

TERM STRUCTURE LEARNING AND INFLATION PREDICTABILITY: A DYNAMIC APPROACH

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Motivation

- Central Banks had reduced policy rates and increase asset purchases in an unprecedented scale in 2019 in order to counter the sharp contraction of growth due to COVID-19, this has led to an increase in inflation.
- After the re-opening of most economies, as a counter measure, central bank rates had to raise policy rates and halt asset purchases to fight inflation.
- At the same time, Russia's war in Ukraine had drove up energy prices and disrupted supply chain, these made matters worse.
- The world supply chain distributional systems were not able to handle an abrupt increase in demand post government lock down, this led to an excess demand over the capacity constraints.
- The combination of these factors leads to uncertainty in inflation expectation (Avdiu & Unger, 2022).

Motivation

- Barro (1976) and Friedman (1977) revealed that uncertainty in inflation compounds the fluctuations in macroeconomic activities.
- Apergis et al. (2021) states that high inflation causes uncertainty, discourages firms to produce, and in turn lead to a decrease in employment levels and financing activities.
- Gao & Ren (2021) opined that the capability to have a reasonably accurate expectation of inflation would contribute to the economic and social welfare of the society.
- However, inflation forecasting is a challenging task and the established traditional forecasting models, which are normally rooted in assumption of time series stationarity, are not always able to provide comprehensive findings (Medeiros, Vasconcelos, Veiga, & Zilberman, 2021).

Motivation

Figure 1. Time Series of CPI from 2018 January to 2022 January.

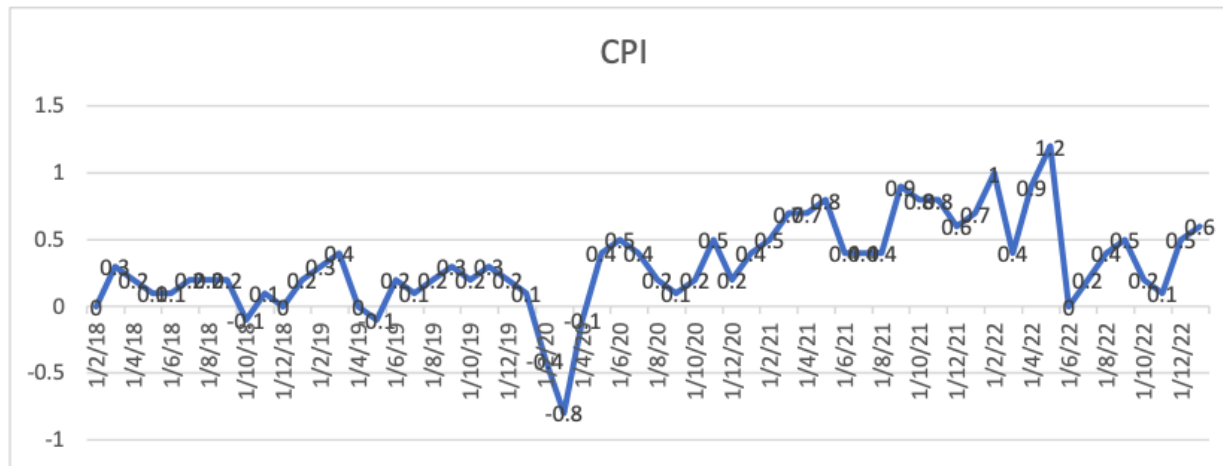
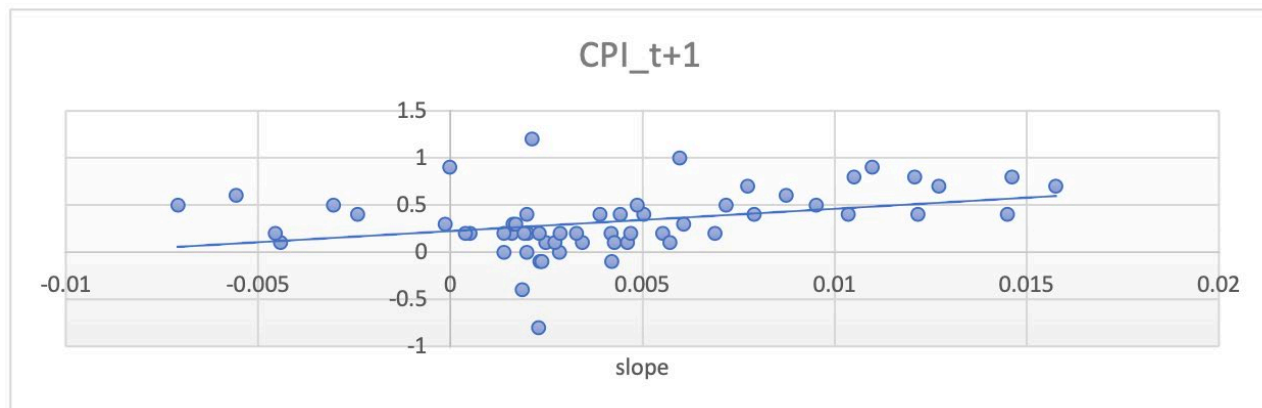


