Forecasting inflation under uncertainty: The forgotten dog and the frisbee

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Abstract

This study is an endeavour to analyse the aspect of adhering to simplicity instead of complexity when one is striving to make a forecast and facing an unprecedented amount of uncertainty. There is substantial evidence on the exchange rate pass-through and equally ample evidence to suggest that the complex models are outperformed by simple solutions and heuristics. In this context, it seems that the Bank of England's post-Brexit forecast is an example of the sub-optimal performance of complex models in the face of high tides of uncertainty. To illustrate this point further, this study employed the data on the consumer price index from January 1989 to June 2019 and compared the post-Brexit inflation forecast by the Bank of England with an ARIMA model and a simple rule which was based on the Bank of England's estimates on pass-through due to exchange rate movements, similar in magnitude to the ones associated with Brexit. It showed that the actual path of inflation substantially diverged from the Bank of England's forecast as the effects of depreciation started to kick in. It implied that in the highly uncertain environment post-Brexit, a better prediction could have been possible by allocating some weights to the effects of sharp depreciation, indeed, that would have been a matter of judgment and simplicity.

Keywords: Complexity, Forecasting, Uncertainty, Exchange Rate, Inflation Forecasting, Heuristics.
JEL Codes: C53, E3, F17, F31, O2.

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1. Introduction

It is difficult to make a forecast, particularly about the future! This difficulty is very often faced by the macroeconomic policymakers including central banks, global economic institutions like the IMF and the World Bank and by the financial intuitions. The foreseeing the future or forecasting, despite its fascination, has been a much debated and critiqued act. To name one such an occasion, failing to predict the Global Financial Crisis 2008-09 led to a great amount of criticism, the scepticism of the forecasting ability of policymakers led to the Queen's famous question[2]. The problem of the forecasts being different from succeeding experience is also widely debated and well recognised by Frank Hyneman Knight as the issue is that the past is not always a good guideline for the future.

"*The existence of a problem of knowledge depends on the future being different from the past, while the possibility of the solution of the problem depends on the future being like the past*."

(Knight, 1921).

In the presence of the possibility of future being different from the past, there have been some suggested solutions including the use of judgment and heuristics (See, Harvey, 2001; Gigerenzer, 2010). In a scenario where the times are very uncertain and one is facing unprecedented events, a possible solution suggested by Haldane (2012) and drawn from the analogy of "*the dog and the frisbee*" is to cure the complexity with simplicity[3]. The notion is that a complex problem can be solved by employing a simple solution (Gigerenzer and Gray, 2017). There will be further elaboration, yet to make the intentions clear in the beginning, this study is an endeavour to investigate whether that principle of adhering to simplicity and heuristics could hold its grounds when it comes to forecasting, and in particular, forecasting the inflation.

Price stability is the statutory mandate of the Bank of England (BoE) since 1997. This burden of responsibility came with the independence of the BoE. As we look at the inflation in the last few years, it has been tamed as suggested by Figure 1. The inflation has been persistently undershooting its 2% annual consumer price index target.

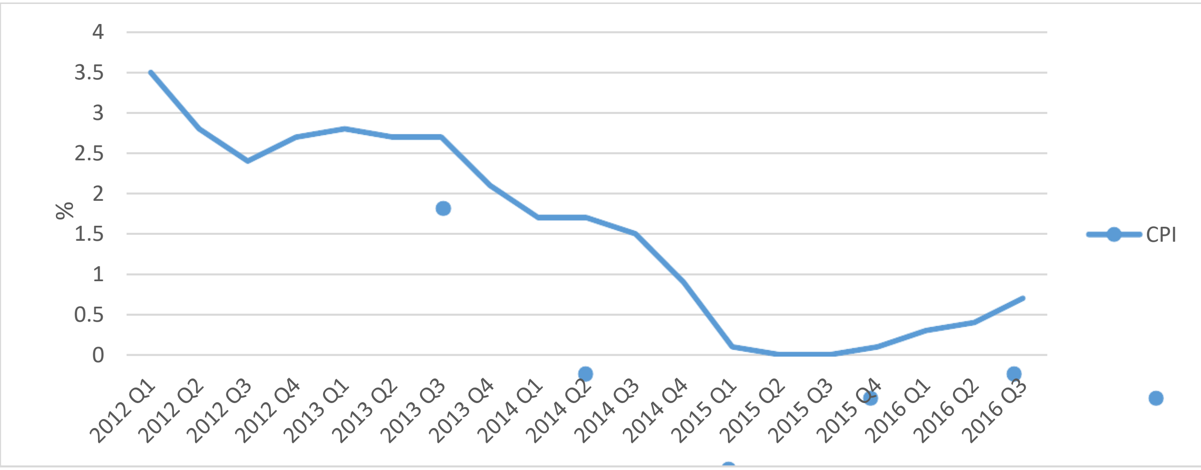

Figure 1: Consumer Price Index (2012-2016): Source ONS (2016)

Keeping that era of low inflation in context, one of the major political and economic events of the year 2016 was the British referendum on the membership of the European Union (Brexit). Straight after Brexit referendum, Sterling sharply depreciated and against US$ it dipped to a historically very low level (£1=$1.21). In the events around Brexit, there have been a number of steps taken by the BoE to restore the confidence among market participants as well as maintaining the liquidity and lines

[2] On her visit to the London School of Economics, Her Majesty the Queen Elizabeth II asked the question "Why did nobody notice it?"

[3] See Haldane (2012) with interesting description of the Dog and Frisbee analogy while employing heuristics.

of credit[4]. While the Bank was dutifully performing its historic and recently reinstated role of financial stability,[5] it also provided its view on the short to the medium-term outlook of the economy and in particular on the inflation forecast. A point to be noted before we look at the most recent forecast and revisions by the Bank of England, that is, in the environment before the Brexit and proceeding announcement of the referendum which came in the second half of February 2016, the outlook of the inflation and its forecast was very sober. The fan Charts[6] in Figure 2 were reported in the February 2016 inflation report which was published just before the announcement of Brexit Referendum[7]. It showed that the inflation rate was expected to remain below the 2% target until early 2018. Furthermore, the numerical parameters of inflation report probability distributions (See Appendix A for details) indicated that in the central view of the forecast, the inflation will be overshooting its target by just a quarter of a percentage by the beginning of 2019.

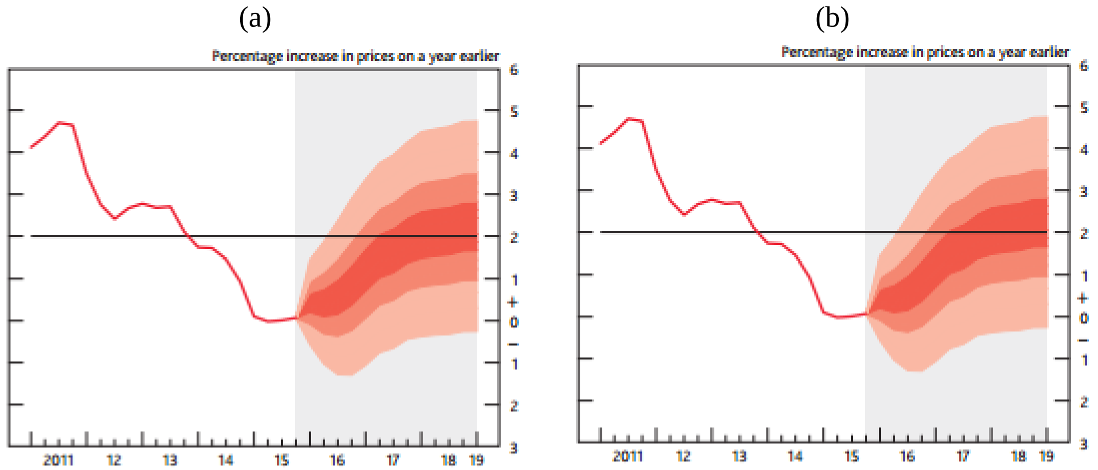

Figure 2: Inflation Fan Chart, Inflation Report February (a) and May (b) 2016.
Source: Bank of England (2016)

The announcement of the referendum came along after the negotiation between Britain and other EU members on 20th of February 2016 which led to the depreciation of Sterling. Over the period since the referendum was announced on the 20th February 2016, based on most exchange rate measures, Sterling depreciated (see, for example, IMF 2016). However, the inflation forecast in May 2016 did not show much of a revision in February 2016 forecast, rather, there was a downward revision as

[4] The efforts included further reduction in the Bank Rate, expansion of Asset Purchase Program (Quantitative Easing) and funding to the bank to help to pass on the rate cuts.

[5] The Bank of England's first role was being the government's banker and debt manager. In the events around Overend and Gurney in 1866 Bank also acted as the *lender of last resort*. The events of Global Financial Crisis 2007-08 led to restructuring of the Bank of England mainly extension of its role in financial stability in the form of Financial Policy Committee (FPC) and Prudential Regulatory Authority (PRA).

[6] The fan charts and associated cross-sections depict the probability of various outcomes for GDP growth, CPI inflation or the unemployment rate. Over the forecast period, the distribution reflects uncertainty over the evolution of GDP growth, CPI inflation or the unemployment rate in the future. If economic circumstances identical to today's were to prevail on 100 occasions, the MPC's best collective judgement is that CPI inflation, the unemployment rate or the mature estimate of GDP growth would lie within the darkest central band on only 10 of those occasions in the narrow-band fan charts and 30 of those occasions in the wide-band fan charts. The fan chart is constructed so that outturns are also expected to lie within each pair of the lighter coloured areas on 10 (narrow bands) and 30 (wide bands) occasions. In any particular quarter of the forecast period, GDP growth, CPI inflation or the unemployment rate are therefore expected to lie somewhere within the fan on 90 out of 100 occasions. And on the remaining 10 out of 100 occasions they can fall anywhere outside the coloured area of the fan chart. Over the forecast period, this has been depicted by the light grey background. In any quarter of the forecast period, the probability mass in each pair of identically coloured bands sums to 10% (narrow bands) and 30% (wide bands). See the box on pages 48–49 of the May 2002 Inflation Report for a fuller description of the fan chart and what it represents.

[7] On 20th Feb 2016 the date of referendum was announced which was set to be 22nd of June 2016. .

numerical parameters of inflation report probability distributions showed that by the end of forecast periods i.e. (2019Q1 & Q2) on the central view (mean) inflation would be just 0.23% above target. To be precise a downward revision of 0.02%. Then, the referendum came and results showed that the majority of British choose to opt for leaving the EU. This led to the earlier cited historical sharp depreciation of Sterling. As the Bank of England revised its forecast on the outlook for the GDP, despite the sharpest depreciation which has theoretically and empirical positive effects on the rate of inflation (Bhattarai, 2011; Wimanda et al 2011; Forbes, 2016; Forbes, 2015a; Yildirim and Ivrendi, 2016; Nasir and Simpson, 2018, Nasir and Vo, 2020) the inflation forecast was not subject to any revisions, as suggested in Figure 3. Nevertheless, the values of the numerical parameters of inflation report probability distributions (Appendix A) did not show much difference as compared to the values presented in the pre-Brexit (May) inflation report.

