Inflation Modelling & Forecasting under high volatility circumstances

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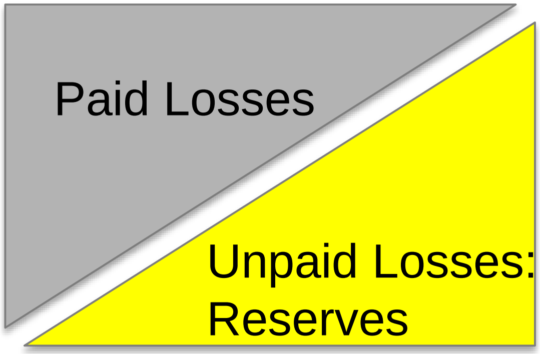
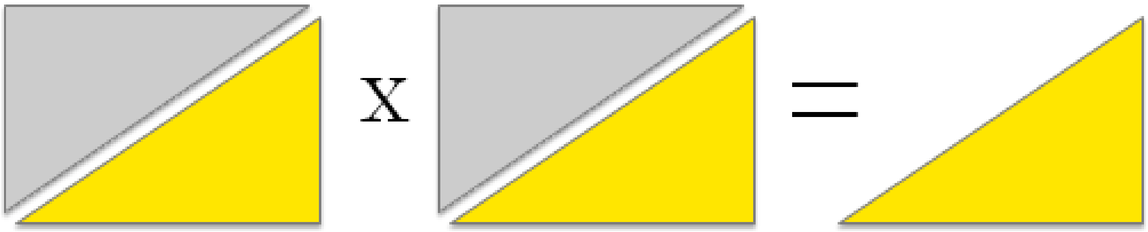
Building a better working world

Reserves

- What are reserves?



- Why are they important?
- Why do you need actuaries?



- What reserving packages does R have?

Challenges in Reserving

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

- Impact of changing economic environment on frequency and severity of claims

- High and changing inflation over different time periods

- Most of the traditional actuarial methods fail due to high and unstable inflation

- Unreliable data to estimate inflation which is one of the most important assumptions in reserving for many developing countries like Argentina

Reserve and Inflation

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

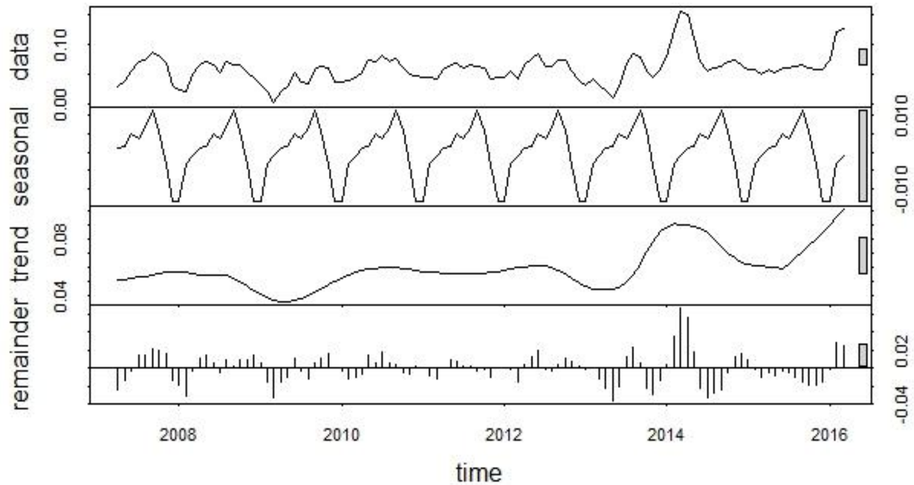
	Months			
Accident Qtr	**3**	**6**	**9**	**12**
Prior				12.9
2015 Q2			17.1	18.3
2015 Q3		18.7	19.3	20.6

