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Zero Lower Bound and negative interest rates: Choices for monetary policy in the UK

Abstract

There have been relatively few analyses of the policy context and consequences of a Zero Lower Bound (ZLB) for nominal interest rates. This paper sets out monetary policy alternatives, including negative interest rates, a revision of the inflation target, and rendering unconventional policy instruments such as QE conventional (permanent). Following extensive discussion of policy options, we set out a model that explores the impacts of the real policy rate on economic growth, employment and inflation, with particular attention to the British economy. We use a Time-Varying Structural Vector Auto-regressive (TVSVAR) Model where the sources of time variation are both the coefficients and variance-covariance matrix of the innovations. It was found that real rates have significant implications for real growth, the labour market and price stability even when monetary policy was constrained at the ZLB in nominal terms. The study additionally applies a discrete break in the data to focus on the Post-Global Financial Crisis and ZLB period. This indicates that the effectiveness of real rates did not diminish and this has important implications in terms of a policy approach which seeks to exploit real negative rates.

Keywords: Zero Lower Bound, Negative Interest Rates, Monetary Policy, Quantitative Easing, Policy Coordination, Fiscal Policy, TVSVAR Model
JEL Codes: C11, E23, E31, E43

1. Introduction:

The Global Financial Crisis (GFC) has been succeeded by an unprecedented global macroeconomic environment of low growth and stagnation which lead to unconventional macroeconomic policy measures. Central banks, particularly in developed countries chose an extraordinary stance, for example including Large-Scale Asset Purchase measures (LSAP). Monetary policy became remarkably accommodative to a degree that the nominal interest rates tended towards the Zero Lower Bound (ZLB). Large Scale Asset Purchases (also known as Quantitative Easing Q.E) which currently stand over US$ 5 trillion globally, with more in the pipeline have been rolled out over time and it may be that the former status quo will not be restored, which then may lead to a situation where central banks are required to take measures to deal with the technical constraints imposed by the ZLB on interest rates (Haldane, 2015). Looking back over recent decades, interest rates in the developed economies have been on a downward trajectory since the 1980s, with some significant variations. The start of the last decade of the previous century was the start of the Great Moderation, a period defined in terms of low inflation and low interest rates. Nevertheless, rates have been exceptionally low, even by this prior standard (and trend) since the GFC, particularly for developed economies like Germany, Japan, UK and USA (Bank of England, 2015). For Japan, official interest rates have been close to the ZLB for the last two decades while the UK, US and Germany have converged around the ZLB in recent years[1]. All of these countries have also augmented their monetary policy with large-scale asset purchases or Q. Es (IMF, 2013)[2]. This low-interest rate environment has not only prevailed in the major economies but can also be observed in some of the developing countries (Bank of England, 2015)

The Zero Lower Bound (ZLB) is a landmark in monetary policy formulation. It has significance in the context that once we reach this point, a question arises regarding what further steps a monetary authority can take. There is a theory-policy fork in the road for the future of monetary policymaking. Three policy options arise: a) *Do more Quantitative Easing* b) *Revise the mandate for and specifics of inflationary targeting for price stability* and/or c) *Opt for negative nominal interest rates*. In the next section, we provide a detailed discussion of the various proposals and options available to policymakers while at the ZLB. The ZLB constraint also reflects the fact that there are limits to what we can expect monetary policy to deliver regarding the goals of price and economic stability. Perhaps, coordination will be required from a fiscal counterpart, as argued by Keynes (1982 [1932] (for more recent discussion, see Leeper, 1993; Dixit and Lambertini 2001, 2003; Davig and Leeper, 2011; Andrew et al. 2011; Dow 2017 for insightful reasoning on the significance of policy coordination).

The traditional view on nominal interest rates has predominantly considered them as a non-negative entity. As Hicks (1937, P. 154-155) famously stated:

> "[*I]f the costs of holding money can be neglected, it will always be profitable to hold money rather than lend it out, if the rate of interest is not greater than zero. Consequently, the rate of interest must always be positive*".

This argument was drawn on the logical foundations laid by Keynes (1936), while emphasising *liquidity preference* of economic agents and that the utility of holding money is always positive, even if more money is held than required for transactions or precautionary motives. However, looking at the practices in the recent history of monetary policy formulation, it is notable that in order to further stimulate economies, Japan, followed by some of the European economies, have chosen to cross the ZLB and tentatively enter into the uncharted territory of negative interest rates territory. This strategy

[1] Pre-Crises wisdom was that the ZLB shall not persist for too long and may only prevail up to one year (See Chung, et al (2012) and Williams (2014) for detailed discussion on failing to ZLB's longevity).