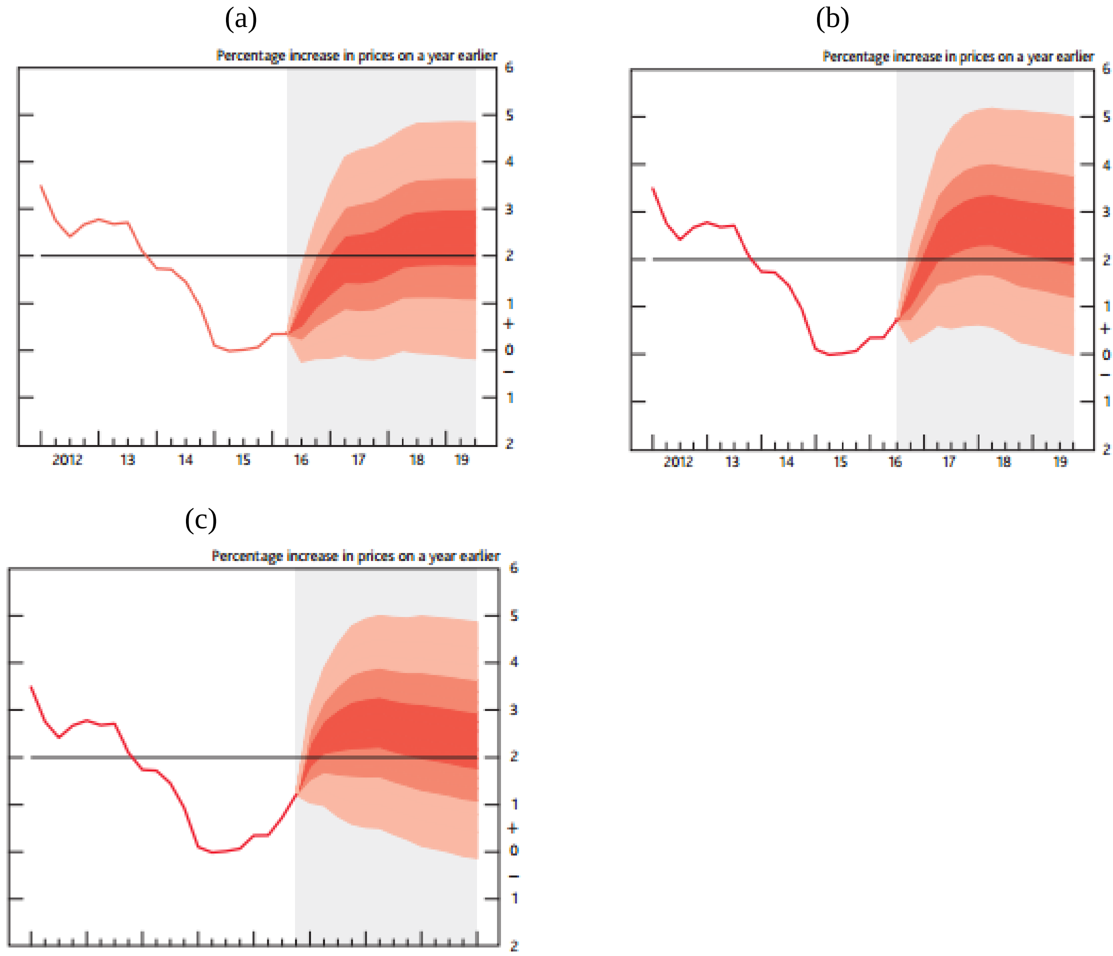

Figure 3: Inflation Chart August (a), November (b) 2016 and February (c) 2017

It is prima facie evident that the forecast did not take into account the depreciation of Sterling. There is a vast empirical literature on the pass-through of exchange rates depreciation (See Menon, 1995; Goldberg and Knetter, 1997; Hänninen and Toppinen, 1999; Campa and Goldberg, 2005; Choudhri and Hakura, 2006; Bache, 2006; Mumtaz et al, 2006; Bhattacharya et al 2008; Burnstein and Gopinath, 2013; Forbes, 2016; Forbes; 2015a; Nasir and Simpson 2018; Nasir and Vo 2020; Nasir et al 2020a, 2020b) which showed various degrees of impact of exchange rates on inflation. Interestingly, the BoE herself has estimated the exchange rate pass-through, and in Forbes (2016) words:

"*The BoE has traditionally estimated that the pass-through from exchange rate movements to UK import prices is roughly 60% to 90%, and the import intensity of the consumer price index (CPI) is about 30%. This generates an overall pass-through coefficient of around 20% to 30%. In other words, the 17% appreciation of Sterling that has occurred since the spring of 2013 would reduce the* *level of the consumer price index by about **3 to 5%**. Even if this is spread across several years, this effect on prices and inflation is meaningful*." (Forbes; 2016, p. 6-7).

Ignoring the dynamics of the exchange rate for inflation and concomitantly for monetary policy formulation is contrary to what Mishkin (2008) suggested, arguing that despite the recent decline in the impact of exchange rate pass-through in some economies, the exchange rate fluctuations are still important for inflation and economic activity. Therefore, monetary policy must continue to take these fluctuations into account to ensure that inflation expectations remain well-anchored. In fact, contrary to the Mishkin (2008) idea that the exchange rate pass-through might have reduced, Forbes (2015a), Nasir and Simpson (2018) and Nasir and Vo (2020) raised the possibility that exchange rate pass-through may be occurring faster today than in the past, accelerating the immediate impact on inflation. The similar argument was made by Fisher (2015) suggesting that the Federal Reserve Board assumes a substantially faster rate of pass-through to inflation.

According to the MPC in May 2016, *"the effect of a vote to leave the EU on inflation would depend on the balance of its effects on demand, supply and exchange rate"* (Carney, 2017). Nevertheless, according to Carney (2017, p. 15), "the committee made its first assessment of these effects in August, "*At that time the sharp fall in the sterling exchange rate following the vote of leave would imply higher imported inflation, meaning upward pressure on inflation*". However, this assessment was not reflected by any revisions in the inflation forecast. Specifically, in terms of forecasting incorporating the effects of exchange rate pass-through into a model can help in obtaining superior forecasts of domestic inflation (Bhattacharya and Thomakos; 2008). Nevertheless, the Bank of England made the first rate cut since March 2009 by cutting the Bank Rate to a new all-time high low of 0.25%. Furthermore, the Asset Purchase programme (Q.E as it is called) was also extended to £ 435 Billion and Term Funding Scheme was also announced to further ease the supply of credit. Intuitively, these expansionary monetary measures may have some implications for inflation. Thus, it would be fair to ask that despite such expansionary policy interventions and a sharp depreciation of Sterling, why the inflation forecast was not substantially revised? Nevertheless, if the Sterling has been depreciated so sharply that it is at 31 years low against $US, concomitantly, this depreciation would have been either absorbed by the cut in markups or pass-through or some combination of both. Somebody there has to pick up the bill or share it. A considerable amount of credible evidence cited earlier suggests a substantial amount of pass-through; however, none of it was reflected in the inflation forecasts. To elaborate, it further, let us consider the following Figures 4.

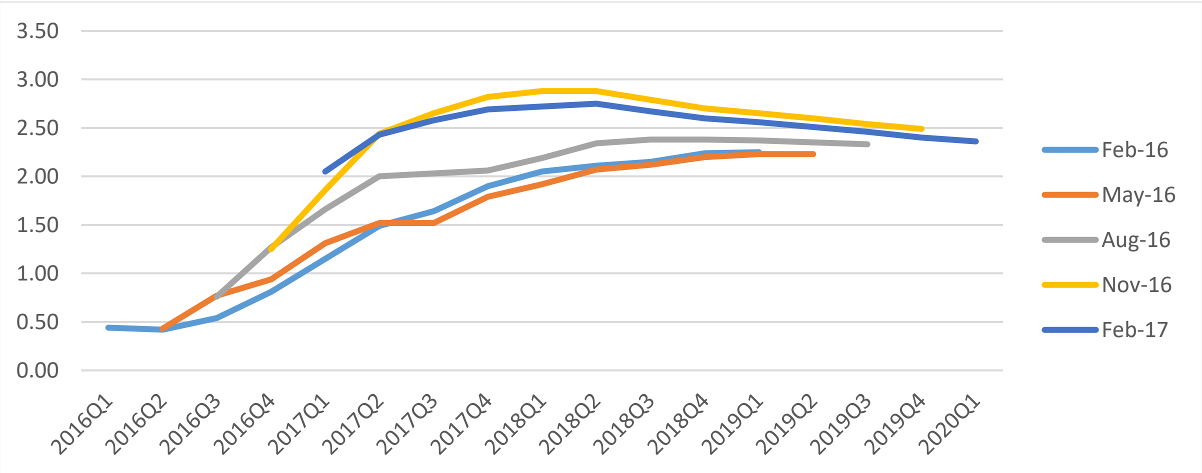

Figure 4: CPI inflation projections based on market interest rate expectations & £375 billion asset purchases: Source: Author's calculations based on BoE's Data. (see Appendix A)

Figure 4 depicts the CPI inflation projections based on market interest rate expectations and £ 375 billion asset purchases (435 billion after August 2016). It is notable that each period projection has started from a higher point after the arrival of new data. However, there seems no major revision in the forecast in the short-medium term. Interestingly, despite considerable divergence on the starting points of forecasts due to the arrival of real data which have to be incorporated, there is a convergence at the ends of the forecasts. What could be the reason of this convergence? It could be either a) due to the underlying modelling approach which entails the aspect of convergence to equilibrium to avoid explosive behaviour or b) due to the assumption of the absence of any future shocks to inflation during the period of forecast. The latter has a practical implication as in the absence of further shocks the past price level rises drops out after a year as the 12-month inflation is the year on year change.

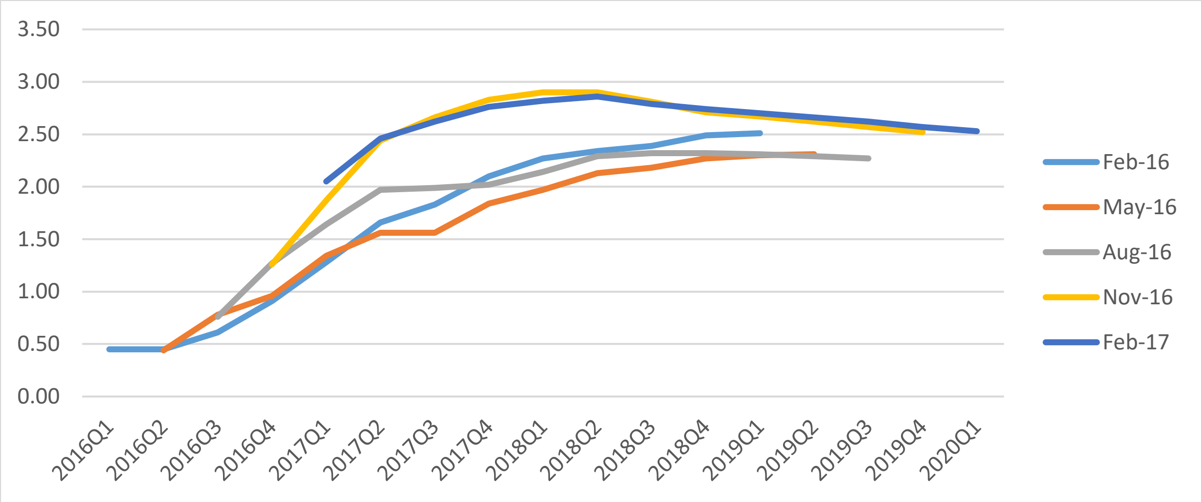

Figure 5: CPI inflation projections based on interest rates constant
Source: Author's calculations based on BoE's Data. (see Appendix A)

The scenario in Figure 5 which shows the CPI inflation projections based on the assumption of interest rates being constant, compliments the outlook in Figure 4. This weak performance of the forecast what Haldane (2017) called "*Michael Fish*" moment raises concerns about underlying framework employed. One explanation of it can be the underlying workhorse model of the forecast *COMPASS* which has been comparatively less effective in producing a good quality forecast for the short-medium term and particularly in the crises (see Fawcett et al 2015; Domit et al, 2016). By this token, it could also be said that in the very complex and unprecedented situations the reliance on complex models has not helped. Perhaps, we forgot about the "*Dog with Frisbee*" and application of heuristics and simplicity? With the benefit of hindsight, it's easy to critique the forecasts made by the Bank of England, however, it also raised a question that what if we have adopted an alternative method, a rather simpler approach to give us some insight into the future in the very complex situation. Concomitantly, in this study, we are investigating that if the forecasts based on a rather simpler approach with fewer parameters and longer dataset i.e. an Autoregressive Integrated Moving Average (ARIMA) model and using a rule of thumb or Heuristic could have been more helpful in predicting the inflation dynamics in the medium term. In so doing, we employed the data on the consumer price index from Jan 1989 to June 2019. We compared the Post-Brexit inflation forecast by the Bank of England (based on the *COMPASS* and a suite forecasting models) with an ARIMA model and a simple rule which was based on the Bank of England's estimates on pass-through due to exchange rate movements, similar in magnitude to the ones associated with Brexit. Our results and comparison benefited by the hindsight of over three years data on inflation suggests that it could not have been any better by using a simpler model with the longer dataset as the higher the uncertainty the lesser is the past data a useful guide. On the other hand, heuristics and simple rule of thumb seemed to be more useful than their counterparts.

