratio to capture dynamics in money growth and employment growth. The first five were identified to have been pulled from the New-Keynsian Phillips curve. The Phillips curve tracks the positive relationship between output and inflation. The dynamics of inflation for forward looking price setting was closely examined by Gali and Gertler. They used "measures of marginal cost as the relevant determinant of inflation instead of ad hoc output gap" in order to develop a forward looking phillips curve model[3]. I chose not to use output gap data in line with these findings.

My intuition for including housing starts as a variable in forecasting CPI is that an increase in new housing should drive up economic activity which would increase inflation. For 10 year t-bond yields, I thought that changes in the bond yields would reflect some comovement with interest rates. For example, if interest rates increase, you would expect the bond yields to increase to compensate for the loss of purchasing power. This intuition is the same for SP500 returns. The intuition is that an increase in inflation would result in higher yields, which would be reflected as positive comovement. The inclusion of SP500 returns was supported by the findings of Canova in his Forecasting G-7 inflation paper. US industrial production output is a measure of production, so the logic for including it was that increases in production would result in

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[2] Canova, Fabio. *Forecasting G-7 inflation* (2002) European Central Bank https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp151.pdf?0eccf9443c3dff3cd19dea75b39da944

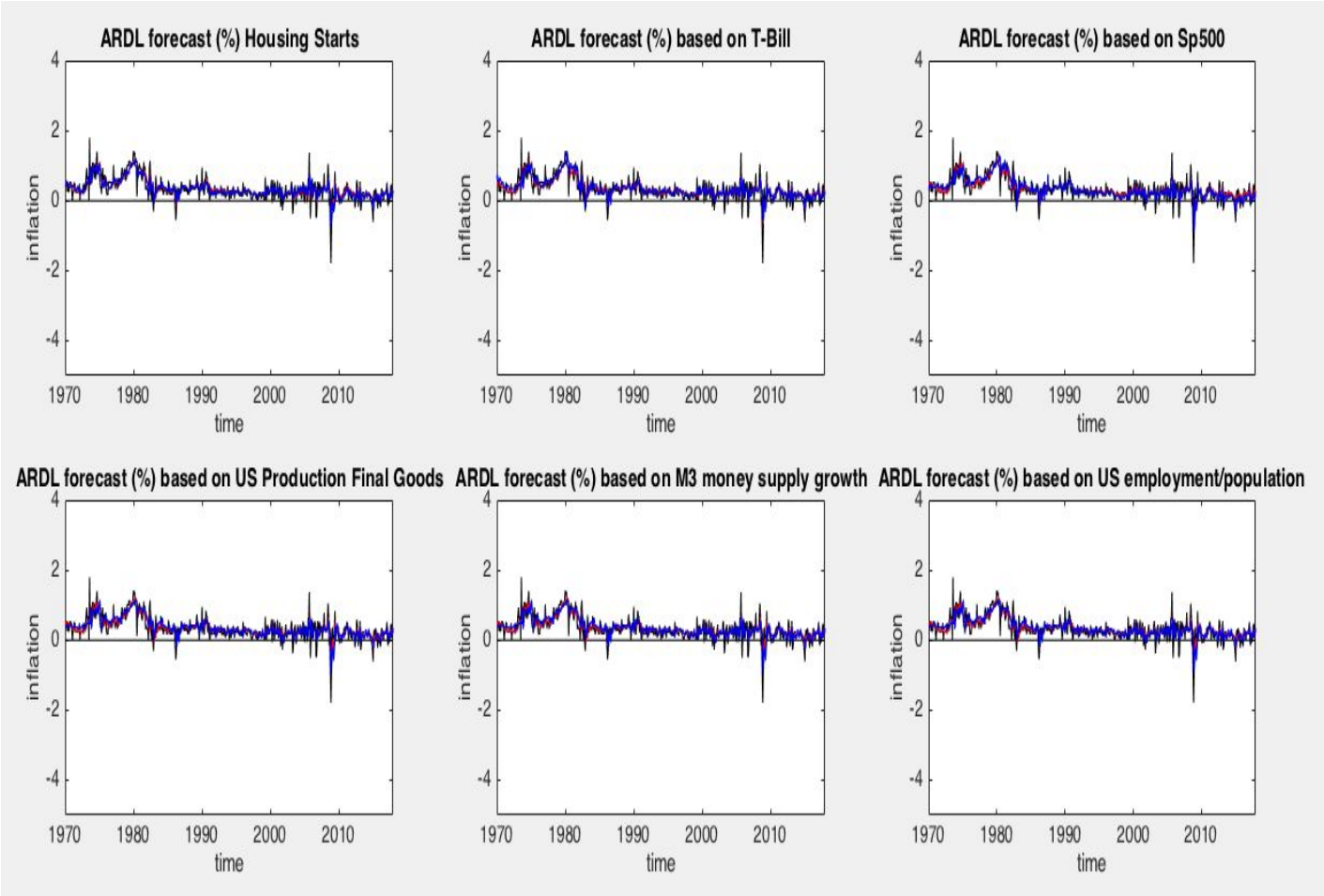
[3] Gali, Jordi, and Mark Gertler. "Inflation Dynamics: A Structural Econometric Analysis." 2000, doi:10.3386/w7551.

