Forecasting short run Gold Spot Prices in India using Mixed Frequency Models

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Agenda

- Introduction and Motivation
- Approach-Mixed Data Sampling
- Data
- Results
- Conclusion and way forward

Introduction and Motivation

- Bullion forecast used by consumers as well as investors
- Enhanced forecast accuracy has positive implications for market efficiency
  - Facilitates rational expectations
- Forecasting Techniques
  - Econometric
    - Non Structural(Reduced form)
      - ARIMA, ARIMAX, MLR, VAR
  - Non Econometric
    - Artificial Neural Networks, Genetic Algorithms, Particle Swarm Optimization etc.
    - Predictive rather than explanatory

Introduction and Motivation

- Traditional forecasting methods require that the dependent variable and predictors are available at same frequency(monthly, yearly quarterly etc.)
- We use aggregation/dis-aggregation to achieve same frequency (granularity!)
- Leads to loss of critical information available in high frequency data
- HF signals can be effectively leveraged to enhance forecast accuracy
- 2015 study by Hassani et al. : Many sophisticated methods unable to beat the random walk forecasts

Approach-Mixed Data Sampling

- Consider a situation when independent variable(s) is/are sampled at a higher frequency than the dependent variable
- Month-end Gold Price forecast using daily Crude Oil Price, daily Stock Prices, daily Exchange Rate etc.
- MIDAS:Proposed by Ghysels et al.(2004)- Exposition by Armesto et al. (2010)
- Option1: Time Averaging the HF Variable

$$Y_t = \alpha + \sum_{i=1}^{p} \beta_i L^i Y_t + \sum_{j=1}^{n} \gamma_j L^j \bar{X}_t + \epsilon_t$$

Approach-Mixed Data Sampling

- Option 2: Step Weighting

$$Y_t = \alpha + \sum_{i=1}^{p} \beta_i L^i Y_t + \sum_{k=1}^{n*m} \gamma_k L_{HF}^k X_t + \epsilon_t$$

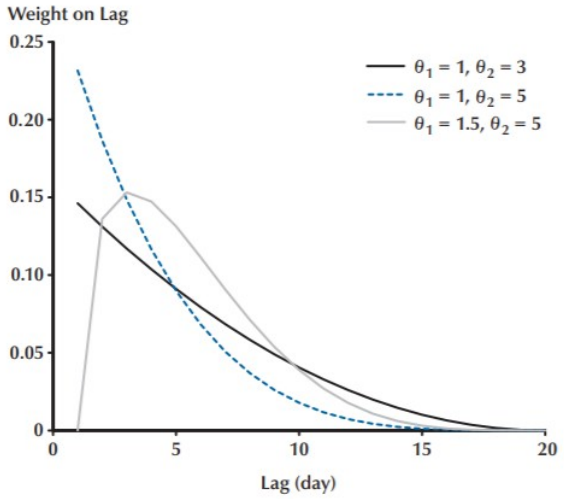
- Option 3: Mixed Data Sampling Regressions

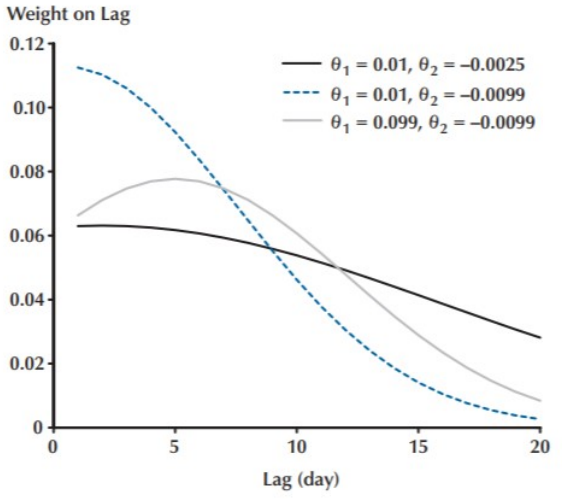
$$Y_t = \alpha + \sum_{i=1}^{p} \beta_i L^i Y_t + \gamma \sum_{k=1}^{m} \Phi(k;\theta) L_{HF}^k X_t + \epsilon_t$$

Approach-Mixed Data Sampling

- One of the most frequently used parametrization is exponential Almon lag function(usually 2 parameters)

$$\Phi(k;\theta) = \frac{exp(\theta_1 k + ... + \theta_Q k^Q)}{\sum_{k=0}^{K} exp(\theta_1 k + ... + \theta_Q k^Q)}$$