The paper proceeds as follow: Section 2 will contextualise the core argument of the subject study by presenting and discussing the existing evidence on the subject. Section 3 will set out the empirical framework to forecast in the presence of uncertainty. Section 4 will present the analysis and findings which will lead us to a conclusion in Section 5.

2.1 Exchange Rate Pass-through to Inflation

The dynamics of the exchange rate are very important for the open and integrated economies of the 21st century. Exchange rate influences the competitiveness, balance of trade, GDP as well as inflation in an economy. Not least, the exchange dynamics also have political implications and attract a great amount of attention (in Forbes, 2016 words "Ado"[8]). However, considering the limited scope of this treatise we are focusing our attention on one aspect of exchange rate dynamics and that is its impact on the Inflation or as commonly called pass-through[9]. In specific to the UK and recent history of pass through, there has been an episode of appreciation of Sterling from spring of 2013 to the end of 2015 as the effective exchange rate appreciated about 17%. This appreciation led to a drag on the inflation (1 ¼ to 1 ½ %)and kept the Monetary Policy Committee (MPC) interest rate on hold despite the promising growth and did not cause a fear of inflation to overshoot its target (Forbes, 2016). Concomitantly, clear evidence that the exchange rates have been a driving force in the inflation dynamics in the UK. Indisputably, the implications of the exchange rate pass-through are nontrivial in the monetary policy formulation (Mishkin, 2008).

There is a substantial amount of literature on the impact of exchange rate dynamics on inflation, including the evidence on the UK (for instance, see Menon, 1995; Goldberg and Knetter, 1997; Hänninen and Toppinen, 1999; Campa and Goldberg, 2005; Choudhri and Hakura, 2006; Bache, 2006; Mumtaz et al, 2006; Bhattacharya et al 2008; Bhattarai, 2011; Wimanda et al 2011; Burnstein and Gopinath, 2013; Forbes, 2014; Forbes, 2016; Forbes; 2015a; Yildirim and Ivrendi, 2016; Nasir and Simpson, 2018; Nasir and Vo, 2020; Nasir et al 2020a, 2020b). Despite the substantial evidence on the subject, the existing models and estimates have substantial limitations and particularly when it comes to UK data on the exchange rate pass-through there are major divergences between the prevailing wisdom on the nexus between inflation and exchange rate and what is actually observed. It led Forbes (2016) to argue that the exchange movements do have a large impact on the prices in sectors with higher import content; internationally competitive sector and effects of exchange on inflation are time-variant. Nevertheless, the need for the improvement of understanding of pass-through possess challenges for the monetary policy and by the same token for inflation forecasting.

While considering the impact of the exchange rate movements on the inflation, it is vital to keep in context the cause of exchange rate movement, whether it is domestic or global demand, domestic, monetary policy, global supply shocks (for instance oil shocks), or productivity dynamics, each factor could be crucial in determining the nature of pass-through. On this aspect, Bussiere et al (2015) reported that the exchange rate appreciations driven by domestic productivity shocks would have different effects on growth than movements driven by surges in capital inflows. In an earlier study, Shambaugh (2008) also showed that the source of the exchange rate shock could affect pass-through. In specific, to the UK, Kirby and Meaning (2015) also reported the implications of different shocks for exchange rate pass-through. Nevertheless, there are structural differences in the exchange rate pass-through in different countries due to a number of factors, for instance, currency composition of invoicing, proportion of debt denominated in foreign currency, monetary policy framework as well as the sectors with high vs low price-change dispersion. (See Stulz, 2005; Gopinath, 2015; Fleer et al; 2015). While it's important to consider the source of exchange rate fluctuation to get insight into its implications for inflation, such an endeavour gets more difficult as the exchange rate sometimes moves in different directions with respect to different currencies. The same holds when the intention is to make a forecast.

"*Analysis that does not consider the source of the exchange rate movement may provide a blurred picture and make it difficult to forecast its effects. For example, we show that when exchange*

[8] Referring to Chinese devaluation of 2% Forbes argued that there has been much uproar by IMF, US Treasury as well as by the Financial Times and Guardian, although it was just 2% not 20% devaluation.

[9] Such a pass-through can be in two phases and at first state (approximately completed in a year) the import prices are affected by the exchange rate dynamics which feed into the overall price level in the second phase. Second stage is difficult to estimate and could take 3 to 5 years (Forbes, 2016).

rate movements result primarily from changes in domestic and global demand, they are associated with very different inflation dynamics than other types of shocks – undoubtedly due to the support to company sales from stronger demand. Incorporating these types of considerations goes some way to explaining why exchange rate movements have been associated with such different effects on prices at different points over the last decade – an issue of much frustration for those of us attempting to forecast inflation" (Forbes, 2016, p. 4).

In another study, analysis on 85 goods and services that comprise the UK headline CPI index by Forbes (2015b) showed that among the sectors whose prices move most closely with Sterling were those related to food and energy (such as air transportation, vegetables, gas, fuels, tobacco, and food products)[10]. Figure 2 provides the depiction of the nexus between the exchange rate dynamics and inflation.

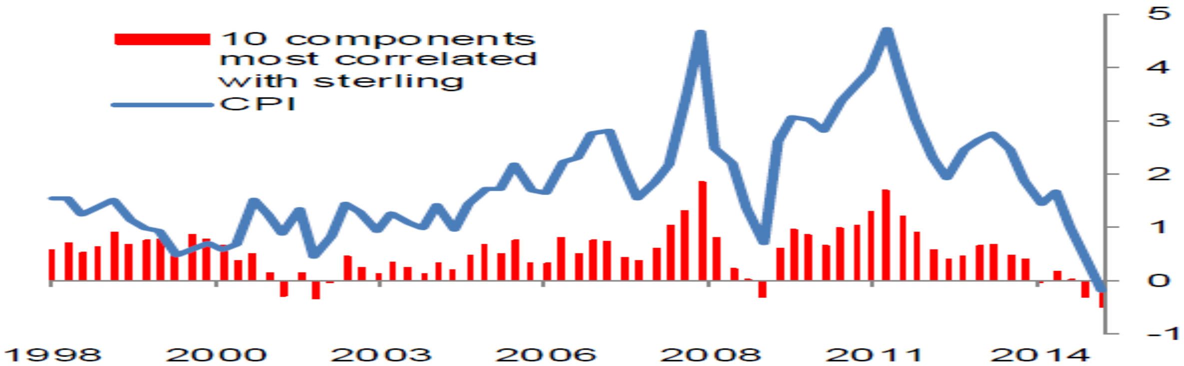

Fig 6: Annual CPI inflation and contributions from the components most correlated with sterling Source: Forbes (2015b).

Note, these are just the 10 goods or services identified as being most sensitive to exchange rate dynamics and Figure 6 is suggesting how much of the inflation is explained solely by them. It showed that the sterling-sensitive basket has accounted for about 29% of the overall CPI from 1998 to 2015q, making it comparatively larger than any other component in influencing CPI with a correlation of 0.85. These estimates by Forbes (2015b) appear to be more intuitive if we match them with the data on the spending habits of UK household which suggests that these categories form a substantial proportion of the UK household expenditure (ONS, 2016). It would have been intuitive to expect that in the forecast on inflation, Consumer Price Index which is the targeted index and is the base of the forecast on the inflation outlook should have incorporated these changes? It is also intuitive that the relationship between the economic entries and more specifically between inflation and exchange rate dynamics may vary over time. There is some literature to support the notion of time-varying pass-through. For instance, Mumtaz et al. (2006) on the UK, Marazzi et al (2005) on the US, Stulz (2005) on and more recently, Fleer et al (2015) on Switzerland reported time-varying pass through. In specific, to UK Forbes (2016) showed that the pass-through has been substantially increased during and since the GFC. Similarly, Nasir and Simpson (2018) on UK and Nasir and Vo (2020) on the UK, New Zealand and Canada reported significant evidence of passthrough. There could be a different explanation for the increase in the pass-through in the recent years, which may include an increase in imports and trade competition or compositional changes in the CPI basket (See, Campa and Goldberg, 2002 for discussion). However, the main point of concern in terms of forecasting shall be that such an increasing pass-through shall be taken into account when it comes to forecasting. Perhaps, on one hand, the time-varying aspect of pass-through adds to the uncertainty, on the other it also indicates the upward trajectory of pass-through making it important for the forecast.

An important point to note here is that in specific to the subject issue of forecast Post-Brexit, the deprecations were associated with the uncertainty about the future of the British economy post-divorce from EU. There is no evidence to acknowledge on uncertainty-induced exchange rate

[10] An 85 component -level regression analysis was performed.

depreciation and its impact on inflation[11]. Almost a decade earlier, during the GFC the sterling's depreciation led to an increase in import prices and inflation by more than expectations which could be associated with a large decline in domestic and global supply. In particular, to GFC Gilchrist and Zakrajsek (2015) argued that in face of a supply shock, the local producer can increase prices to meet the cost of production which could dilute the negative impacts of bleak demand on inflation. The fall of Sterling in 2008-09 around the episodes of GFC cushioned the negative effects of crisis though it could not outweigh them. A difference between the two episodes of Sharpe depreciation is that at that time depreciation came with crises and at this time the depreciation is in anticipation of the Brexit and its consequences for the trading channel between UK-EU, none of them has materialised yet. Therefore, this situation provides a phase of a bonanza for businesses (See, Broadbent, 2017). Through the course of 2016, the export prices rose 12%, an obvious boon for exports in terms of profitability and incentive to invest. The nexus between the exchange rate and inflation is not merely a matter of exports prices, contemporary association with both exports and imports of goods as well as services prices is depicted in Figure 7.

