Modelling the impact of reserving in high inflation environments

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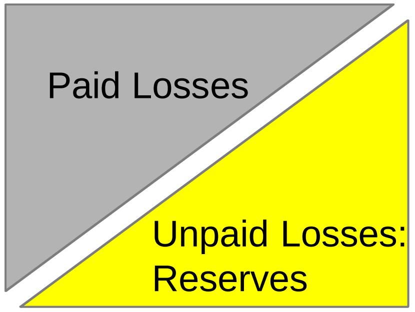
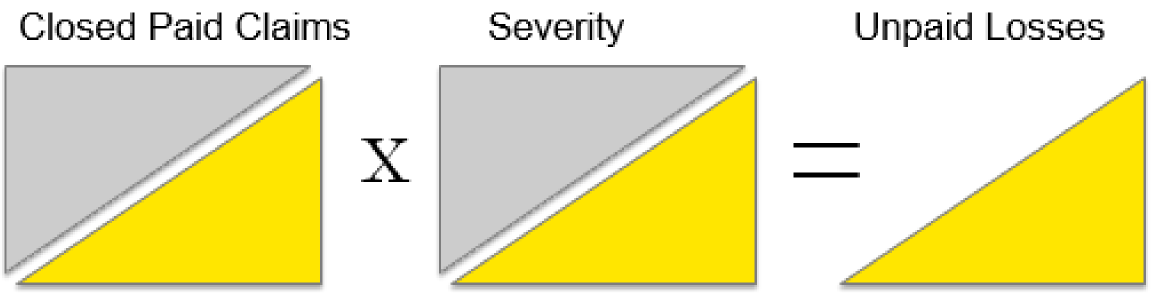
Building a better working world

Reserves Background

- **What are reserves?** Funds set aside by insurers to pay claims for which they are liable.



- **Why are they important?** Largest liability on the P&C balance sheet.
- **Why do you need actuaries?** Due to its uncertainty, it becomes more than an accounting exercise.



- **What packages does R have?**
- **Chain Ladder** (Gesmann and Murphy), which calculates deterministic and stochastic reserving and **Actuar** package, which has many actuarial functions

Challenges in Reserving for Argentina Auto

We were hired to perform and independent reserve study for Auto Liability in Argentina. We faced the following challenges:

1. Higher uncertainty in reserving for long tail lines of business (common in Liability lines) due to longer reporting and settlement delays

2. High and changing inflation over different time period

3. Unreliable data to estimate inflation which is one of the most important assumptions in reserving for countries like Argentina, who was censured by the IMF for providing inaccurate data

- Challenges 1 and 2 led to failure of traditional actuarial methods (chain ladder, BF).

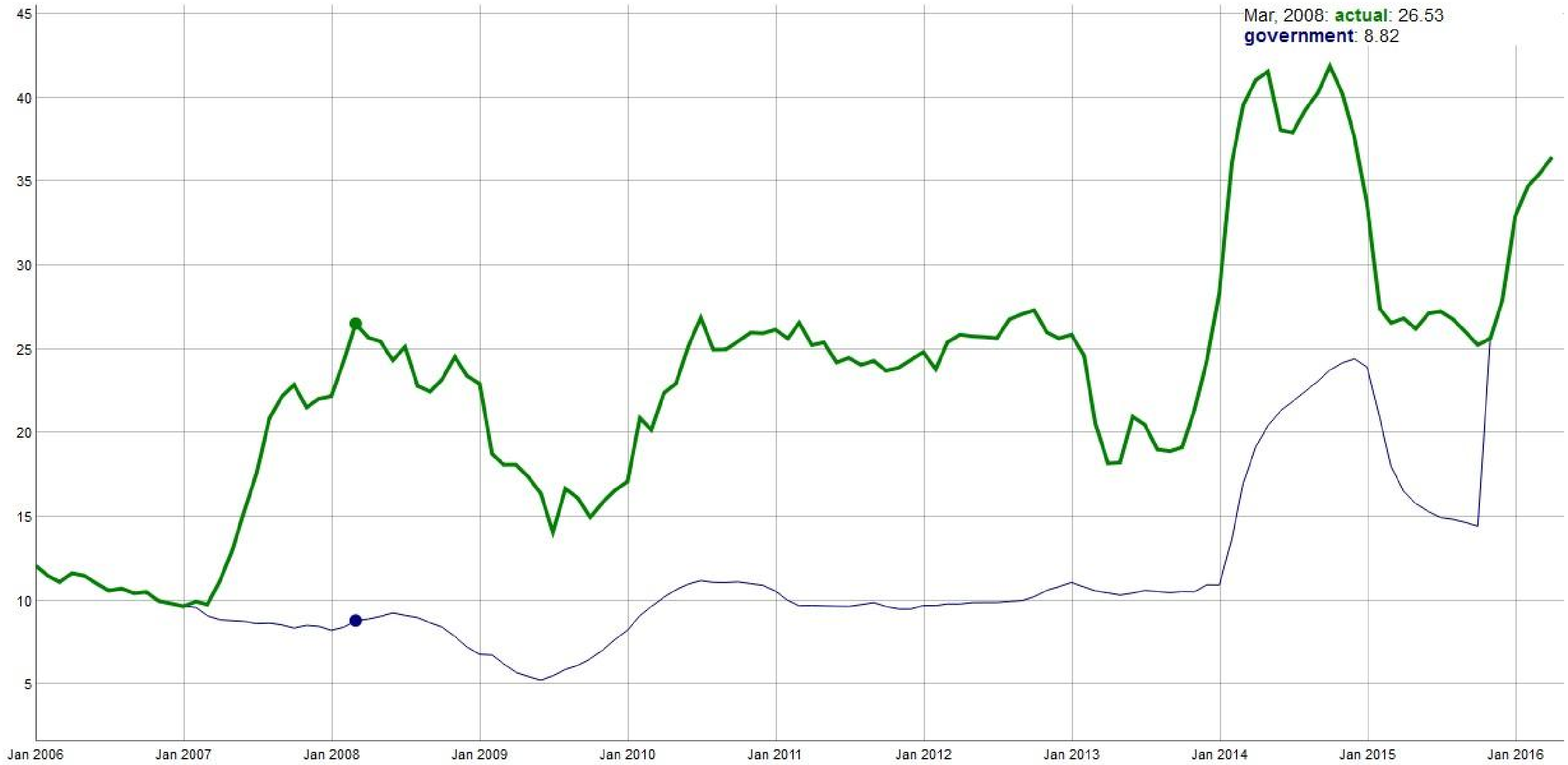
- Challenge 3 was the main motivation for building an inflation model

