MSc Thesis: Forecast Structural Breaks with Hidden Markov Model Update 26 May 2018

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Abstract

The current progress is reported in four parts below. 1. Literature Review 2. Data Collection 3. Testing a naive model with a simple DGP 4. Following methods.

Literature Review

Three relevant papers/ library have been reviewed and found to be particularly useful in generating ideas. Christos Ntantamis Jan 2010 used a variant of HHM, Iterative Conditional Expectation-Generalized Mixture (ICE-GEMI) algorithm in detecting structural breaks. The purposed iterative process is a feedback loop of the simulated data where fitted HMM serves as the DGP. The methodology however doesn't seems to serve as an ex-ante forecast of structural breaks.

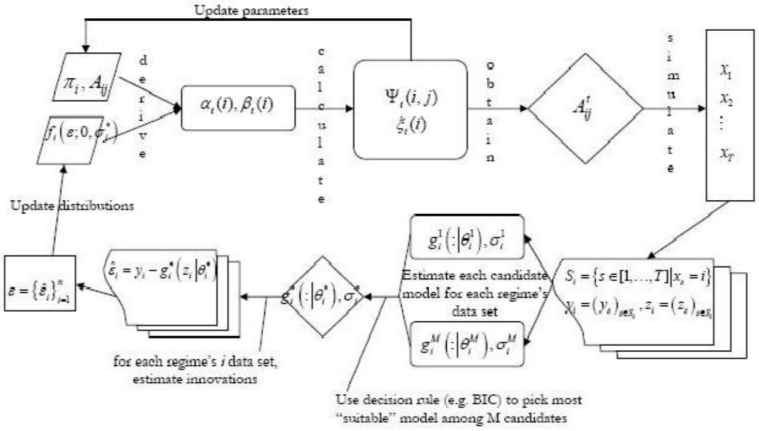

Figure 1: ICE-GEMI algorithm

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Yong Song Oct 2010, "Modelling Regime Switching and Structural Breaks with an Infinite Dimension Markov Switching Model". He argued a finite state model is not sufficient as prior states should have not predicting power over future states. He purposed an infinite state model is needed to accommodate the richer dynamics in US interest rate such that a state cannot recurred. The methodology is sound but it bypassing the assumption of mean reverting process of the data. More reading of the model are needed as well as the algorithm behind.

The Input-Ouput Hidden Markov Model was purposed for sequence processing [1]. The structure

[1] https://github.com/Mogeng/IOHMM

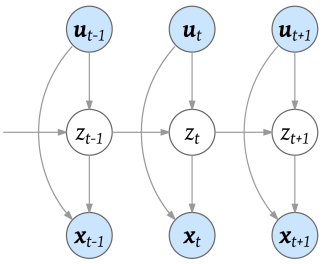

Figure 2: IOHMM model

where u and x are observable inputs and outputs. This structure allows HMM to be estimated/ trained as 1. Unsupervised Learning 2. Semi-Supervised Learning 3. Supervised Learning. An application of the second and third cases would be the Macro-News/ Market Surprises in our FX and crypto currency data. Market Surprises can be served as u in th IOHMM model as market anticipated an regime shift. Difficulties lie on the timing of input news as market could turn volatile or even shifts state before news are announced.

Data collection

FX and cryptocurrency data starting from 09/11/2018 are extracted from Bloomberg in csv format. USDEUR, USDGBP, USDJPY, EURJPY, EURGBP, GBPJPY and XBTUSD, XETUSD, XRPUSD, XBTEUR, XETEUR, XBTJPY, XETJPY (XBT: BitCoin and XET: Ethereum) bid-ask quotes including Open, Close, High, Low, trade, in 5 min interval data were collected. Some intervals are mismatched or missing among the cryptocurrency data. Since Bloomberg only stored a limited amount of high frequency data, next data collection is set to be next month. US equities will also be added in the next data collection. Economic calender data were collected from FXStreet in csv format. Data is not concatenated with the Bloomberg data however. Cryptocurrency calender is virtually non-existing. One way is to estimate the sentimental indicator based on tweets but it would require massive effort in natural language processing. We are keeping it out of the scope for now.

Testing a naive model with a simple DGP

Assuming a mean reverting continuous Gaussian process in each state with a finite number of states. The HMM transition probability matrix is estimated via MLE of historical data (hence, unsupervised learning). Our goal is to forecast an imminent state based on historical data. An naive solution is to fit HMM of a rolling window of historical data. We take the first difference of the probability transition matrix Π and forecast a break is imminent if

$$\Delta_{t-1,t}\pi_{01} > \Delta_{t-1,t}\pi_{00} \text{ when current state } = 0$$
$$\Delta_{t-1,t}\pi_{10} > \Delta_{t-1,t}\pi_{11} \text{ when current state } = 1$$

A DGP of two hidden states with two state shifts was used to test the purposed naive method.

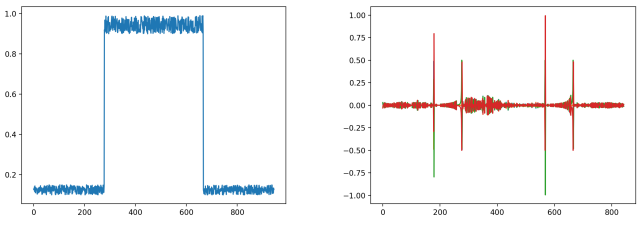

Figure 3: Left: Actual DGP. Right: First difference of the transition probabilities

This naive approach seems to forecast the DGP regime shift with the two massive jumps. Noted there is a smaller jump after the regime shift. The mathematics behind is unclear to me yet and

much digging is needed in the Bayesian framework. A pairs trading strategy has been developed using the naive method as the basis of trading signal. If the mathematics is clear and sound we may even skip the use of IOHMM.

Following Method

Much reading on the Bayesian setting of HMM supporting the naive approach is needed. The IOHMM library has to be explored and "play around" on my side. FX data needed to be concatenated with the economic calender data.

References

Modelling Regime Switching and Structural Breaks with an Infinite Dimension Markov Switching Model, Yong Song 2010
Input-output HMMs for sequence processing, Y. Bengio P. Frasconi 1996
Detecting Structural Breaks using Hidden Markov Models, Christos Ntantamis 2011