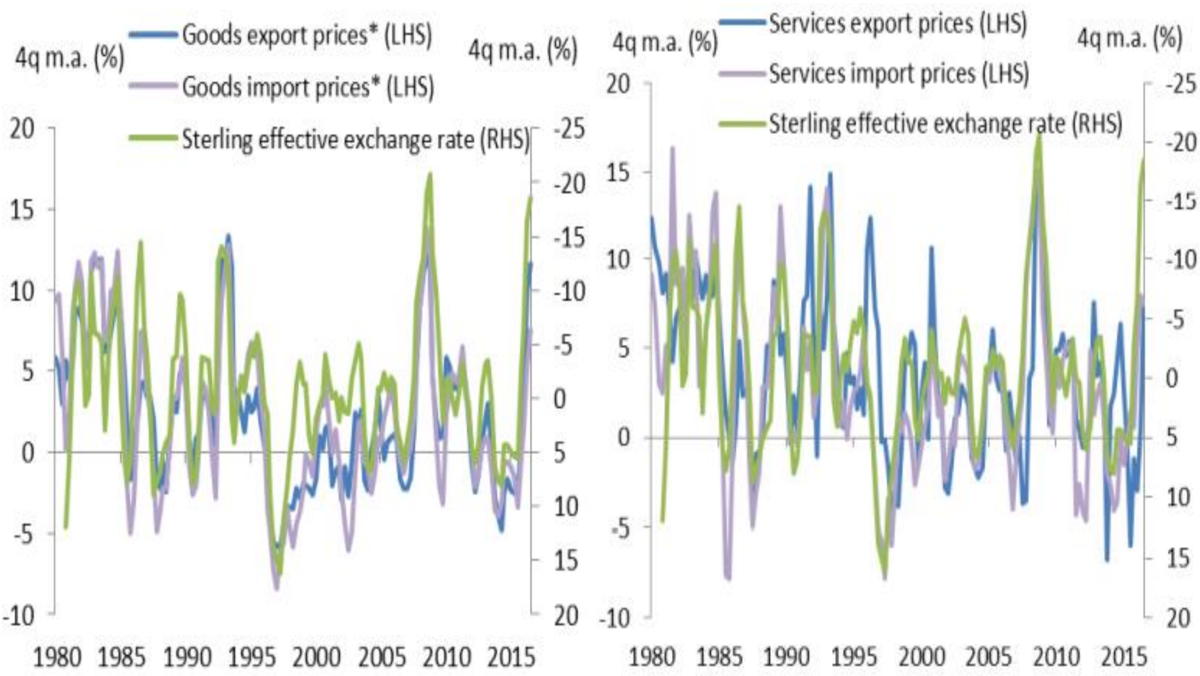

Figure 7: Sterling depreciation, Prices of Exports and Imports
Source; Broadbent, (2017), based on data from ONS and Bloomberg.

Figure 7 suggests a historically close association between prices of imports and imports in both goods and services and Sterling's depreciation. The depreciation around the exit from the Exchange Rate Mechanism (ERM) in the 1990s led to an improved UK trade balance which approximated to about 2% of GDP in later 3 years. In specific to the Brexit, there was a very strong correlation between the Sterling movement and expected results since the announcement of the referendum as depicted in Figure 8:

[11] Forbes et al (2015C) reported on the pass through under six causes of exchange rates fluctuation, which included UK supply shocks, UK demand shocks, UK monetary policy shocks, exogenous exchange rate shocks, global supply shocks, and global demand shocks.

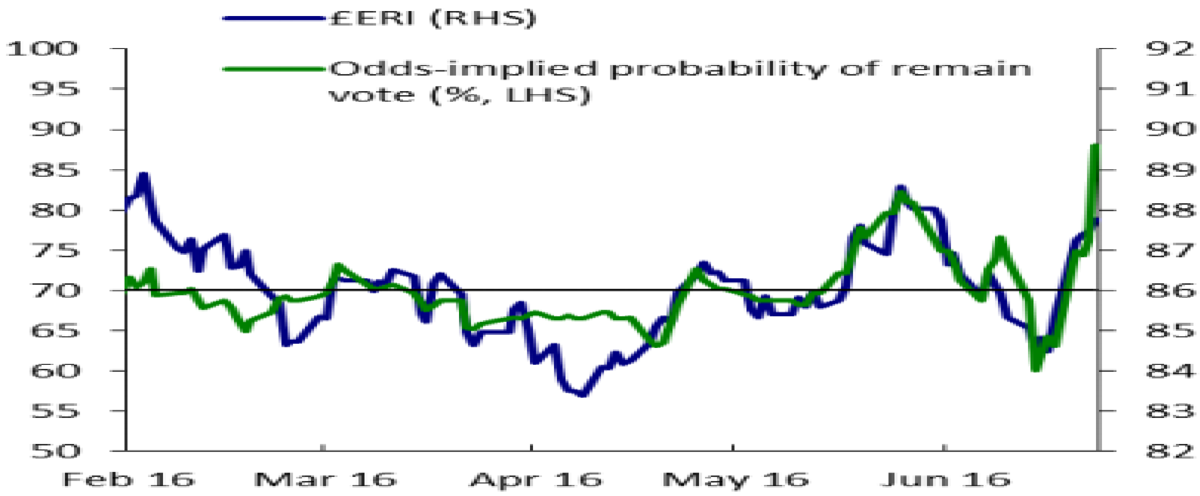

Figure 8: Correlation between Probabilities of Remain and Exchange
Source; Broadbent, (2017), based on data from ONS and Bloomberg.

It showed that close to the referendum the correlation has almost reached to one. In this scenario, it was absolutely clear that in the event of a vote to exit from the EU, one shall be certain about a sharp depreciation. Perhaps, a "Sharp correction" as suggested by MPC. An important, point to note here is that in May 2016, MPC conditioned its forecast on the outcome of "remain" and hence assumed a higher path of the exchange rate. Contrary to the underlying condition of the forecast, the outcome was a vote of "leave" and sharpest fall in the Sterling against US$ on 23-24th June 2016 which was the worst since the devaluation of 1967 (Broadbent, 2017, Nasir and Morgan, 2018). Now, it's absolutely reasonable to say that forecast is based on some assumptions and if they don't hold we get it wrong, fair enough. However, the next forecast came in August 2016 which was Post Brexit and we have witnessed the sharpest depreciation. Why was it not reflected the inflation outlook? Particularly, when the forward inflation rates by the end of 5 years, suggests the nominal exchange rates are to be 16% lower than they were at the beginning of 2016.

It could be that despite the depreciation, the inflation forecast was not revised because of another assumption which was to turn out to be wrong, i.e. sharp contraction in the economy and through the lenses of the Philips curve (which has been flat in recent years anyway). It is interesting, thought to entertain that the forecast of inflation was completely unchanged because of an assumption coupled with an axiom which has been often absent in recent years. Although, we have no evidence to acknowledge in a scenario like, however, a study by Forbes et al (2015C) reported that the demand-shock induced appreciation also have implications for inflation, though very mild. Hence, completely, ignoring the shape depreciation of Sterling in the forecast is completely incomprehensible. Particularly, when the Bank of England (2016) herself had acknowledged the effects of deprecations in the August 2016 inflation report in the following words. "*The fall in sterling is likely to push up on CPI inflation in the near term, hastening its return to the 2% target and probably causing it to rise above the target in the latter part of the MPC's forecast period before the exchange rate effect dissipates thereafter*. It is prima facie evidence that unfortunately, this acknowledgement was not reflected in the inflation projection provided by the COMPASS and suite of models. Perhaps, even if the demand has been subdued, it would have helped to keep the exchange rate low and that would imply pass through to persist.

In terms of forecasting, one can argue that, as Brexit is an unprecedented event, so historically it is not possible to match it with any past experiences of such a depreciation which adds further to the difficulty one may face. In that notion, one can easily empathise and comprehend the difficulty of making a forecast. Yet, an interesting aspect of such a situation is that there is no certainty that the decision making is not going to be done in an uncertain environment, hence, a state where one is certain about uncertainty. This then leads to the next logical question that what tools are at hand when one is faced with decision making under uncertainty?

2.2 Forecasting, Complexity vs Simplicity

Forecasting under uncertainty! of course, the forecast is always uncertain and this uncertainty just exacerbates when coupled with uncertain environments. On the failure of the BoE's forecasting around the Brexit referendum Skidelsky (2017) argued that the forecasting models were based on unrealistic premises and assumptions. The predicted fall in sterling is assumed to lead cut in consumer spending while people are in fact "creatures of habit".

"*The models of quantifiable Risk Fail when faced with radical uncertainty. The challenge is to develop macroeconomic models that can work in stormy conditions: models that incorporate radical uncertainty and therefore a high degree of unpredictability in human behaviour".*

(Skidelsky, 2017, p. 2).

To deal with the issues around uncertainty, there have been some suggestions, for instance, Frydman and Goldberg, (2011) proposal to "incorporate psychological factors without presuming that market participants behave irrationally. Hence, the "imperfect knowledge economics," which also involves refraining from "sharp predictions" and using "guidance range"[12]. A different, proposal by Masch (2015) to use the "Risk-Constrained Optimisation". However, Skidelsky (2017) argued that such an effort suffers from the impossibility of taming ambiguity with maths and computing. The issue is that the decision-making under risk is different from decision making under uncertainty, the path less popular is the inability to form priors on the distribution of future outcomes rather than risk (Knight, 1921; Haldane 2012). The frameworks in economics and finance developed by Arrow-Debreu (1954) and Merton-Markowitz (Markowitz, 1952 and Merton 1969) do not address the uncertainty rather are built on "stringent assumptions about humans state of knowledge and cognitive capacity, for instance, rational expectations. Haldane, (2012) argued that these assumptions have not traditionally been the centre of economic profession, rather, in fact, prominent economists from different schools of thought i.e. Keynes to Hayek and Simon to Friedman, kept in sight the imperfection in information and uncertainty in decision-making[13].

There is an interdisciplinary acknowledgement of the importance of uncertainty in decision making, for instance, physicist Richard Feynman words, "*It is not what we know, but what we do not know which we must always address, to avoid major failures, catastrophes and panics*." *"Relying on simplistic faith in arguably proven risks and formulas is intrinsic incompetence*". Similarly, in philosophy, Russell (1950) argued that "The importance of "Most of the greatest evils that man has inflicted upon man have come through people feeling quite certain about something which was false." The –re-acknowledgement did come from economics and the profession rediscovered itself, as Taleb (2007) argued, "What you don't know is far more relevant than what you do know". In conjunction with the re-acknowledgement, decision making under uncertainty has gathered interest in recent economic scholarship, for instance, Hansen and Sargent (2010) presented a model of representative consumers which deals with selection problem and misspecification which foster pessimism that puts countercyclical uncertainty premia into risk prices. Similarly, Kirman (2010) provided critical insight into the limitations of rational expectation and general equilibrium framework.

In a complex situation, while one is to make a decision, considering rationale expectation and risk the adequate reopens to complexity is the state-contingent rule (see, for instance, Morris and Shin

[12] Of course, it then leads to issues around the range and central tendency.

[13] Haldane (2012, page 2), referred to Hayek's Nobel address, "The Pretence of knowledge" where Hayek "laid bare the perils of over-active policy if we assumed omniscience" (Hayek, 1974) and Friedman (1960) "lack of knowledge as K% monetary policy rule".

(2008)[14]. In specific to risk, the policy response can be "fine-tuned" and calculated. Contrarily, under uncertainty, there is an argument that the logical response should be the other way around. The complex environment requires simple decision rules which are robust to ignorance hence, as Haldane (2012, p.3) argued, "*Under uncertainty, the policy may only respond to every thunderstorm; it is coarse-tuned*." Under uncertainty, Simon (1972) argued that human behaviour follows simple rule or Heuristics, perhaps due to the reason that humans operate in the complex system.

"*Human beings, viewed as behaving systems, are quite simple. The apparent complexity of our behavior over time is largely a reflection of the complexity of the environment in which we find ourselves".* (Simon 1972, p. 110).