High and changing inflation in Argentina

- Inflation rates are affected not only by economic factors but also by political factors.

Unreliable data to estimate inflation

- Government started tampering with the data in Jan 2007. We relied on private sources like “Billion Prices Project” to obtain actual inflation rates.



Reserve and Inflation

- We used **fGarch** package to forecast inflation
- We used **Plotly** and **Dygraphs**, along with **Shiny** for the interactive graphs

Billion Prices Project output

Modeling inflation using an ARMA (1,48) GARCH (1,1)

Modified Fisher Lange produces estimates reserves

Months

Accident Qtr	3	6	9	12
Prior				12.4
2015 Q2			16.5	17.6
2015 Q3		18.0	18.6	19.9

Months

Accident Qtr	3	6	9	12
Prior				12.9
2015 Q2			17.1	18.3
2015 Q3		18.7	19.3	20.6

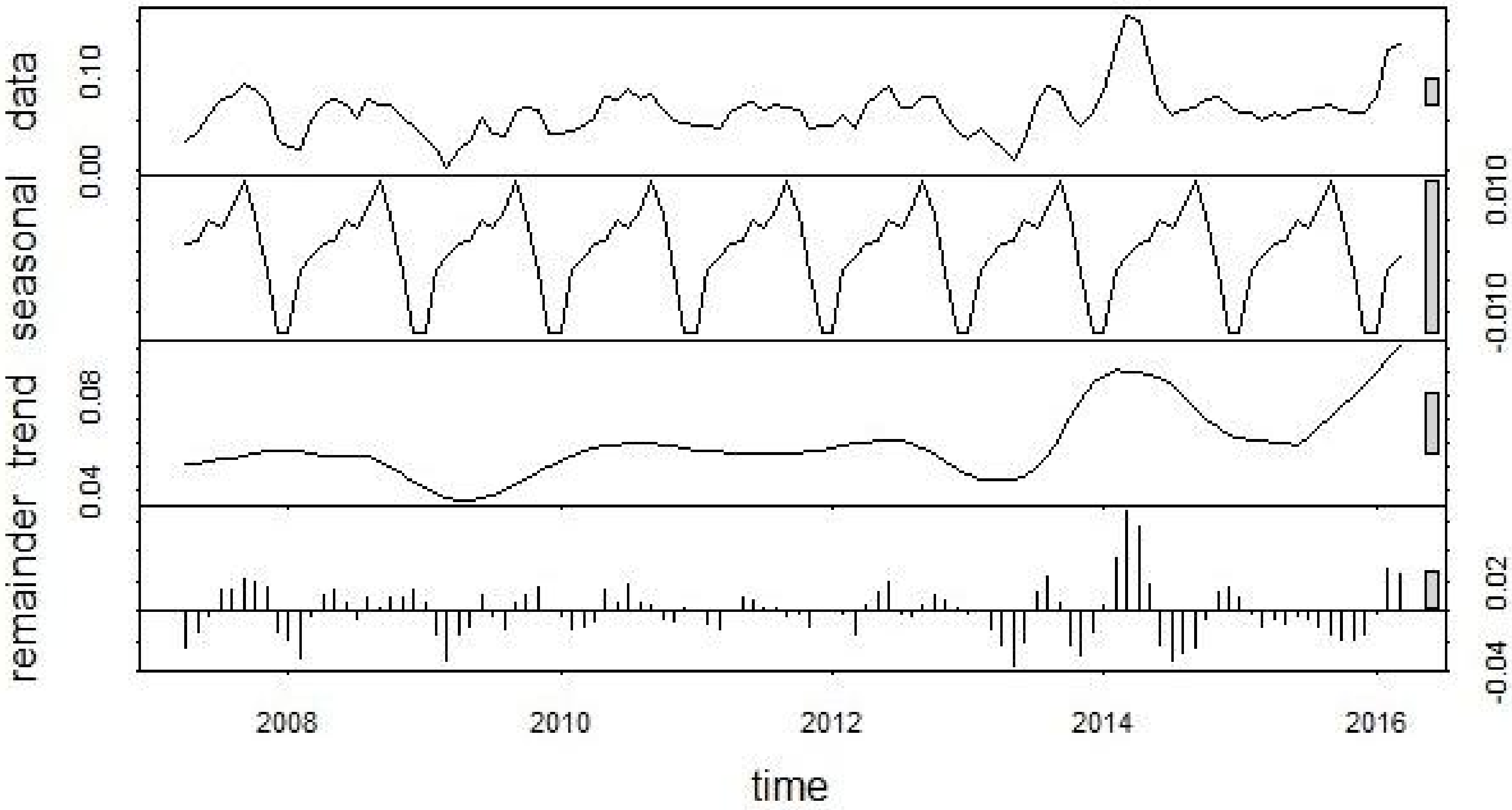
30% inflation yields $103.2 M in reserves