Data

- Period: 01-January 2011 to 30-Nov-2019

Data/Variable	Frequency	Source
Gold Price(Real-Inflation adjusted)	Monthly	MCX portal
Crude oil price	Daily	MCX portal
Stock Index(BSE Sensex)	Daily	BSE portal
Exchange Rate(USD INR)	Daily	RBI DBIE portal

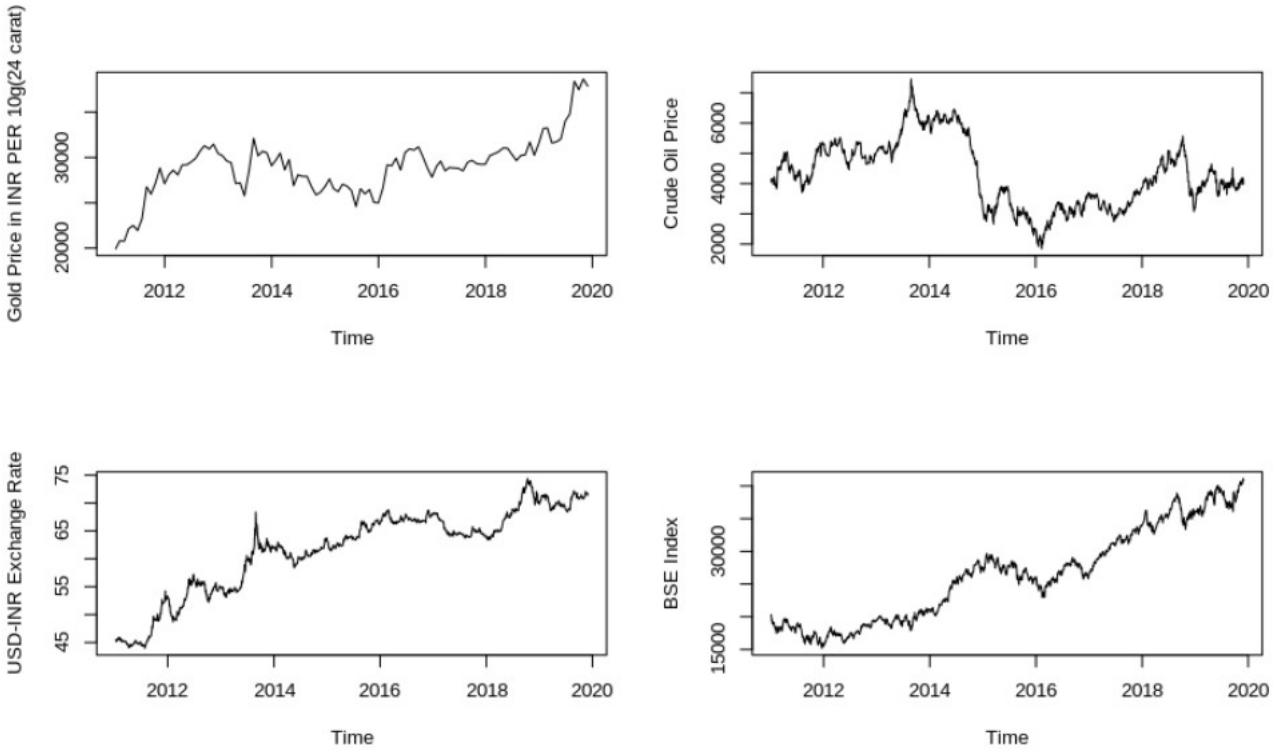
Table 1: Variables used, frequency and data sources

Data/Variable	Transformation
Gold Price(Real-Inflation adjusted)	No transformation required
Crude oil price	First difference
Stock Index(BSE Sensex)	First difference
Exchange Rate(USD INR)	First difference

Table 2: Transformations on variables to achieve stationarity

Data

Figure 1: Plot of variables under study



Results

- In Sample forecast Accuracy(Fitted)

  Period:

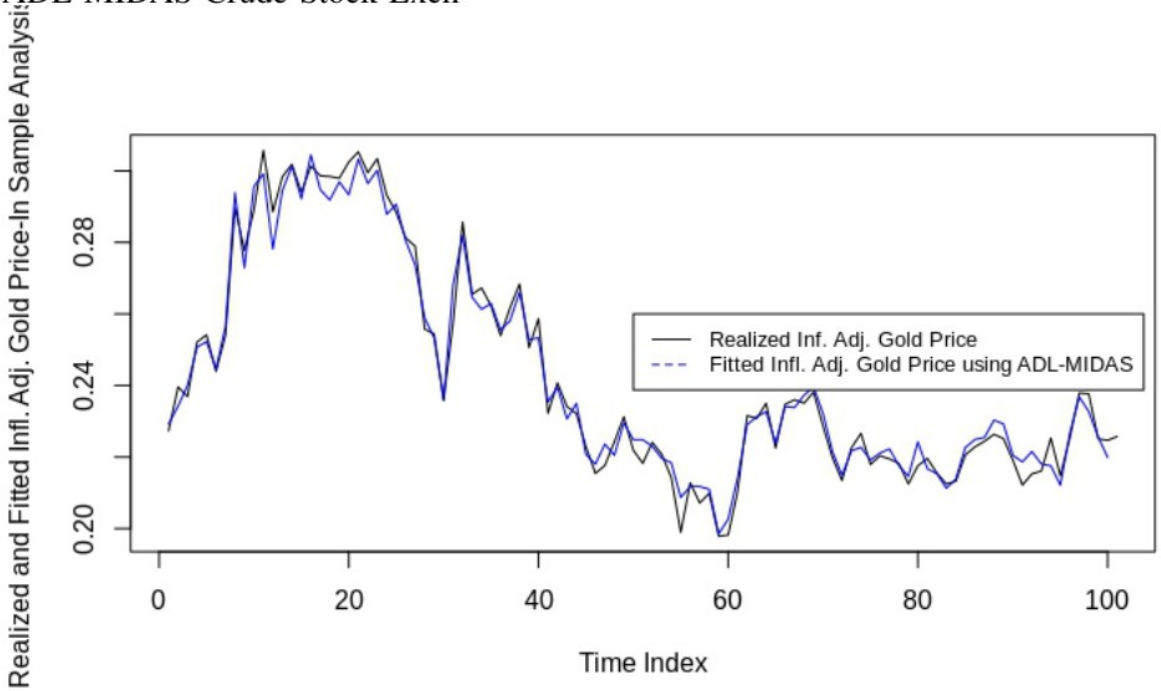
In Sample RMSE for forecasts using different model specifications	
Method	**RMSE**
ADL-MIDAS-Crude	0.00984
ADL-MIDAS-Stock	0.00978
ADL-MIDAS-Exchange	0.00964
ADL-MIDAS-Crude-Stock-Exch	0.00946
ARIMA	0.17215
ARIMAX-Crude-Stock-Exchange	0.09923

Table 3: In-sample RMSE(Recursive)

Results

- In Sample(Fitted)

Figure 3: Realized and Fitted Infl. Adj. Gold Price-In Sample Analysis using ADL-MIDAS-Crude-Stock-Exch