The Heuristics are perceived to be embedded in the evolutionary responses and experience which is passed down generationally or accumulated in the present nature (See Selten, 2001)[15]. Famously, seminal work by Kahneman and Tversky (1974) substantially contributed to the notion of heuristics and rules of thumbs[16]. The use of Heuristics is very common in the real world. The reason of the "ubiquitous-ness" of Heuristics or rule of thumb can include the cost of information processing in a complex environment (See Gigerenzer, 2007, Gigerenzer and Gray, 2017) "bounded rationality and satisficing (Simon, 1956). However, it is not only a matter of efficiency; heuristics could lead to a better decision (Gigerenzer, 2010).

An economic forecast based on the econometric model and very short sample can be a victim of overfitting and the mistake of considering noise as signal, such a model can yield fragile forecast. The bad gets worse when the parameter space becomes larger, in simple words, small sample and large parameter space both add to worsening performance of the complex models[17]. Hence, Haldane, (2012) argued that the "recognition heuristic" can outperform the complex methods of predictions. Nevertheless, the experimental evidence suggests that the simple rules and Heuristics are helpful in health (Gigerenzer and Kurzenhäuser (2005), criminology and crime prevention (Snook et al, 2005) investment in stock (DeMiguel et al, 2007), consumer behaviour (Wübben and von Wangenheim (2008) and even in War (Gigerenzer and Gray, 2017). On the other hand, complex decision rules in a complex environment can lead to adverse outcomes[18]. At this juncture, one may argue to avoid uncertainty by non-engagement or non-intervention, for instance, on uncertainty, Taleb (2017) argued that the empirically complex systems do not have obvious one-dimensional cause and effect mechanism; hence, it is better to not engage. Furthermore, " and when a blow-up happens, they invoke uncertainty, something called a Black Swan, not realising that one should not mess with a system if the results are fraught with uncertainty, or more generally avoid engaging in action if you have no idea of the outcomes (Taleb 2017 pages 3). Unfortunately, avoidance is not the luxury Bank of England can have afforded when it came to forecasting, like in this case around Brexit[19].

The notion put forward by Von Neumann and Morgenstern (1944) that optimal decision-making involves probabilistically weighing all possible future outcomes, the issue is that in an uncertain environment the probabilities are unknown. Concomitantly it makes the past probabilities a poor guide and weighting them an unfruitful endeavour to predict the future. In such a situation, Gigerenzer

[14] Financial Regulation in a System Context.
[15] Neurological and experimental research like Selten (2001) supported the notion put forward by Simon.
[16] Also led to significant development in the behaviour economics including work by Camerer (2003) on Behavioural Game theory and considering emotions and learning in strategic decision making rather pure rationality.
[17] In fact, Haldane (2012) suggested that the complex rules only out-perform the simple rules when we have a data of around 3000 months or say 250 years. In his recent, critique of the BoE forecast Skidelsky (2017) seems less than fully convinced by Haldane's idea.
[18] For instance, Harford (2011) showed that the complex control of a complex environment is often catastrophic.
[19] Perhaps, at the same juncture, one may also argued that the Brexit is not really a Black Swan event, at least in its absolute sense, as it was fairly probable to start with.

and Brighton (2009) suggested that ignoring weights (Tallying) lead to better predictions[20]. A most recent study conducted by the ECB, Ca' Zorz and Rubaszek (2018) showed that the exchange rate forecasting can be best done by a simple calculation, so simple that it could be done on the "*Back of a Napkin*". In his seminal work "*The Theory of Probability*", Sir Harold Jeffreys argued that

> "The simplest law is chosen because it is the most likely to give correct predictions"
> (Jeffreys, 1961, p 4)[21].

If that is so, in specific to the issue of Brexit and associated uncertainty and complexity the inflation forecasting could have been based on rather a simple rule? Perhaps, before answering that question, one may entertain the thought of querying the rationale or irrationality of choosing the complex rule despite clarity and benefit of simple rules. One reason is falling foul of complexity and acting defensively by sticking to those rules. There are examples of such behaviour in public health as illustrated by Gigerenzer and Kurzenhäuser (2005). Similar, inclination towards complex rulebook is found in the other professions e.g. law and financial regulations[22]. So does it imply that basing forecasting on the complex model like COMPASS in the time of high uncertainty and ignoring all the evidence on the exchange rate depreciation and pass through led to the "*Michael Fish*" movement? It seems it might be so. However, we will illustrate it further by providing some evidence of this notion.

3. Methodology

In order to see the aspect of using simpler approaches with lesser parameters as well as the use of heuristics, we employed an Autoregressive Integrated Moving Average (ARIMA)[23] model as well as a rule of thumb. The notion of using the simpler approach as ARIMA model has its rationale embedded in the Haldane (2012) argument that the large and complex models lead to fragile forecast and there are also issues of over-fitting and over-parameterisation. Nevertheless, there is empirical evidence on the comparative performance of the model which suggested the that AR models perform well in the short-run (See Gürkaynak et 2013 or more recently and in specific to the UK, see Fawcett et al 2015 and Domit et al, 2016). To explain the behaviour of the series, ARIMA framework takes into account the past values of the underlying series (i.e. AR to an order (*p*), the order of integration requires to make it stationarity i.e. I to an order of (*d*) and values of the immediate past errors i.e. MA to the order of (*q*)[24]. The model takes the following general form:-

$$Y_t = \emptyset_1 Y_{t-1} + \emptyset_2 Y_{t-2} + \cdots + \emptyset_p Y_{t-p} + u_t + \theta_1 u_{t-1} + \theta_2 u_{t-2} + \cdots \theta_q u_{t-q} \quad (1)$$

Equation 1 can be re-written using summations as follows;

$$Y_t = \sum_{i=1}^{p} \emptyset_i Y_{t-i} + u_t + \sum_{j=1}^{q} \theta_j u_{t-j} \quad (2)$$

Alternatively, using the lag operator it can be express as:

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[20] Same method was found to be fruitful in the studies of avalanches by (McCammon and Hägeli (2007). Most interestingly, it was also found superior to the portfolio strategy of weighting by risk and return suggested by Merton-Markowitz, on this aspect DeMiguel et al (2007) showed that the simple rule of 1/N outperformed the weighting by risk and return. Haldane, (2012) and Gigerenzer and Brighton (2009) argued that Indeed, Markowitz himself pursued a 1/N, rather than Markowitz, strategy when investing for retirement.

[21] Zellner (2006, page 334) argued that the "Simpler laws have the greater prior probabilities and hence called Simplicity postulate"

[22] The financial regulations have become increasing painstaking from Basel I to Basel III and Glass-Steagall Act of 1933 to Dodd-Frank Act of 2010. (See Haldane, 2012)

[23] ARIMA models are introduced by Box in Jenkins (1976) and are widely used since then, though with some modifications to initial framework e.g. accounting for the seasonality in AR and MA processes.

[24] Due to this reason, the ARIMA model is expressed as (*p.d.q*). *A point to acknowledge here is that in a model with I (1) a constant term is included if the series has a non-zero average trend. The above specification (Eq. 1) is for presentation only, the actually model contains intercept.*

$$Y_t(1 - \emptyset_1 L - \emptyset_2 L^2 - \cdots - \emptyset_p L^p) = (1 - \theta_1 L - \theta_2 L^2 - \cdots - \theta_q L^q)u_t \qquad (3)$$

$$\Phi\,(L)Y_t = \Theta\,(L)u_t$$

As the series may require to be differenced to be stationary, it can be expressed as

$$\Delta^d Y_t(1 - \emptyset_1 L - \emptyset_2 L^2 - \cdots - \emptyset_p L^p) = (1 - \theta_1 L - \theta_2 L^2 - \cdots - \theta_q L^q)u_t \qquad (4)$$

On heuristic or rule of thumb, we need to build it on some logic, rationale and intuition. We used matching, based it on the sharp depreciation post-Brexit and a significant amount of appreciation from early 2013 to late 2015 which according to Forbes (2016) was about 17% and according to the Bank of England's estimates, it should have been weighing on inflation about 3 to 5% evenly spread over years[25]. As the size of depreciation Post-Brexit is almost the same as the magnitude of earlier appreciation, it would be fair to expect an approximately similar effect though in the opposite direction. Using the 1/N rule, we created a scenario where in addition to the inflation projections already made by the Bank of England by the point of Brexit, this impact (i.e. 3, 4 and 5% respectively) is spread over the 3 years forecast horizon. Alternatively, the notion of inflation drag between 1 ¼ and 1 ½ due to appreciation could have also be used as a rule of thumb (Forbes, 2016). Although once accounted for the year on year inflation rise it would have been similar in magnitude. In addition to that, another alternative or maybe a better alternative could have been to embed this rule of thumb into the forecasting framework employed by the Bank of England. Doing so could have led to "guiding the model" and with reciprocity from the model, it could have led to a better outcome. However, we do not have accesses to the framework employed by the Bank of England which to some extents limits the full demonstration of the idea put forward in this treatise.

We used the quarterly and monthly data on Consumer Price Index from January 1989 to June 2019 to compare the forecasts by the BoE, ARIMA model and our rule of thumb with the actual data in the Post-Brexit 3 years period. The data is obtained from the Office for National Statistics (ONS).

4. Comparison of Forecasts

To start with, a comparison of ARIMA models with various specifications is performed. There were a total of 225 ARIMA models compared to select the best model. The choice was made based on Akaike Inflation Criteria (AIC). The selected ARIMA model is ARIMA p (2) d (1) q (1)[26] i.e. It includes two Autoregressive (p) 1st difference (d) and one moving average terms (q). To conserve the space the results of the ARIMA model are attached as Appendix B. The main point we would like to make in this section is the comparison of the projections made by the Bank of England's Monetary Policy Committee in August 2016[27], ARIMA model projection, and projections based on the rule of thumb (1/n) on pass through. We would also benefit from hindsight and three years of actual data until June 2019. The comparison is presented in Figure 9 below[28]:

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[25] The pass-through from exchange rate movements to UK import prices is roughly 60% to 90%, and the import intensity of the consumer price index (CPI) is about 30%. This generates an overall pass-through coefficient of around 20% to 30%.

[26] Considering the fact we allowed for the seasonality, to be precise it is SARISMA model (3, 1, 2) (0, 1) model. The data was found to be integrated of order I (1) using ADF unit root with structural break (dated 1993Q2). The results are not presented here to conserve the space, however can be made available on request.

[27] This involves use of COMPASS as well as Bank of England's suite of models which contains 50 separate models. Hence, it won't be wrong to argue that we are making a comparison with a forecast which is based on 50 models (See Burgess et al 2013).

[28] Of course, a forecast comparison can also be made using standard matrixes such as Mean Squared Error, Mean Absolute Error etc. In the subject case the clear blue water as prima facie evident in visual depiction.