Leverage Effect: A 1% increase in inflation (31%) results in an increase of 3% in reserves

* Scaled by a factor

Initial analysis of the time series – decomposition into seasonality and trend

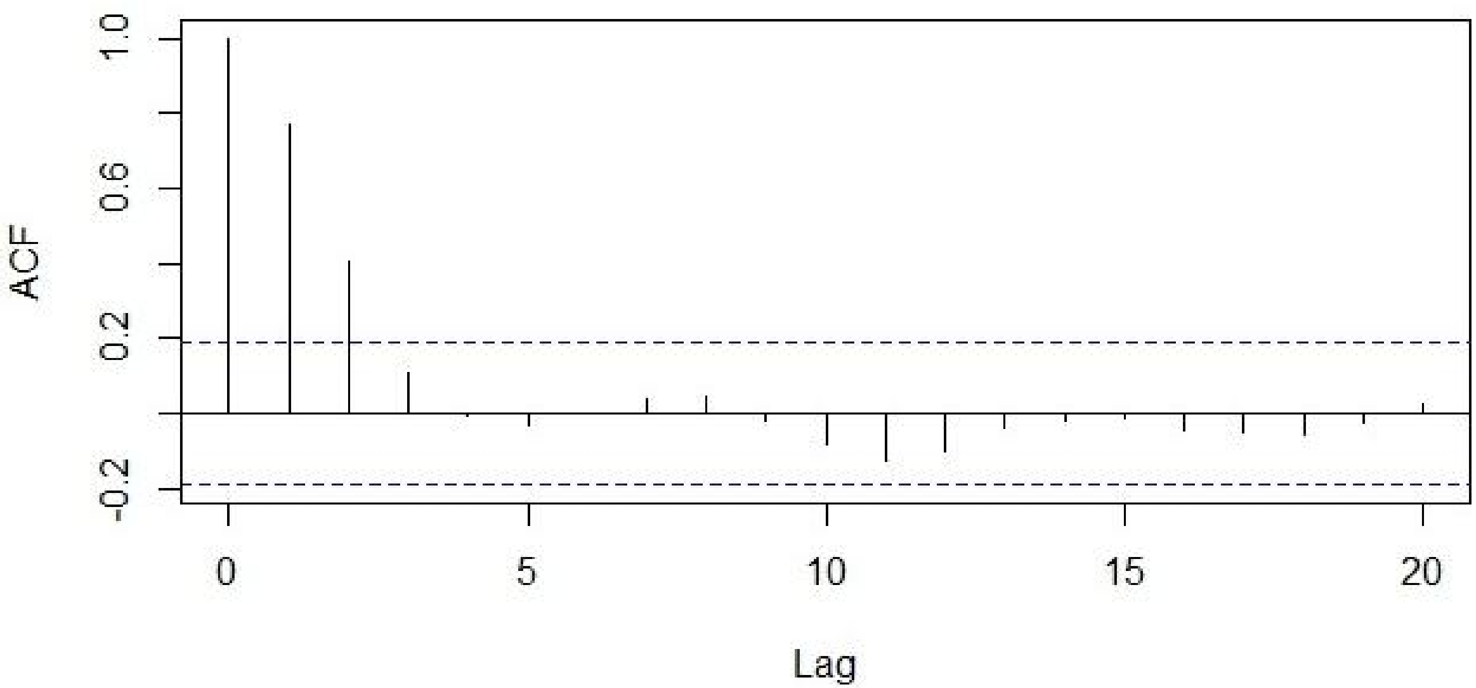
- Even after removing seasonality and trend, the remainder has high and changing volatility, i.e, it shows **heteroscedastic** behavior.



EY

Initial analysis of the time series – determining the AR lag component

- We used **ACF** to measure the linear predictability of the time series at different lags. Lags 1 and 2 are significant for autocorrelation component. Hence AR(1) and AR(2) terms are considered for modelling purposes.
- We validated this by analyzing scatter plots with **lowess** smoothing lines.