Figure 2. Scatter plot between future CPI and the slope of yield curve.



Motivation

- We take into account of the current interest rate term structure, in conjunction with the variables included in the Quantity Theory of Money (QTM).
- Our estimation equation contains market traded information (expressed via the term structure), as well as key economic indicators as specified by the QTM.
- Simple and innovative model: creating a limiting “oscillatory” effect on the dependent variable.
- Implement machine learning techniques to dynamically drop (include) the insignificant (significant) explanatory factors, conditional on regimes of inflation.

Hypotheses

- *Hypothesis 1a: the term structure of yield curve positively predicts the one month ahead reported inflation rate ($t+1$).*
- *Hypothesis 1b: the term structure of yield curve positively predicts the two month ahead reported inflation rate ($t+2$).*
- *Hypothesis 2: the positive prediction from the term structure only works for high-inflation regime, implying that under different inflation regimes, the set of eligible variables should be readjusted dynamically.*
- *Hypothesis 3: K-nearest neighbour models using different sets of variables work obtain higher accuracy rate at lowest and highest regime, but not in the middle regime.*

Summary Statistics

- Expected price level (EP) :

$$E(P) = \frac{VM_2}{T},$$

where velocity of money for all transactions (V) is 1.28 as the average over the past five years reported by Bloomberg, US Money Supply as M2, aggregate real value of transactions as the average between ISM Manufacturing PMI Index and Service PMI Index as T.

<i>Variable</i>	Obs	Mean	Std. dev.	Min	Max
<i>CPI_t+1</i>	59	0.322	0.336	-0.800	1.200
<i>slope</i>	60	0.004	0.005	-0.007	0.016
<i>CPI</i>	60	0.317	0.336	-0.800	1.200
<i>CPI-square</i>	60	0.211	0.290	0.000	1.440
<i>EP</i>	60	407.568	73.739	296.650	560.145
<i>M2</i>	60	17.836	3.063	13.841	21.846
<i>M2-square</i>	60	327.361	109.062	191.573	477.252
<i>DP</i>	59	0.011	0.053	-0.174	0.272
<i>lowRate</i>	60	0.133	0.343	0	1
<i>midRate</i>	60	0.65	0.481	0	1
<i>highRate</i>	60	0.217	0.415	0	1

Correlation Coefficients

- Slope, CPI, lagged CPI, CPI-square, EP, M2 and M2-square are all positively related to future CPI, statistically significant at 5%.

	<i>CPI_{t+1}</i>	<i>slope</i>	<i>CPI</i>	<i>CPI_{lag}</i>	<i>CPI²</i>	<i>EP</i>	<i>M</i>	<i>M²</i>	<i>DP</i>
<i>CPI_{t+1}</i>	1								
<i>slope</i>	0.3450*	1							
<i>CPI</i>	0.6033*	0.3031*	1						
<i>CPI_{lag}</i>	0.3355*	0.2527	0.6033*	1					
<i>CPI-square</i>	0.3391*	0.2990*	0.6995*	0.4360*	1				
<i>EP</i>	0.4566*	-0.1808	0.3838*	0.2649*	0.3839*	1			
<i>M2</i>	0.6115*	0.1249	0.5992*	0.5723*	0.5491*	0.8773*	1		
<i>M2-square</i>	0.6156*	0.1064	0.6064*	0.5838*	0.5533*	0.8711*	0.9989*	1	
<i>DP</i>	-0.0182	-0.0473	-0.3023*	-0.3702*	-0.0221	0.1605	-0.0244	0.8545	1