increases in inflation. This follows the framework of the New-Keynsian phillips curve developed by Roberts in 1995[4]. M3 growth rate and US civilian employment/population came from the Canova study. In isolation, none of these variables outperformed the benchmark, but through a combination forecast they showed an improvement on the benchmark.

Summary Statistics			
	Mean%	Volume%	Sharpe
CPI(GFD)	1.2277	0.63043	1.9474
Housing Starts (GFD)	5.7325	0.8004	0.0001
10 year T-bond yields(GFD)	2.4673	0.5723	0.0043
SP500 returns(GFD)	3.748	2.343	0
US industrial production growth(GFD)	2.7289	0.5324	0.0005
M3 growth rate(FRED)	2.2145	0.7049	0.0003
US civilian employment/population(GFD)	2.3915	0.0538	0.0044

[4]Roberts, John M. (1995). "New Keynesian Economics and the Phillips Curve". *Journal of Money, Credit and Banking*. **27** (4): 975–984. JSTOR 2077783.

Actual values and AR, ARDL forecasts



Red line - AR

Blue line - ARDL

Black line - Actual

The auto regressive (AR) forecast is constructed by selecting an optimal lag structure for the time series variable you wish to forecast using Akieke and or Schwartz information criterion, and running an Ordinary Least squares regression on the equation with the lagged variables on the right hand side. For macrovariables, the AR proves to

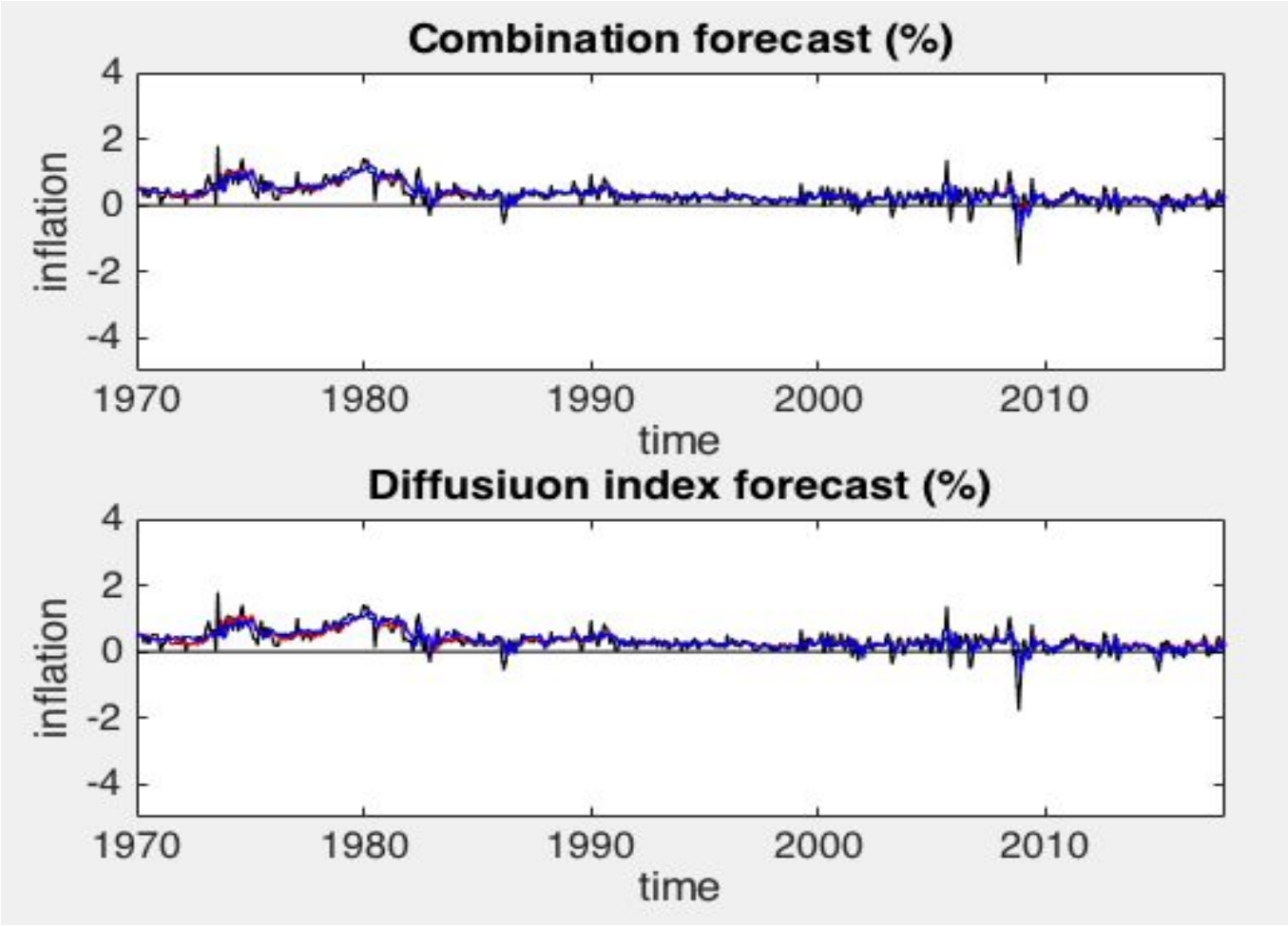
be a stringent benchmark. The Akieke and Schwartz criterion control for the in smple fit to parsimony trade off in order to select optimal lags for the purposes of forecasting.