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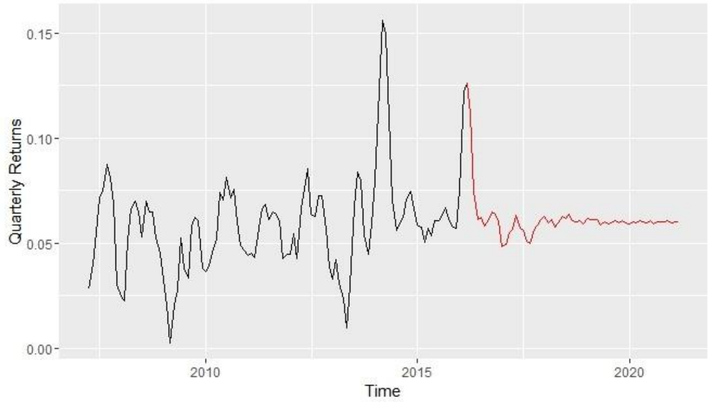
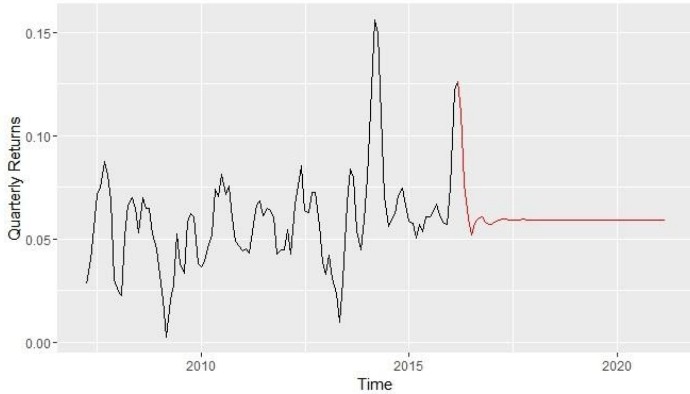
Inflation Model Evolution

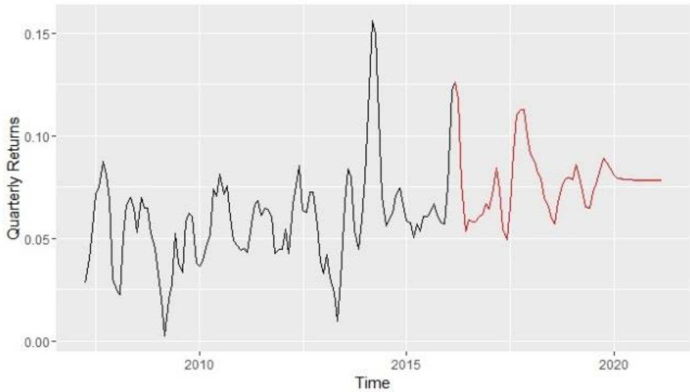


AR using OLS

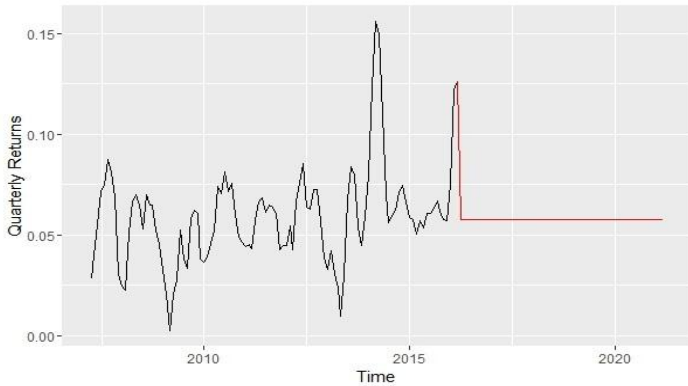


ARMA

ARMA for modelling mean inflation rates and GARCH for modelling its volatility



ARMA GARCH



GARCH

The Model – ARMA+GARCH

ARMA(m,n)+GARCH(p,q) equation is given by

$$y_t = c + \sum_{i=1}^{m} \varphi_i \, y_{t-i} + \sum_{j=1}^{n} \theta_j \tau_{t-j} + \tau_t$$