Inflation Prediction (reported)

$$CPI_{t+1} = \beta_0 + \beta_1 slope_t + \beta_2 CPI_t + \beta_3 CPI_{t-1} + \beta_4 CPI_t^2 + Controls + \varepsilon_t$$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
<i>slope</i>	23.647*** (2.78)	28.040*** (3.84)	20.834*** (2.81)	20.087*** (2.68)	34.978** (2.63)	25.346*** (2.70)	29.238*** (3.63)	19.192** (2.43)	18.965** (2.36)	36.738** (2.05)
<i>EP</i>		0.002*** (4.77)	0.002*** (3.85)	0.002*** (3.29)	0.001 (0.83)		0.002*** (4.29)	0.002*** (3.40)	0.002*** (3.06)	0.002 (0.82)
<i>CPI</i>			0.623*** (4.11)	0.667*** (4.16)	0.501*** (3.17)			0.672*** (3.98)	0.687*** (3.81)	0.509** (2.71)
<i>CPI_lag</i>			-0.098 (-0.82)	-0.065 (-0.52)	-0.328** (-2.30)			-0.115 (-0.86)	-0.105 (-0.75)	-0.340** (-2.09)
<i>CPI-square</i>			-0.354** (-2.25)	-0.385** (-2.38)	-0.444*** (-2.97)			-0.317* (-1.72)	-0.328* (-1.72)	-0.383** (-2.10)
<i>DP</i>				0.633 (0.86)	-0.104 (-0.13)				0.225 (0.26)	-0.621 (-0.63)
<i>M2</i>					-0.846** (-2.09)					-0.897* (-1.74)
<i>M2-square</i>					0.025** (2.33)					0.026* (1.95)
<i>month FE</i>	NO	NO	NO	NO	NO	YES	YES	YES	YES	YES
<i>_cons</i>	0.224*** (4.10)	-0.750*** (-3.58)	-0.660*** (-3.20)	-0.614*** (-2.88)	6.556** (2.05)	0.229 (1.30)	-0.700** (-2.66)	-0.623** (-2.52)	-0.604** (-2.33)	6.883* (1.72)
<i>N</i>	59	59	58	58	58	59	59	58	58	58
<i>adj. R-sq</i>	0.104	0.351	0.494	0.491	0.574	-0.029	0.253	0.450	0.437	0.524

Inflation Prediction (actual)

$$CPI_{t+2} = \beta_0 + \beta_1 slope_t + \beta_2 CPI_t + \beta_3 CPI_{t-1} + \beta_4 CPI_t^2 + Controls + \varepsilon_t$$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
<i>slope</i>	25.941*** (2.94)	27.924*** (3.70)	27.863*** (3.16)	25.692*** (2.95)	31.791** (2.10)	28.545*** (2.94)	30.213*** (3.75)	30.065*** (3.17)	28.227*** (3.03)	48.157** (2.40)
<i>EP</i>		0.002*** (4.67)	0.002*** (3.99)	0.002*** (3.27)	0.000 (0.05)		0.002*** (4.60)	0.003*** (3.89)	0.002*** (3.18)	0.002 (0.87)
<i>CPI</i>			-0.014 (-0.08)	0.097 (0.52)	-0.048 (-0.27)			0.023 (0.11)	0.141 (0.68)	-0.057 (-0.27)
<i>CPI_lag</i>			0.119 (0.85)	0.195 (1.36)	-0.126 (-0.78)			0.114 (0.72)	0.186 (1.16)	-0.086 (-0.46)
<i>CPI-square</i>			-0.090 (-0.49)	-0.166 (-0.91)	-0.237 (-1.40)			-0.140 (-0.65)	-0.218 (-1.02)	-0.281 (-1.38)
<i>DP</i>				1.519* (1.82)	1.072 (1.19)				1.686* (1.75)	0.728 (0.67)
<i>M2</i>					-0.611 (-1.33)					-1.019* (-1.78)
<i>M2-square</i>					0.019 (1.61)					0.029* (1.99)
<i>month FE</i>	NO	NO	NO	NO	NO	YES	YES	YES	YES	YES
<i>_cons</i>	0.210*** (3.71)	-0.766*** (-3.57)	-0.794*** (-3.27)	-0.693*** (-2.84)	4.781 (1.32)	0.039 (0.22)	-0.948*** (-3.65)	-0.972*** (-3.35)	-0.836*** (-2.84)	7.669* (1.72)
<i>N</i>	58	58	57	57	57	58	58	57	57	57
<i>adj. R-sq</i>	0.118	0.357	0.331	0.360	0.464	-0.003	0.308	0.268	0.304	0.418