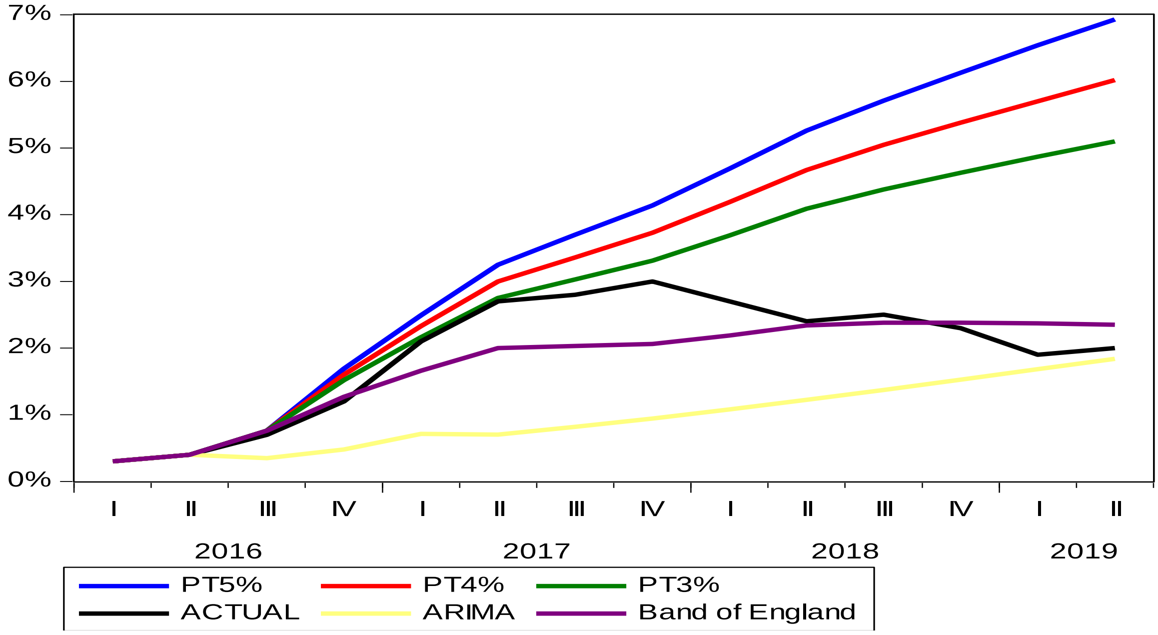

Figure 9: Comparison of Forecasts with actual quarterly data until June 2019

The comparative depiction of projections and actual data clearly suggest that despite initial accuracy which might be associated with the earlier availability of inflation data to MPC there is a clear divergence between the forecast by the Bank of England and actual data, particularly till the end of 2017. It is prima facie evident that the actual rate of inflation is rather surging after the 3rd quarter of 2016. An important point to note here is that in our rule of thumb (1/n), we have evenly spread the pass-through rates (i.e. 3, 4 and 5% respectively) over the forecast period by adding to the forecasts made by the Bank of England's August 2016 inflation report (about six weeks after the point of Brexit)[29]. As said earlier, the figures of the pass-through rates are based on the Bank of England's estimates of a shock of a similar magnitude i.e. 3- 5% (see Forbes (2016). This leads to a slightly higher forecast in the beginning. However, as the effects of depreciation started to kick in, the actual inflation caught up with the rule of thumb. The comparison of ARIMA and the BoE forecast shows interesting trajectory towards convergence in the long-run which is another indicator of the inability of these frameworks to reflect on any further shocks which can influence the inflation dynamics, nevertheless, the feeding of pass-through. The ARIMA performed worst so far, which is contrary to the suggestion by See Gürkaynak et al (2013) and Fawcett et al 2015 and Domit et al (2016) that the Autoregressive model performs well for the short-run prediction. What we witness here is that this approach performed worst in the short run. A logical reason for this is that this approach suffers from the fundamental problem of the future being different from the past as we acknowledged in the very first paragraph of this treatise while referring to Knight (1921). This aspect is in addition to the issue with the ARIMA approach that it retains the constancy of the first and second moments, limits the phase of the cycle to a symmetrical instance and only reproduces the dynamics of the stationary variable (Jawadi; 2012). Concomitantly, given that the ARIMA framework draws heavily on the recent past, it shall not be expected to be a good device for forecasting when faced by the high level of uncertainty due to fundamental changes in the macroeconomic landscape. Moreover, the suggestion by Haldane (2012 and 2017) to use a longer time period will not improve much either since ARIMA will be only drawing on the recent observations which are not far back in the past.

As discussed earlier, an important aspect to consider is that the inflation (CPI) estimates are year on year, hence the price rises beyond one year are dropped out from estimation. Therefore, it is vital to include this aspect into the analysis to get the precise forecasts, we did so and results are presented in Figure 10:

However, the comparison based on numerical measures also showed consistent results i.e. rule of thumb outperforming, particularly in the earlier periods and until end of 2017.

[29] One may see the range of 3-5% as a bandwidth or range of forecast.

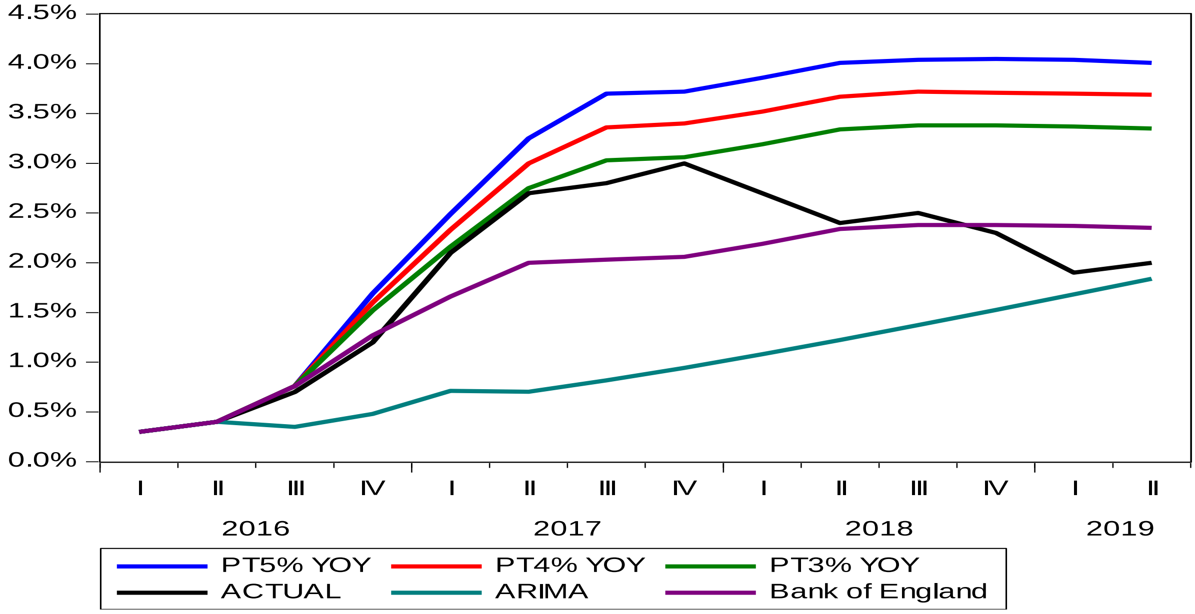

Figure 10: Comparison of Forecasts with actual quarterly data until June 2019

It showed that doing so led to the smoothing of the inflation projection which is intuitive as the rises in the level of prices in previous periods starts to drop out. Nonetheless, it also improved the forecasts based on our rule of thumb as prima facie evidence in Figure 10. Perhaps, this is just a matter of looking at the same phenomena from a different angle, yet an important aspect to get the precise projections.

Given that, the August 2016 forecast came at a point when we had the actual data for the July and August release i.e. 2/3rd of the 3rd quarter of 2016. The depreciation Post-Brexit had occurred. The projection could have been made on the monthly frequencies which could have been more informative. We excised this option and the results are presented in Figure 11 below:

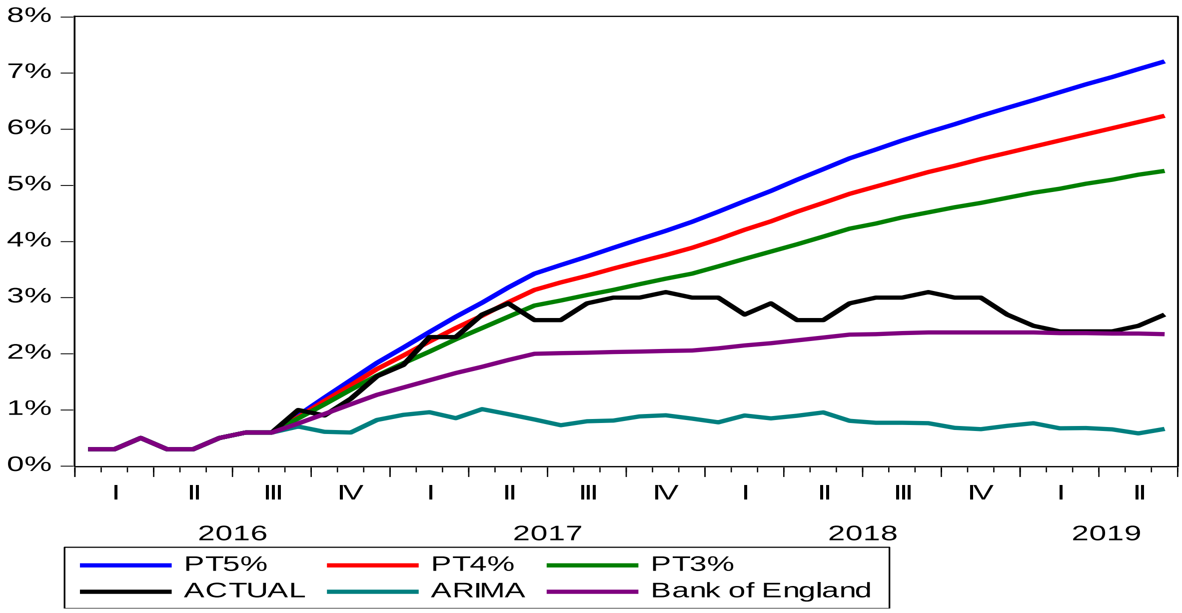

Figure 11: Comparison of Forecasts with actual monthly data until June 2019

The comparison of the ARIMA[30], BoE's forecast and projections based on the rule of thumb made it even clear. It showed that as we zoomed in by considering the behaviour of the actual inflation, there is a rather greater divergence from the BoE's and ARIMA projections. Although after 2017, the actual data started to converge to the BoE forecast, it is worth noting that this is 18 months after the forecast. In the first year and a half, the rule of thumb has outperformed both the BoE's and ARIMA projections. In the case of quarterly data, one would have to wait until the successive quarter estimates come in while in the case of monthly data the dynamics of the inflation become clear earlier. To get the precise estimates, once again we consider the aspect of the year on year inflation (CPI) estimation and the adjusted projections are presented in Figure 12 as follows:

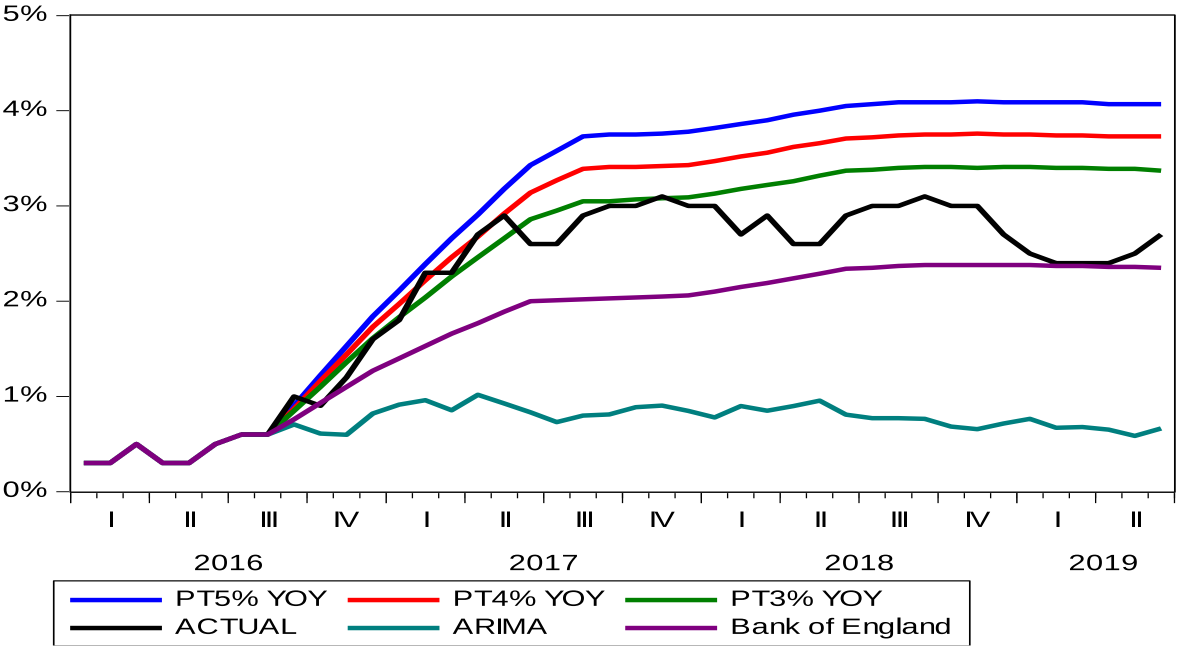

Figure 12: Comparison of Forecast with actual monthly data until June 2019

Once again, it showed that in the first 18 months, the actual inflation was closer to the projections based on the rule of thumb than the BoE's and ARIMA forecasts. Putting all together, the results showed that the rule of thumb provided better projections so far. Of course, it is with the benefit of hindsight that we can make this comparison. Nonetheless, it is clear that neither the complex nor the simplest model performs well when faced with a high tide of uncertainty. As stated earlier and reiterated here to make it clearer that the suggested approach involving the application of the heuristic or rule of thumb could have been more effective if the rule could have been embedded in the workhorse-forecasting framework of the Bank of England. Further adjustments can also be made to incorporate the effects of appreciation or reversion of exchange rates to the long-term trend. In so doing, one can draw on the traditional approaches which perform reasonably well as the fog of uncertainty settles.

5. Conclusion and Policy Implications

Among the limited points of consensus, the difficulty of forecasting is prima facie, particularly when faced with high levels of uncertainty. It is also evident that the compasses of forecasting and projection frameworks based on complex models and past observations perform worst when the tides of uncertainty are high, perhaps when these compasses and frameworks are most needed to give us some insight into the future. The alternative suggested by the proponents of simplicity, judgment and heuristic is the one which can be helpful. In specific to the post-Brexit forecast, it is obvious that the

[30] Results of ARIMA are attached as appendix "C", the comparison based on AIC criteria favoured ARIMA p, d, q (1, 1, 1) model.

vital aspect of exchange rate pass-through was ignored when it came to forecasting inflation. The interesting aspect is that there was substantial evidence that the exchange rate appreciation in the period between 2013-2015 had been weighing on inflation, leading to inflation persistently undershooting the Bank of England's target. However, in the post-Brexit period when exchange rate sharply depreciated, this nexus seemed to be forgotten or condoned in the projections of inflation for the short to medium term. A possible explanation can be that the analogy of *the dog and the frisbee* was rather swayed by the glitter of the complex models. Nonetheless, the notion that the longer series or more data can be helpful becomes paradoxical when put together with a simpler framework to avoid over-parameterisation. Such a simpler framework suffers from the curse of future distributions being different from past distributions. Hence, it can be concluded that instead of using merely a larger dataset, a simple rule of thumb which can be based on using relevant data of a similar event and episode can be more useful to make a judgment in addition to the workhorse models employed by the forecasting institutions. The idea of the development of the rule of thumb for forecasting is preliminary and invites further debate and methodological scrutiny. In a nutshell, the lesson we draw here is that embedding such a rule in the existing framework could be very fruitful. In this way, using heuristics and rule of thumb, we can guide the model before the model can guide us!

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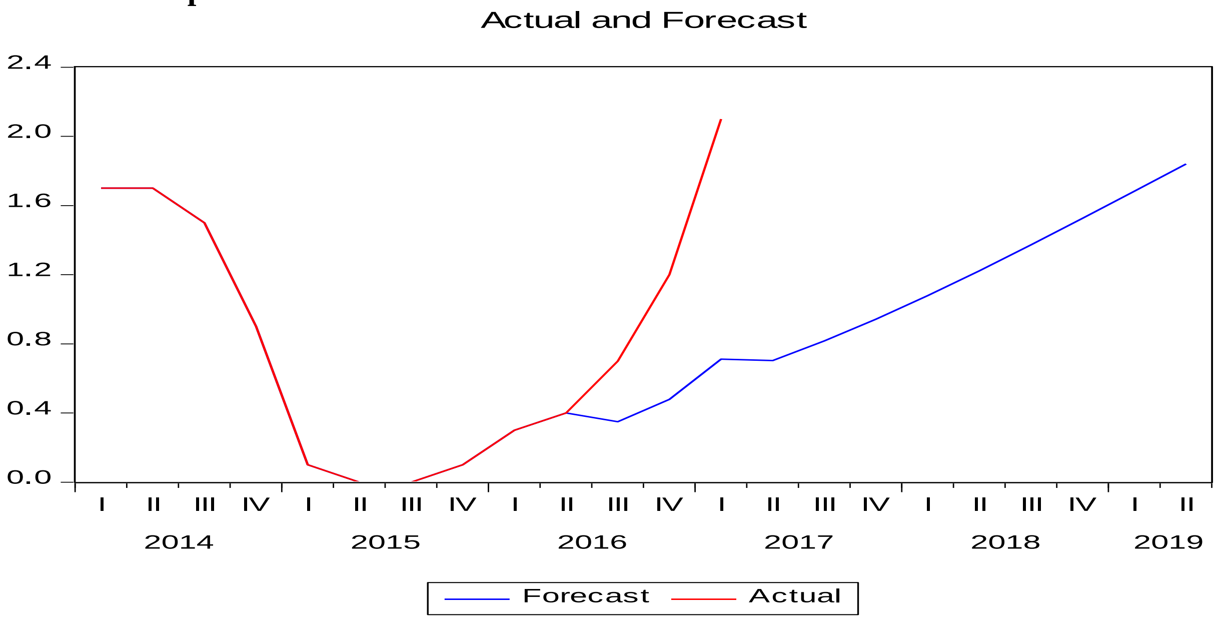
Appendix “A”: Numerical Parameters of Inflation Report Probability Distributions

CPI inflation projections based on market interest rate expectations & £375 billion asset purchases																	
Feb-16	**2016Q1**	**2016Q2**	**2016Q3**	**2016Q4**	**2017Q1**	**2017Q2**	**2017Q3**	**2017Q4**	**2018Q1**	**2018Q2**	**2018Q3**	**2018Q4**	**2019Q1**	**2019Q2**	**2019Q3**	**2019Q4**	**2020Q1**
Mean	0.44	0.42	0.54	0.81	**1.15**	1.49	1.64	1.90	**2.05**	2.11	2.15	2.24	**2.25**				
May-16		**2016Q2**	**2016Q3**	**2016Q4**	**2017Q1**	**2017Q2**	**2017Q3**	**2017Q4**	**2018Q1**	**2018Q2**	**2018Q3**	**2018Q4**	**2019Q1**	**2019Q2**			
Mean		0.43	0.77	0.94	1.31	**1.52**	1.52	1.79	1.92	**2.07**	2.12	2.20	2.23	**2.23**			
Aug-16			**2016Q3**	**2016Q4**	**2017Q1**	**2017Q2**	**2017Q3**	**2017Q4**	**2018Q1**	**2018Q2**	**2018Q3**	**2018Q4**	**2019Q1**	**2019Q2**	**2019Q3**		
Mean			0.76	1.27	1.66	2.00	**2.03**	2.06	2.19	2.34	**2.38**	2.38	2.37	2.35	**2.33**		
Nov-16				**2016Q4**	**2017Q1**	**2017Q2**	**2017Q3**	**2017Q4**	**2018Q1**	**2018Q2**	**2018Q3**	**2018Q4**	**2019Q1**	**2019Q2**	**2019Q3**	**2019Q4**	
Mean				1.25	1.86	2.44	2.65	**2.82**	2.88	2.88	2.79	**2.70**	2.65	2.60	2.54	**2.49**	
Feb-17					**2017Q1**	**2017Q2**	**2017Q3**	**2017Q4**	**2018Q1**	**2018Q2**	**2018Q3**	**2018Q4**	**2019Q1**	**2019Q2**	**2019Q3**	**2019Q4**	**2020Q1**
Mean					2.05	2.43	2.58	2.69	**2.72**	2.75	2.67	2.60	**2.56**	2.51	2.46	2.40	**2.36**
CPI inflation projections based on interest rates constant at 0.50% & £375 billion asset purchases																	
Feb-16	**2016Q1**	**2016Q2**	**2016Q3**	**2016Q4**	**2017Q1**	**2017Q2**	**2017Q3**	**2017Q4**	**2018Q1**	**2018Q2**	**2018Q3**	**2018Q4**	**2019Q1**	**2019Q2**	**2019Q3**	**2019Q4**	**2020Q1**
Mean	0.45	0.45	0.61	0.91	**1.28**	1.66	1.83	2.10	**2.27**	2.34	2.39	2.49	**2.51**				
May-16		**2016Q2**	**2016Q3**	**2016Q4**	**2017Q1**	**2017Q2**	**2017Q3**	**2017Q4**	**2018Q1**	**2018Q2**	**2018Q3**	**2018Q4**	**2019Q1**	**2019Q2**			
Mean		0.44	0.78	0.96	1.34	**1.56**	1.56	1.84	1.97	**2.13**	2.18	2.27	2.30	**2.31**			
CPI inflation projections based on interest rates constant at 0.25%, other policy actions as announced																	
Aug-16			**2016Q3**	**2016Q4**	**2017Q1**	**2017Q2**	**2017Q3**	**2017Q4**	**2018Q1**	**2018Q2**	**2018Q3**	**2018Q4**	**2019Q1**	**2019Q2**	**2019Q3**		
Mean			0.76	1.27	1.64	1.97	**1.99**	2.02	2.14	2.29	**2.32**	2.32	2.31	2.29	**2.27**		
Nov-16				**2016Q4**	**2017Q1**	**2017Q2**	**2017Q3**	**2017Q4**	**2018Q1**	**2018Q2**	**2018Q3**	**2018Q4**	**2019Q1**	**2019Q2**	**2019Q3**	**2019Q4**	
Mean				1.26	1.87	2.44	2.66	**2.83**	2.90	2.90	2.81	**2.71**	2.67	2.62	2.57	**2.52**	
Feb-17					**2017Q1**	**2017Q2**	**2017Q3**	**2017Q4**	**2018Q1**	**2018Q2**	**2018Q3**	**2018Q4**	**2019Q1**	**2019Q2**	**2019Q3**	**2019Q4**	**2020Q1**
Mean					2.05	2.46	2.62	2.76	**2.82**	2.86	2.79	2.74	**2.70**	2.66	2.62	2.57	**2.53**