Where $\tau_t = \varepsilon_t * \sigma_t$

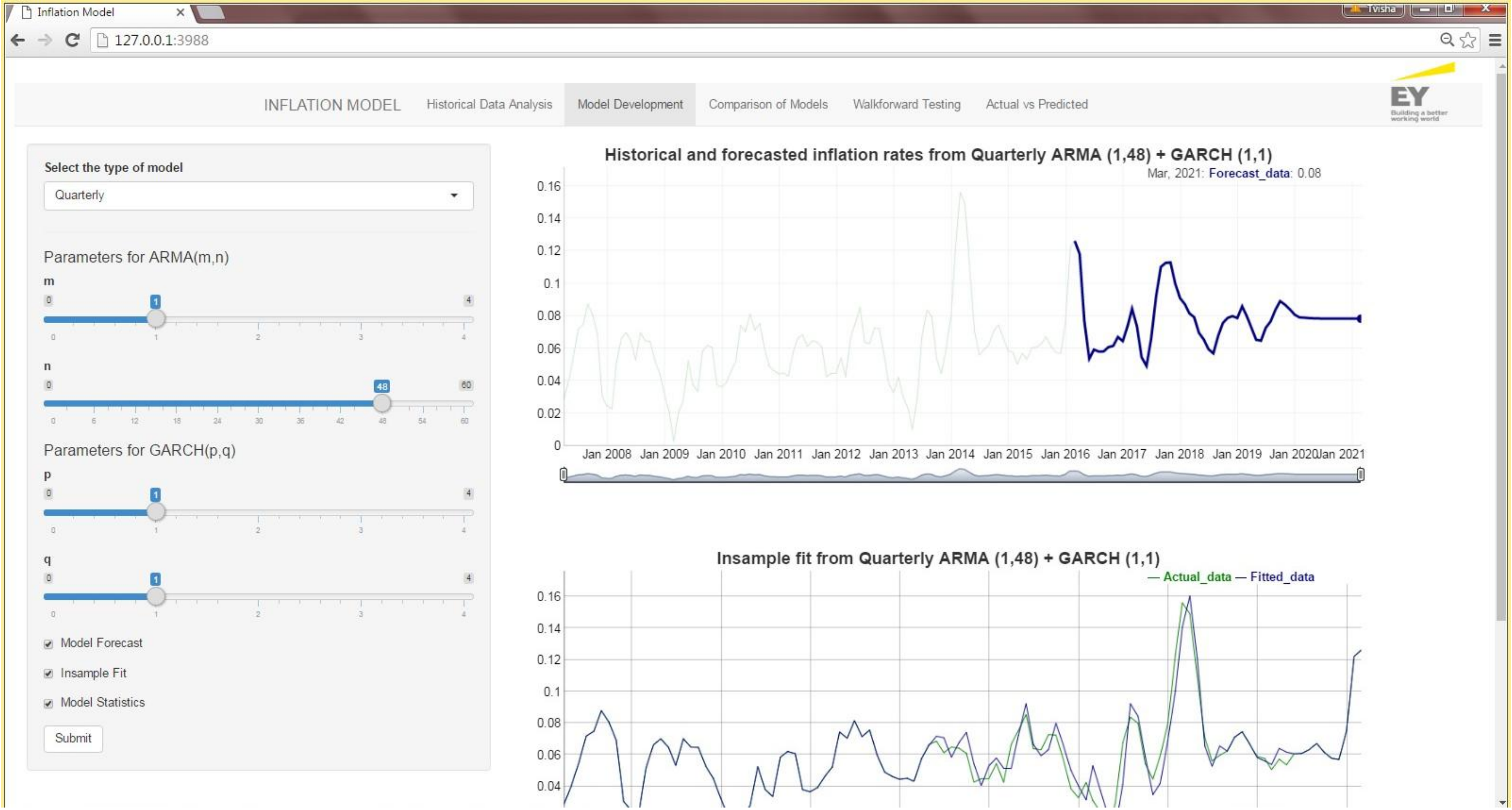
σ_t follows the GARCH(p,q) model where

GARCH(p,q) model is described by

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \, \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j \, \sigma_{t-j}^2$$

is a sequence of i.i.d (0,1) random variables

Snapshot of inflation modelling tool in Shiny



Model Iterations: Performance using statistical tests

Model Execution in R

```
fgarch.fitted <- fGarch::garchFit(~ arma(1,48)+garch(1,1), data = rate, trace =  FALSE)
forecast <- predict(fgarch.fitted, n.ahead = 60)
```

Comparison of Models

Model Specification	LLH	AIC	Persistence	MAPE
ARMA(1,48)+GARCH(1,1)	683.6	-11.7	0.9	6.3%
ARMA(2,48)+GARCH(1,1)	611.2	-10.3	0.9	9.4%
ARMA(1,48)+GARCH(1,2)	598.4	-10.1	0.9	6.4%
ARMA(2,48)+GARCH(1,2)	609.8	-10.3	0.9	6.8%
ARMA(1,36)+GARCH(1,1)	517.2	-8.8	0.9	7.2%
ARMA(2,36)+GARCH(1,1)	535.9	-9.1	0.9	7.3%
ARMA(1,36)+GARCH(1,2)	533.3	-9.1	0.9	7.3%
ARMA(2,36)+GARCH(1,2)	533.3	-9.1	0.9	7.3%