Regimes

$$Regime_{t+1} = \beta_0 + \beta_1 slope_t + \beta_2 CPI_t + \beta_3 CPI_{t-1} + \beta_4 CPI_t^2 + Controls + \varepsilon_t$$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
<i>slope</i>	-11.045 (-1.19)	-13.916 (-1.51)	-14.238 (-1.54)	-13.460 (-1.42)	-21.507 (-0.90)	26.764** (2.49)	32.718*** (3.38)	18.549* (1.82)	18.460* (1.77)	70.228*** (2.97)
<i>EP</i>		-0.001* (-1.87)	-0.002** (-2.30)	-0.001* (-1.96)	-0.002 (-0.48)		0.002*** (3.68)	0.001* (1.85)	0.001* (1.70)	0.006* (1.92)
<i>CPI</i>			-0.657*** (-3.19)	-0.698*** (-3.17)	-0.619** (-2.45)			0.351 (1.54)	0.355 (1.46)	-0.000 (-0.00)
<i>CPI_lag</i>			0.159 (0.98)	0.132 (0.78)	0.231 (1.05)			0.184 (1.03)	0.188 (1.00)	0.012 (0.05)
<i>CPI-square</i>			0.746*** (3.30)	0.773*** (3.32)	0.794*** (3.24)			0.053 (0.22)	0.050 (0.20)	0.074 (0.30)
<i>DP</i>				-0.598 (-0.57)	-0.206 (-0.16)				0.069 (0.06)	-2.021 (-1.55)
<i>M2</i>					0.402 (0.58)					-1.968*** (-2.87)
<i>M2-square</i>					-0.012 (-0.65)					0.053*** (3.00)
<i>month FE</i>	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
<i>_cons</i>	0.227 (1.43)	0.726** (2.35)	0.935*** (3.12)	0.883*** (2.80)	-2.460 (-0.46)	0.335* (1.83)	-0.699** (-2.15)	-0.422 (-1.28)	-0.416 (-1.19)	15.293*** (2.87)
<i>N</i>	60	60	59	59	59	60	60	59	59	59
<i>adj. R-sq</i>	-0.055	-0.002	0.203	0.190	0.169	0.042	0.243	0.341	0.325	0.445

KNN

$$P(x|G_i) = \frac{q_i f_i(x)}{\sum_{j=1}^g q_j f_j(x)} = \frac{q_i P(x|G_i)}{\sum_{j=1}^g q_j P(x|G_j)} = \frac{\frac{q_i k_i}{n_i}}{\sum_{j=1}^g \frac{q_j k_j}{n_j}}$$

Classified [1]						Classified [2]						Classified [3]					
TRUE	1	2	3	Total	Accuracy	1	2	3	Total	Accuracy		1	2	3	Total	Accuracy	
1	8	0	0	8	100%	7	0	1	8	88%		7	0	1	8	88%	
2	11	13	15	39	33%	13	19	7	39	49%		10	21	7	38	55%	
3	1	0	12	13	92%	1	0	12	13	92%		0	0	13	13	100%	

Classified [4]						Classified [5]					
TRUE	1	2	3	Total	Accuracy	1	2	3	Total	Accuracy	
1	7	0	1	8	88%	8	0	0	8	100%	
2	10	21	7	38	55%	6	25	7	38	66%	
3	0	0	13	13	100%	1	0	12	13	92%	

Conclusion

- A positive predictability of the slope of the yield curve to the following two months reported inflation rate in the US from 2018 to 2022, after a series of control variables.
- As such, our model captures nonlinearities of the market and model-implied features of the previous literature, with a simple regression analysis.
- The positive predictability we documented persists in the high inflation regime but not the other.
- Our empirical evidence implies that to use the slope of the yield curve as a reliable inflation predictor, the parameters should be adjusted dynamically based on the prevailing inflation regime.
- KNN suggested that for extreme inflation regime prediction, machine learning approach could be of great help, due to its nonlinear features and pattern recognition at higher dimensions.

Thank you!