Results

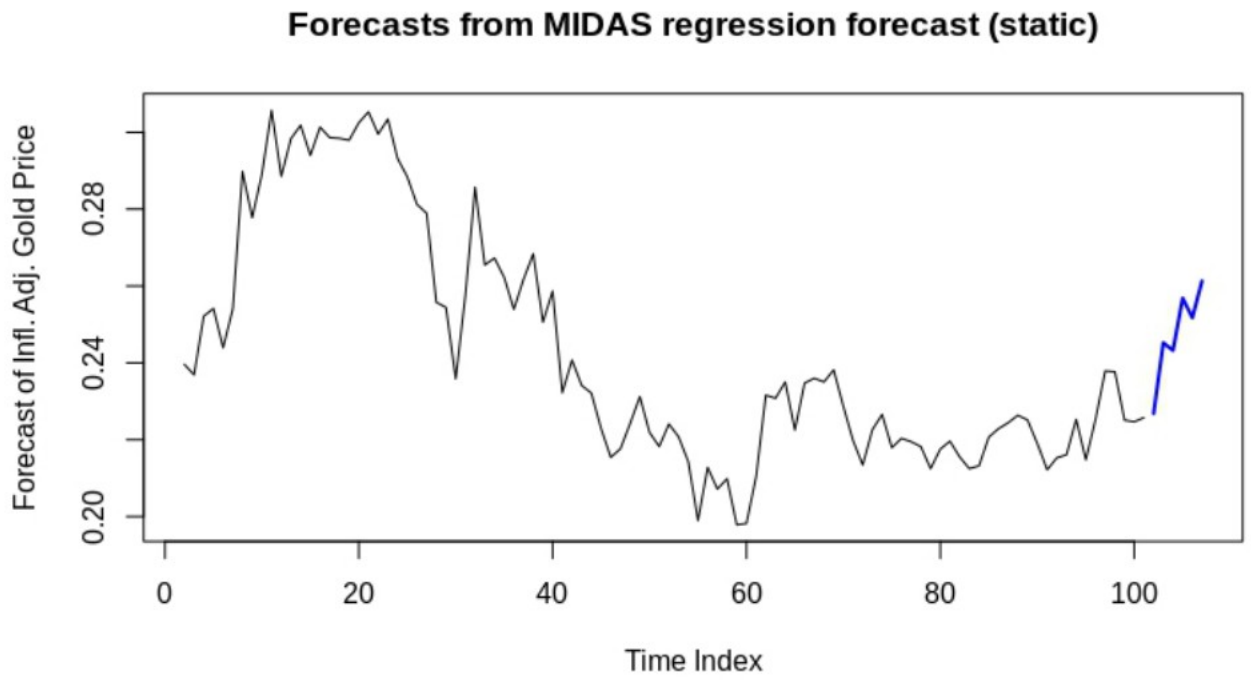
- Out of sample forecast accuracy

Out of Sample RMSE for forecasts using different model specifications	
Method	**RMSE**
ADL-MIDAS-Crude	0.0112
ADL-MIDAS-Stock	0.0118
ADL-MIDAS-Exchange	0.0112
ADL-MIDAS-Crude-Stock-Exch	0.0109
ARIMA	0.1921
ARIMAX-Crude-Stock-Exchange	0.1012

Table 4: Out-of-sample RMSE for 6 month period from June-2019 to Nov 2019(Recursive)