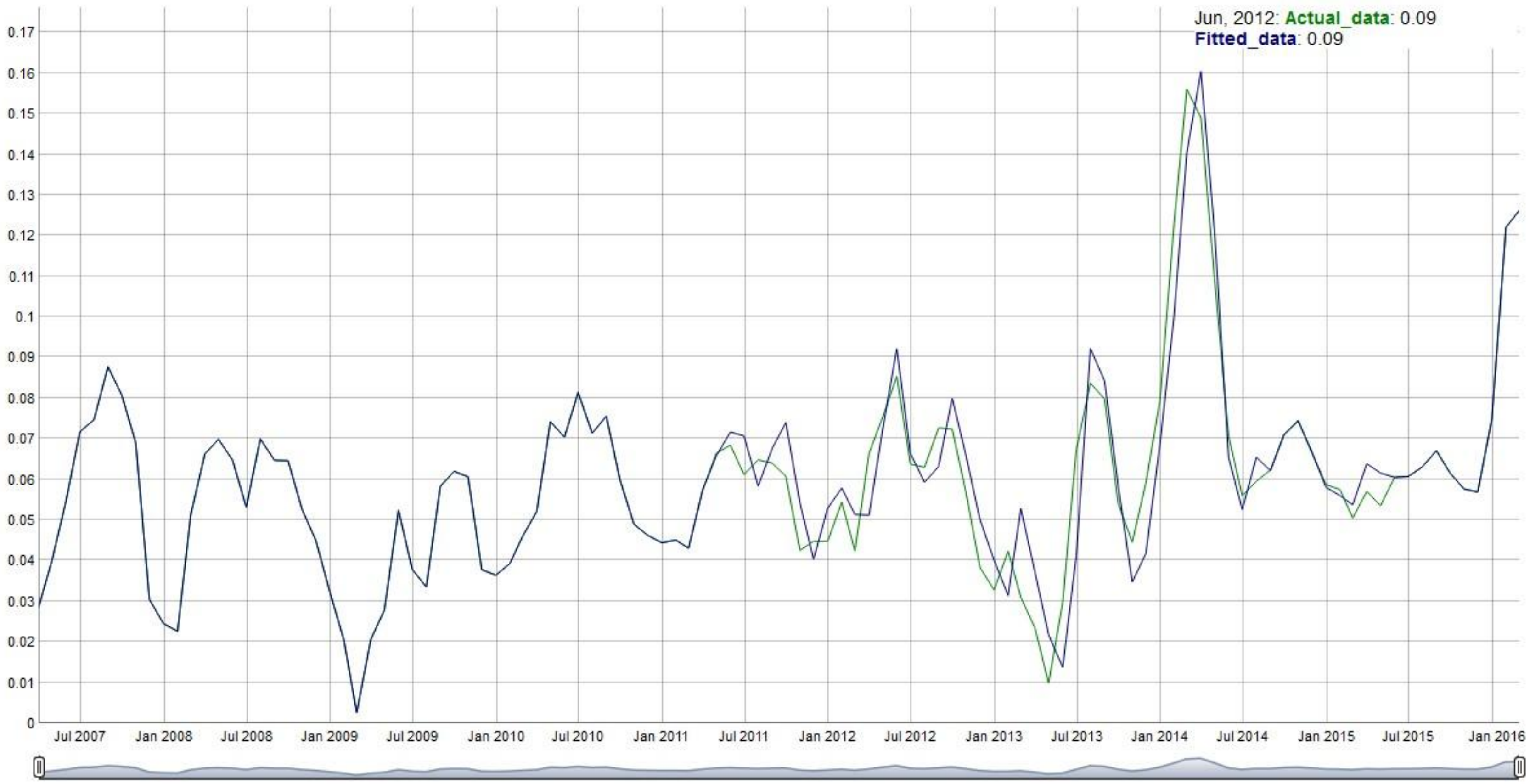
	Challenger Model
	Champion model

Iterations on diff. frequencies of data – monthly, quarterly, annual, etc.

Model Specification	Original Reserves	New Reserves	% Change	Out-of-Sample Error	Walk Forward Tests
ARMA(1,48)+GARCH(1,1) - Monthly	3,100,255,266	4,170,333,320	34.5%	46.95%	Walk Forwards Okay
ARMA(1,48)+GARCH(1,1) - Quarterly	3,100,255,266	4,225,801,893	36.3%	29.38%	Good Walk Forwards