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

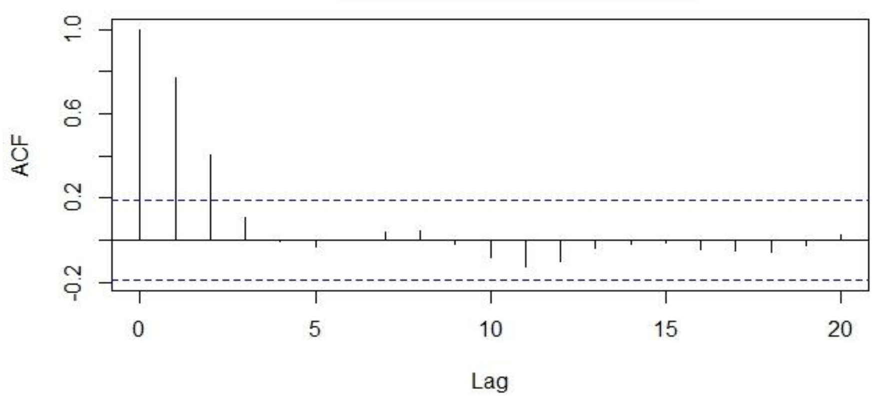
Initial analysis of the time series



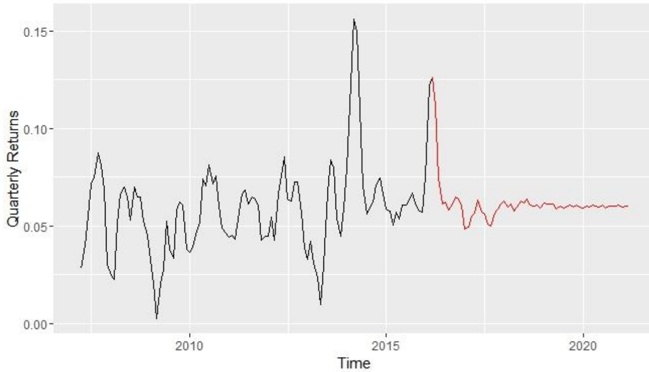
Decomposition of the time series into seasonal and trend components

The remainder left after removing the seasonal and trend components is heteroscedastic as well.

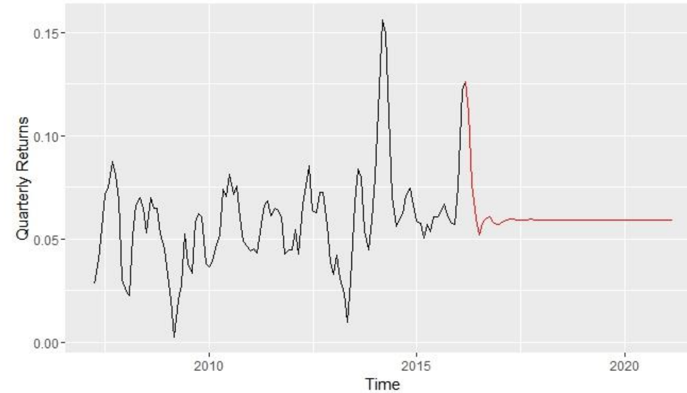
ACF of the time series



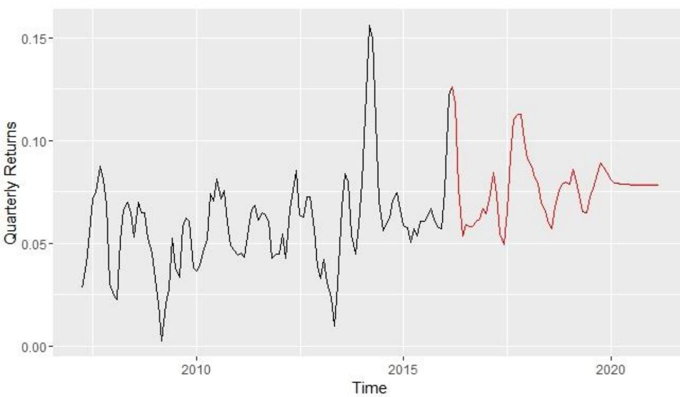
Inflation Model Evolution



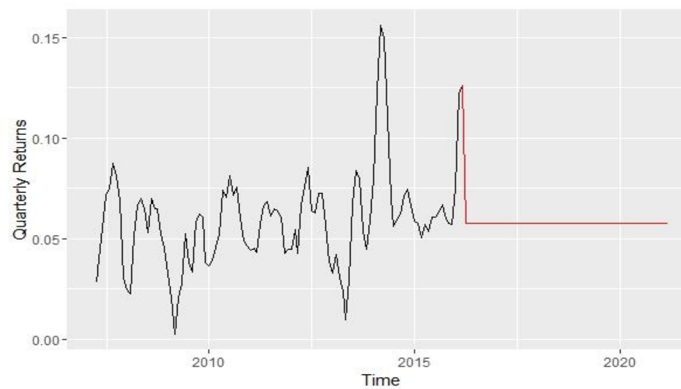
AR using OLS



ARMA



ARMA GARCH



GARCH

The Model

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

Model Iterations

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%

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

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

EY

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