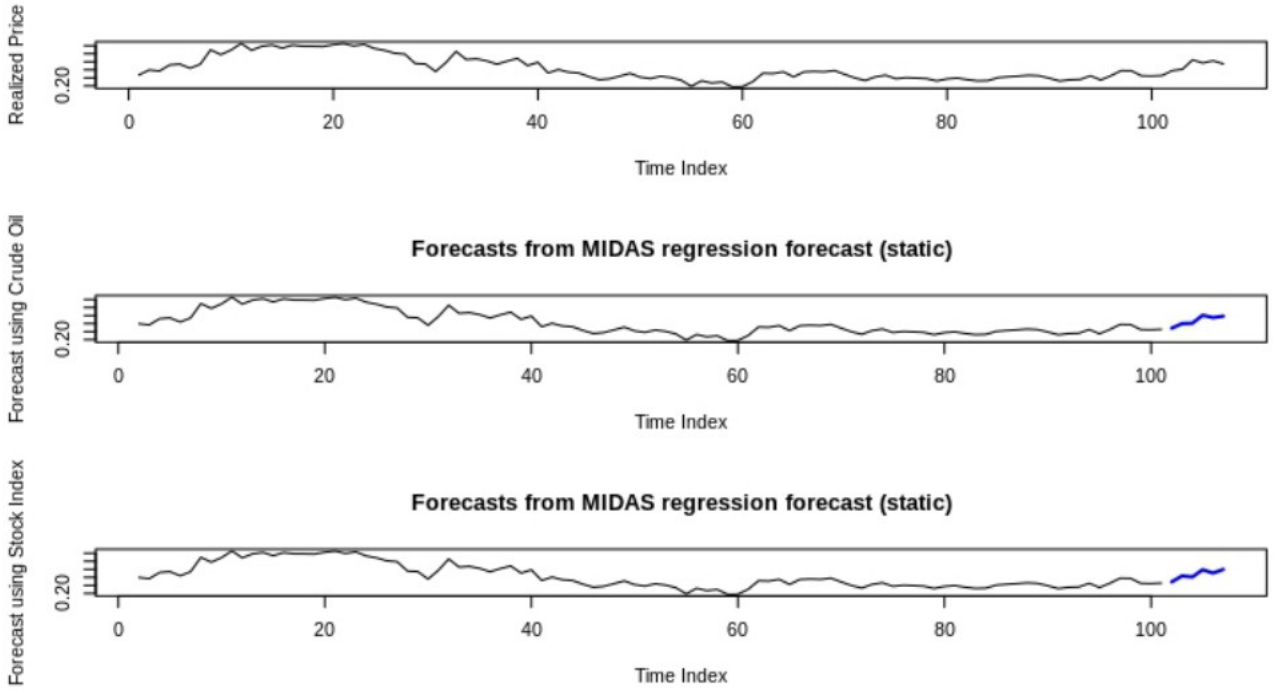
Results

- Out of sample forecast accuracy



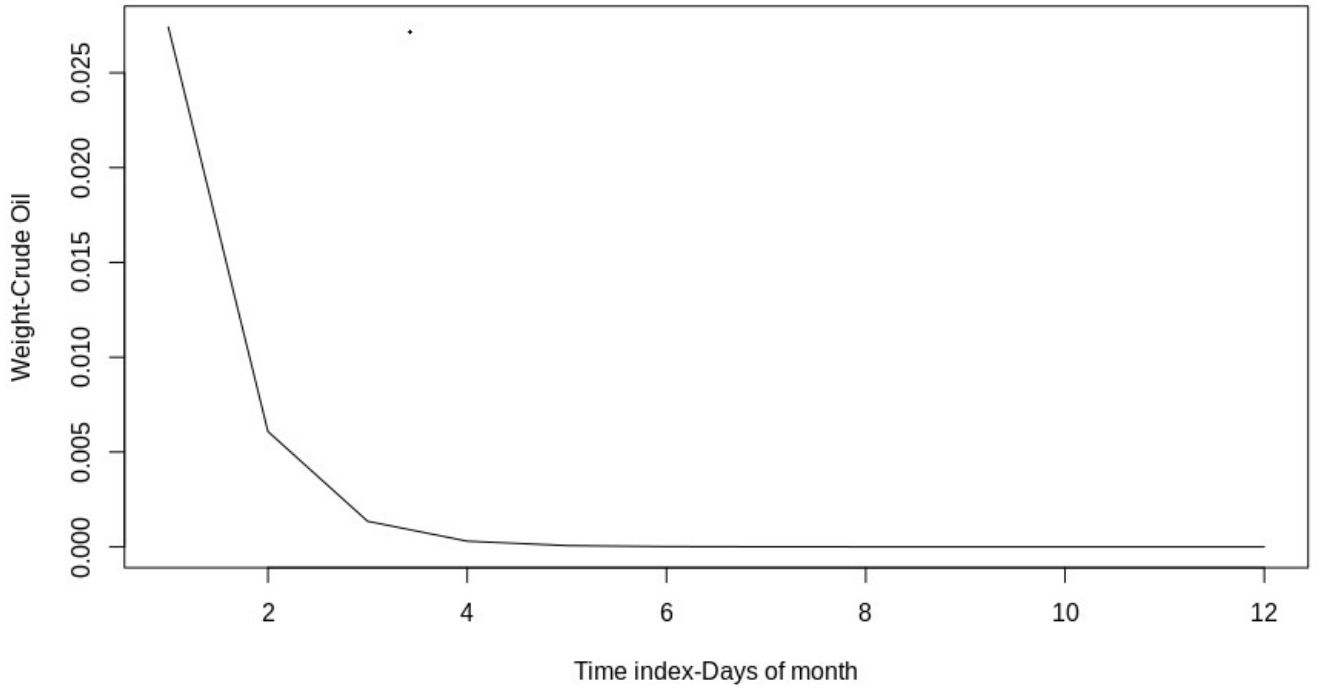
Results

- Out of sample forecast accuracy



Results

- Let us look at lag weights



Results

- Most recent price of crude oil is the key determinant of the spot gold price
- Gold spot market is very sensitive to changes in crude oil prices
- Gold price rises as INR depreciates as compared to USD which confirms the hedging function served by gold
- Most recent exchange rate is not very important in this case
- Investors/consumers seem to take a long term view while forming expectations while considering exchange rate
- In the short term, gold prices are negatively related to stock prices which again corroborates the hedging role of the yellow metal

Conclusion and Way Forward

- Enhanced forecast accuracy using Mixed Data Sampling Regression(MIDAS) models as compared to ARIMA and ARIMAX models
- We are using CPI value to get Inflation Adjusted Gold Price but..
- Casting the model in daily -hourly(for HF variables), although straightforward, may be of immense value for investors/traders
- Leverage the key strength of MF models: now-casting
- A real-time price forecasting application as HF signals evolve
- Adding more variables!

References

- Armesto, M. T., Engemann, K. M., & Owyang, M. T. (2010). Forecasting with mixed frequencies. Federal Reserve Bank of St. Louis Review, 92(6), 521-36.
- Ghysels, E., Santa-Clara, P., & Valkanov, R. (2004). The MIDAS touch: Mixed data sampling regression models.
- Hassani, H., Silva, E. S., Gupta, R., & Segnon, M. K. (2015). Forecasting the price of gold. Applied Economics, 47(39), 4141-4152.

Note

For ease of exposition, some equations have been taken *ad verbatim* from the cited references

Thank you..