Testing the Champion Model using in sample fit

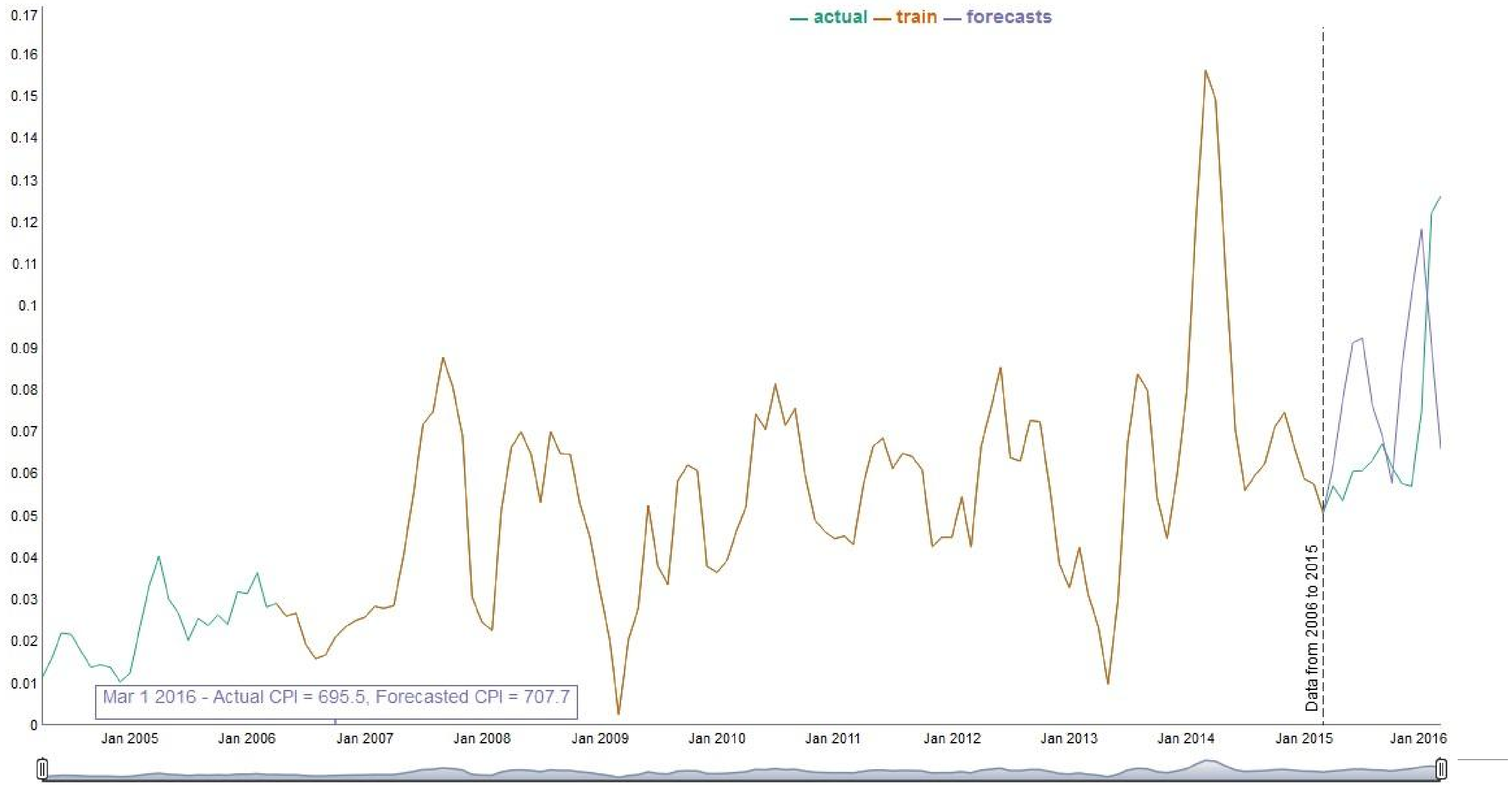
- We validated the results of the champion model by testing its performance on past data.
- We separated the data sets into build and test data sets and perform an in sample fit



EY

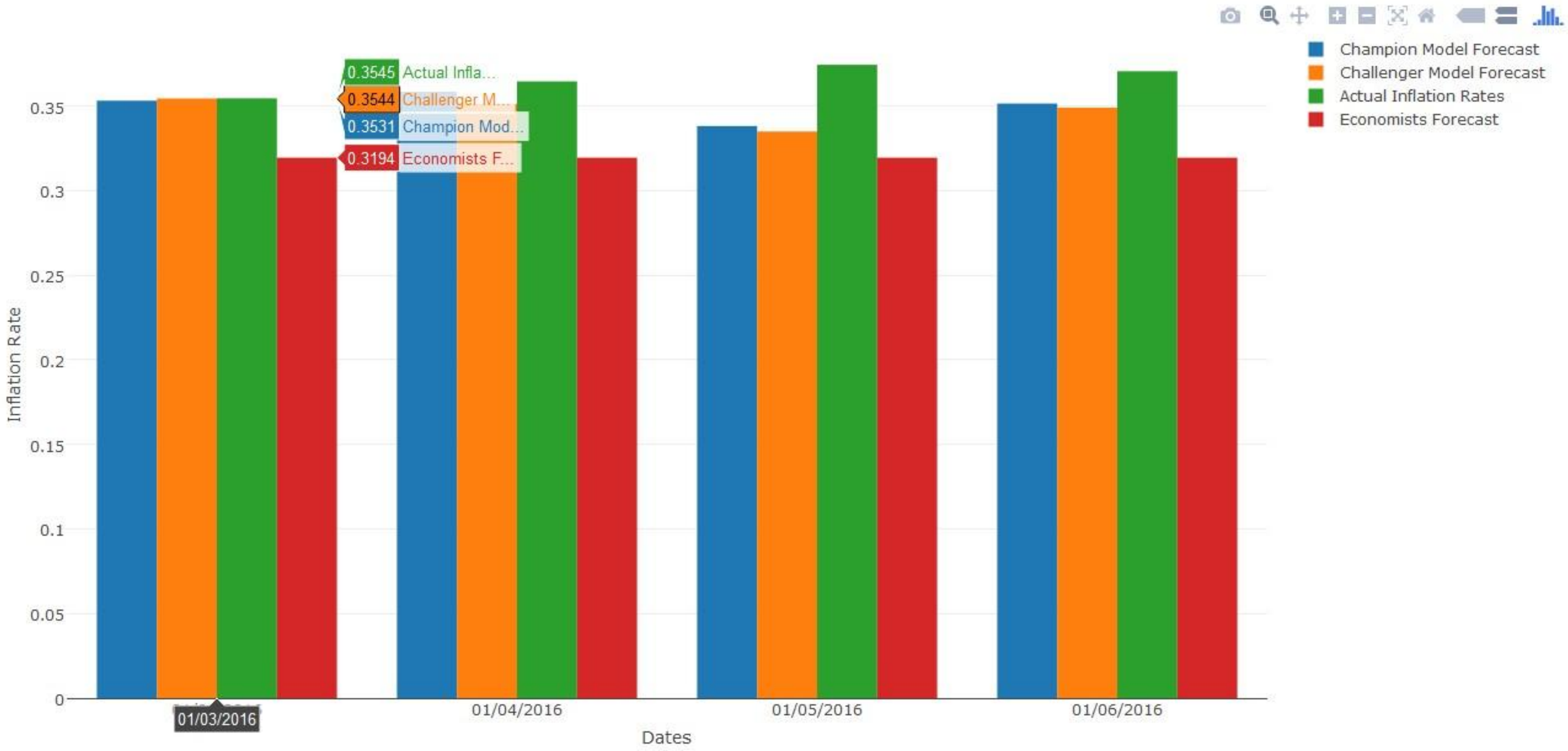
Testing the Champion Model using walk forward tests