The auto regressive distributed lag (ARDL) model is constructed in a similar fashion to the AR, but it includes an explanatory variable in addition to the variable we wish to forecast. Optimal lag structure is selected for both the variable we are forecasting as well as the explanatory variable. ARDL runs an OLS regression with both lagged variables on the right hand side, and the variable we wish to forecast on the right.

The combination forecast takes the arithmetic average of all of the ARDL forecasts. Combination forecasts generally perform well relative to the individual forecasts contained within. The simple averaging of forecasts allows the combination forecast to capture dynamics from multiple predictive variables.

The diffusion index finds an underlying common factor as a first principal component and uses the eigen values from the first principal component to in addition to an optimally selected lag structure (using AIC and SIC) to generate an ARDL with the selected lag structure of the variable we wish to forecast and the first principal component on the right hand side of the equation.

Combination and dIffusion index forecasts



Red line - AR forecast

Blue line - ARDL forecast

Black line - actual

ARDL, Combined, and Diffusion vs AR Benchmark					
	MSFE_ratio	CW	performance results	Statistical conclusion	
Housing Starts (GFD)	1.0095	0.6534	underperform benchmark	not significant result	
10 Year t-bond yields	1.0434	0.663	underperform benchmark	not significant result	
SP500 returns(GFD)	1.0623	0.5468	underperform benchmark	not significant result	
US industrial production growth(GFD)	1.0344	1.4104	underperform benchmark	not significant result	
M3 growth rate(FRED)	1.0058	1.2191	underperform benchmark	significant result	
US civilian employment/population(GFD)	1.0188	1.6909	underperform benchmark	significant result	
Combined forecast	0.9957	1.8375	outperform benchmark	significant result	
Diffisuion index forecast	1.0387	1.2369	underperform benchmark	not significant result	

CW stat significance level at 95% confidence interval: 1.645
H_null: Competing forecast does not outperform benchmark
H_alt: Competing forecast outperforms benchmark

None of the ARDL forecasts outperformed the AR benchmark in isolation as indicated by Mean Squared Forecast Error criterion higher than 1. However, the combination forecast showed a slight, statistically significant, improvement over the benchmark. Statistical significance is measured by the Clark and West statistic which is a one sided upper tail test. The combination forecast was the only one to show an

improvement over the AR. The M3 growth rate, US civilian employment/population, and combination forecasts were the only results to be statistically significant.

In summary, none of the ARDL models in isolation outperformed the benchmark AR forecast. However, the combination forecast slightly outperformed the benchmark, which was a statistically significant event. The diffiusion index did not outperform the benchmark. Some areas for further research may be the connection between the New Keynsian Phillips Curve as a theoretical model for future expectations of next period's inflation and what we observe in accurate forecasts of CPI that improve on the AR benchmark. It would be an interesting study to compare several measures of actual behavior to their theoretical underpinnings.

Works Cited

- Canova, Fabio. *Forecasting G-7 inflation* (2002) European Central Bank, working paper 151 https://www.ecb.europa.eu/pub/pdf/scpwps/ecbwp151.pdf?0eccf9443c3dff3cd19dea75b39da944
- Federal Reserve Bank of San Francisco https://www.frbsf.org/education/publications/doctor-econ/2006/march/inflation/
- Roberts, John M. (1995). "New Keynesian Economics and the Phillips Curve". *Journal of Money, Credit and Banking*. **27** (4): 975–984. JSTOR 2077783.