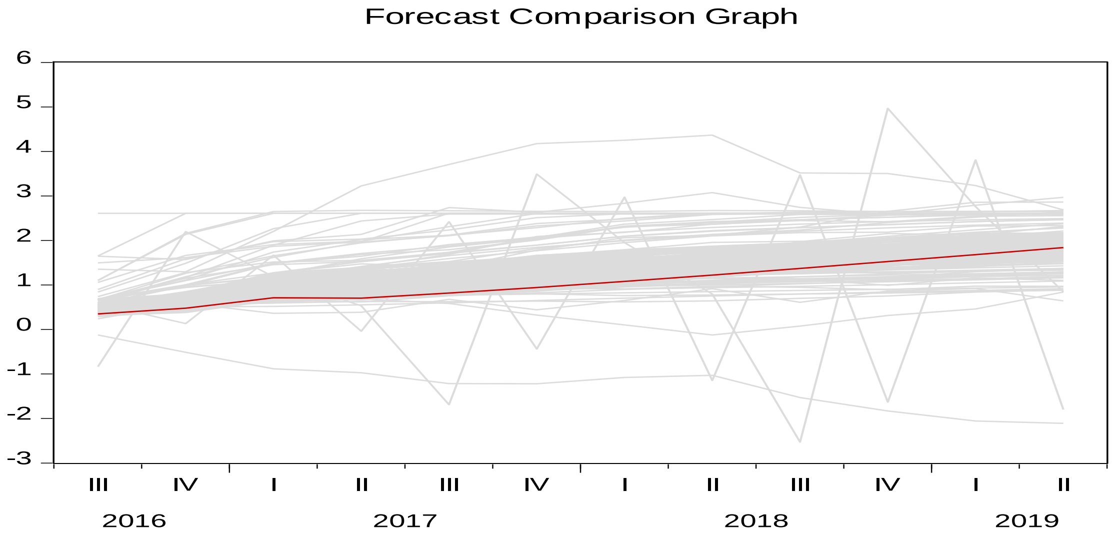
Appendix "B" ARIMA Model

Dependent variable: CPI
Sample: 1989Q1 2016Q2
Included observations: 110
Forecast length: 12
Number of estimated ARMA models: 225
Number of non-converged estimations: 0
Selected ARMA model: (2,1)(0,1)
AIC value: 1.47047647609

Forecast Graph:



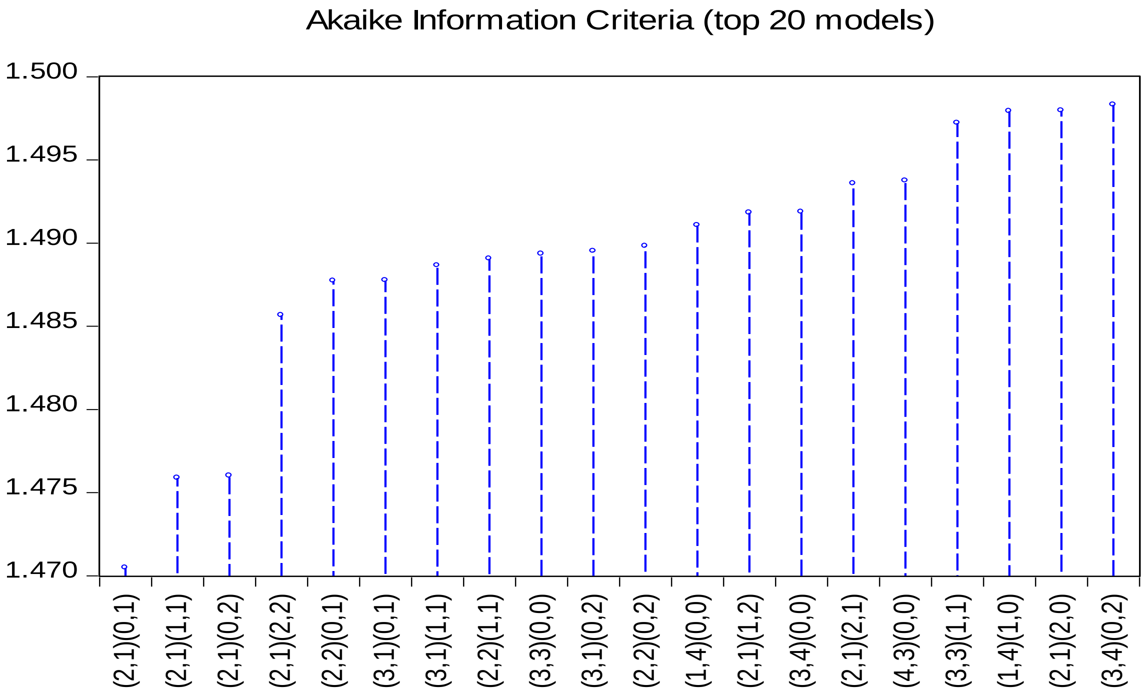
Forecast Comparison Graphs:



Estimated Model:

Method: ARMA Maximum Likelihood (BFGS)				
Sample: 1989Q1 2016Q2				
Included observations: 110				
Convergence achieved after 21 iterations				
Coefficient covariance computed using outer product of gradients				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
Dependent Variable: CPI				
C	2.374575	0.44675	5.31522	0.000
AR(1)	1.945098	0.027042	71.93009	0.000
AR(2)	-0.955926	0.026711	-35.78737	0.000
MA(1)	-0.765032	0.085321	-8.966519	0.000
SMA(4)	-0.653496	0.092282	-7.081518	0.000
SIGMASQ	0.218158	0.023721	9.196783	0.000
R-squared	0.932987	Mean dependent var		2.61
Adjusted R-squared	0.929765	S.D. dependent var		1.812543
S.E. of regression	0.480358	Akaike info criterion		1.470476
Sum squared resid	23.99734	Schwarz criterion		1.617775
Log likelihood	-74.87621	Hannan-Quinn criter.		1.530222
F-statistic	289.5868	Durbin-Watson stat		1.945846
Prob(F-statistic)	0.000000			
Inverted AR Roots	.97-.10i	.97+.10i		
Inverted MA Roots	0.9	0.77	.00+.90i	-.00-.90i
	-0.9			

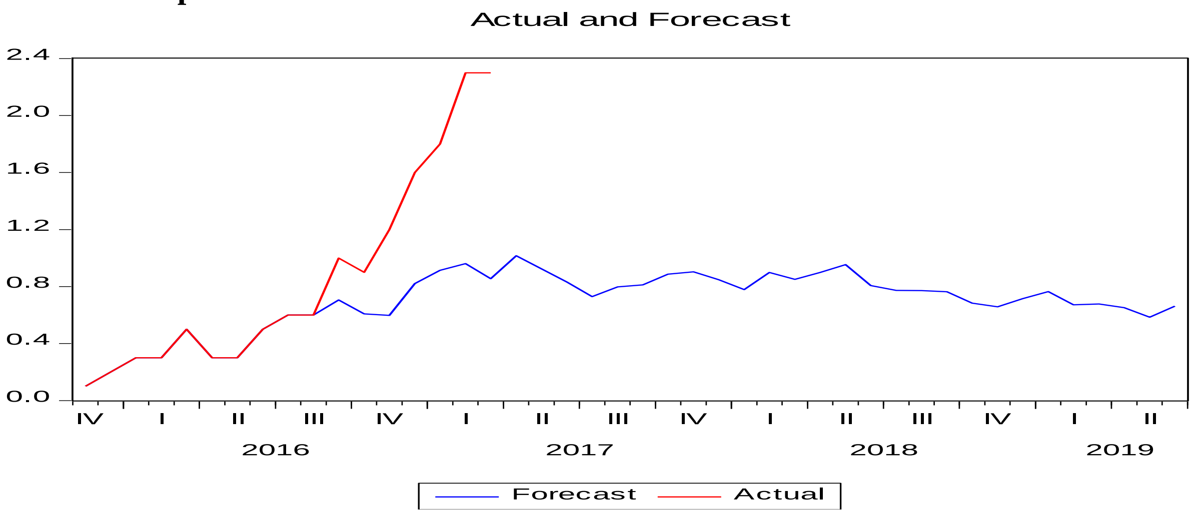
ARIMA Criteria Graph



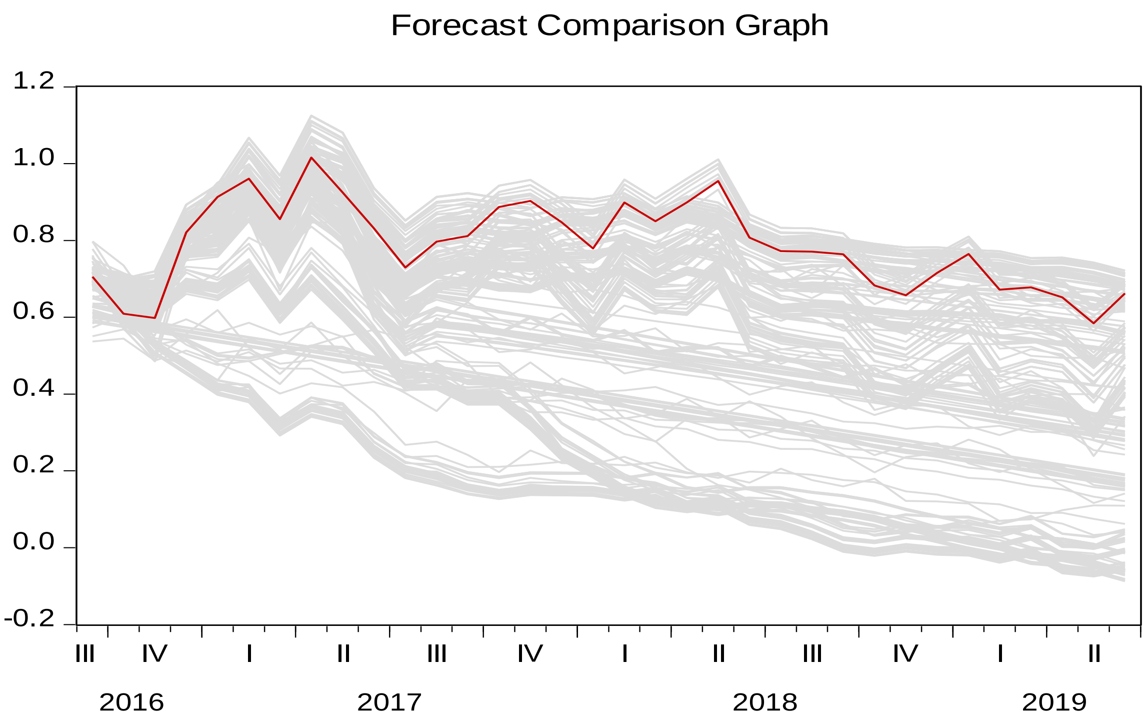
Appendix "C" ARIMA Model

Selected dependent variable: D(CPI)
Sample: 1989M01 2016M08
Included observations: 331
Forecast length: 34
Number of estimated ARMA models: 225
Number of non-converged estimations: 0
Selected ARMA model: (1,1)(2,2)
AIC value: 0.254772943593

Forecast Graph:



Forecast Comparison Graphs:



Estimated Model

Method: Least Squares				
Sample: 1989M02 2016M08				
Included observations: 331				
Convergence achieved after 120 iterations				
Coefficient covariance computed using outer product of gradients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent Variable CPI				
C	-0.011143	0.012103	-0.920708	0.358
AR(1)	0.941495	0.05102	18.45359	0.000
SAR(12)	-0.717042	0.114216	-6.277959	0.000
SAR(24)	0.142916	0.070149	2.037327	0.042
MA(1)	-0.863051	0.071912	-12.00144	0.000
SMA(12)	0.227966	812.4949	0.000281	1.000
SMA(24)	-0.772026	3805.514	-0.000203	1.000
SIGMASQ	0.06798	19.2236	0.003536	0.997
R-squared	0.294497	Mean dependent var		-0.013
Adjusted R-squared	0.279208	S.D. dependent var		0.31088
S.E. of regression	0.263939	Akaike info criterion		0.25554
Sum squared resid	22.5014	Schwarz criterion		0.34744
Log likelihood	-34.29231	Hannan-Quinn criter.		0.29219
F-statistic	19.26137	Durbin-Watson stat		1.91515
Prob(F-statistic)	0.000000			

ARIMA Criteria Graph