- We further validated the results of the champion model by performing walk forward tests on 1 year, 2 years and 3 years.
- Walk forward tests the stability of the model by answering the question “If we had used this model a year ago, how will this model perform?

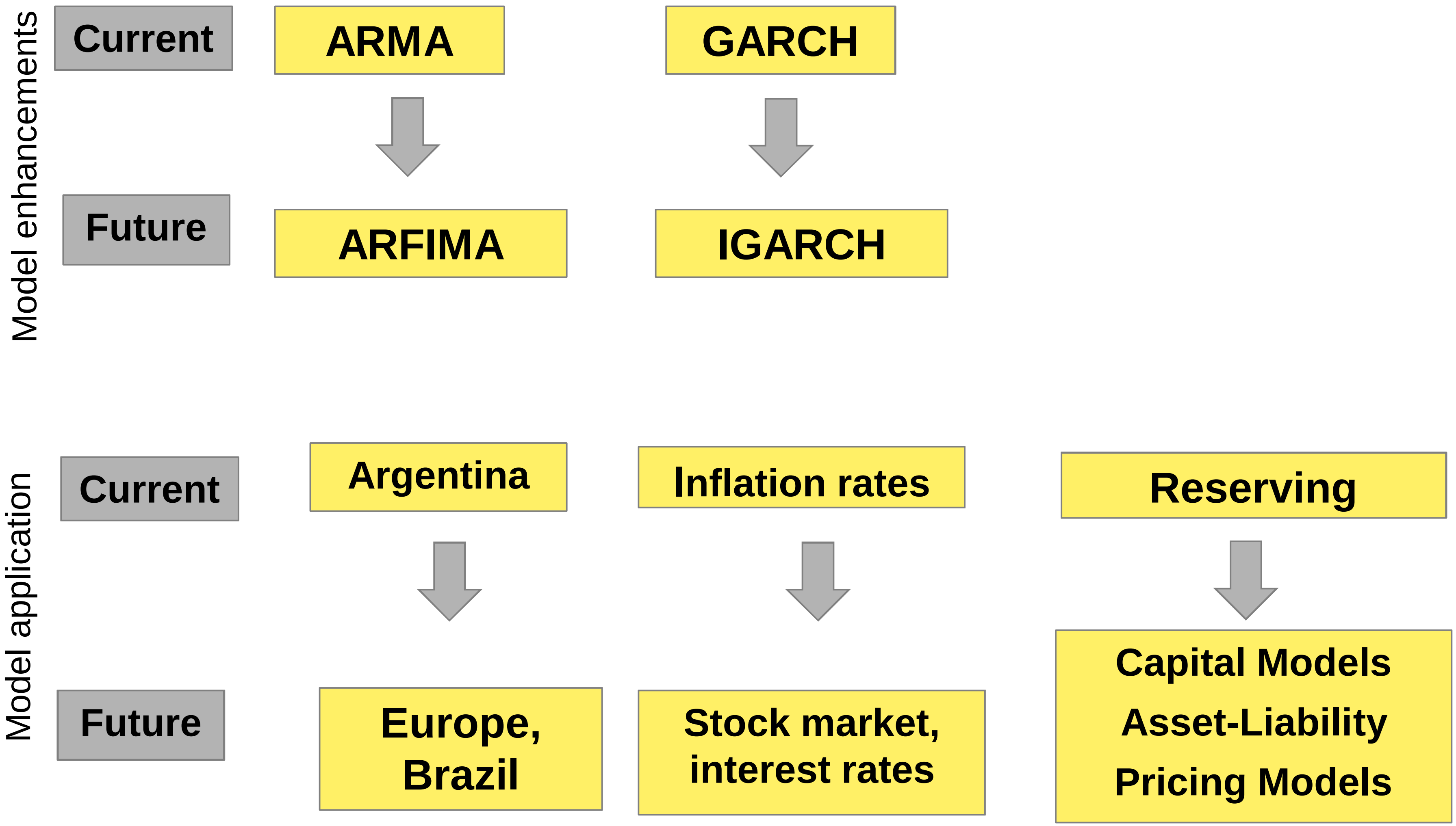


Testing the Campion Model on real data

- We built the model in march 2016 so by the time we published this presentation we had 3 months of real “unseen” data to test the model.



Next Steps


Model enhancements
Current
ARMA
GARCH
Future
ARFIMA
IGARCH
Model application
Current
Argentina
Inflation rates
Reserving
Future
Europe, Brazil
Stock market, interest rates
Capital Models
Asset-Liability
Pricing Models

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