[2] The strategy of the Large Scale Asset Purchases (LSAP) is supported with the rationale that it can complement the growth even when there is ZLB on nominal rates (See, McCallum 2000; Svensson 2001; Bernanke and Reinhart 2004; Bernanke et al, 2004)

of negative interest follows a rationale to diminish the utility of holding money, beyond that which is required for transactions or precautionary motives. Significantly, the economic context, notably the emergence of a situation of secular stagnation, renders some confluence of new monetary policies, which potentially influence the holding of cash attractive to policymakers.

However, on theoretical and practical grounds, the case for the negative interest rates does not seem strong. On theoretical grounds, there are some difficulties in the adoption of negative interest policy, as highlighted by Keynes (1973[1936], recently discussed by Dow, 2017, details in the next section). In practice, there is not much evidence of great success or appetite for such a policy. For instance, in the case of the British economy, which has performed comparatively well until the onset of the Brexit saga[3], the general impression has been that official interest rates have not and will not require crossing the ZLB. It has been typically argued that although stimulative policy measures are structured to boost domestic demand, there are limits to the extent to which this can be achieved by negative rates. These limits include, first, banks might not be able to fully pass negative policy rates to their respective retail customers, a reflection of concern commonly expressing the view that negative rates could reduce banks' profitability; and second, negative rates could lead to the export of excessive saving leading to a global liquidity trap (See Carney, 2016 for details[4]). This position seems to be shared by the US Fed (Posen, 2016) and has been maintained by the Bank of England, since the onset of Brexit (the UK policy rate has remained historically low and stable just above zero). UK growth has been modest yet positive in the period after Brexit and despite revisions to inflation forecasts, there has been no concerted pressure to cross the ZLB (Bank of England, 2016)[5].

However, it would not be extraordinarily surprising if reductions in interest rates were to occur in the future. Given the modest expectations of growth, the uncertainty created by Brexit and most recently after the Coronavirus (COVID-19) outbreak, there is a question as to whether the Bank of England should follow the course adopted by some of its counterparts and opt for negative interest rates to provide further stimulus. Ultimately, the Bank is in the best position to assess this but it is a question worth asking because of the possible implications interest rates can have when held constant at the ZLB. A point to be noted here is that although current nominal interest rates are close to the ZLB in many countries including the UK, real interest rates have not been fixed and have changed frequently in the Post Global Financial Crisis period. If the Bank of England keeps the policy rate at zero and does not opt for the sub-zero option, and inflation occurs then real rates may still be negative or tending downwards. Nevertheless, the Bank of England can still influence real rates through its policy response to inflation and by using instruments other than nominal interest (Bank) rates. For example, Q.E, revision of the inflation mandate and/or quantitative and qualitative "forward guidance". Here, an accommodating fiscal expansion as argued by Keynes (1936) can undoubtedly provide a helping hand to monetary policy by exploiting the inflation and real rates nexus[6].

The confluence of issues stated provides a rationale to investigate the implications of real rates for the economy, and this is the core modelling focus of this paper. We use a Time-Varying Structural Vector Auto-regressive (TVSVAR) framework, which accounts for the time variation in the association between variables of interest and employed data, from 1989M to 2016M. Our key findings indicate that real rates are effective for economic growth and in the labour market as well as to influence

[3] According to IMF forecast, UK is expected to be fastest growing economy among G-7 in 2016. In response to the referendum on the European Union (EU) membership, as held on 23 June 2016, to decide whether the UK should leave or remain in the EU. Leave won by 52% to 48%.

[4] In his speech at the G20 conference, Shanghai (2016), Governor of the Bank of England, Mark Carney reflected on the limitations of negative interest rates and their implications. In addition to that, US Federal Reserve, Chairperson Janet Yellen wrote to the US Congress that "while the idea of negative interest rates is not completely ruled out, it would require a lot of consideration and could be only as a last resort (Posen, 2016). Nevertheless, despite being cut to - 0.4% the Deposit rates in Euro area are since then held unchanged.

[5] The GDP was estimated to have increased by 0.5% in Quarter 3 (July to Sept) 2016 and was 2.3% higher in Quarter 3 2016 compared with the same quarter a year ago.

[6] A preference for the accommodative monetary policy while fiscal policy plays more actively in economic slack is also what Galbraith proposed (see, Sheehan, 2018 for details).

inflation even when monetary policy is constrained at the ZLB in nominal terms. This provides a profound policy implication. There is a nexus to be exploited between real rates and the economy through the dynamics of inflation by using non-conventional monetary and perhaps, well-coordinated fiscal measures as proposed by Keynes when at the ZLB. There is, more than ever before, a *prima facie* need for coordinated fiscal-monetary measures.

The paper proceeds as follows: to provide context Section 2 provides an extensive discussion of the competing choices available to policymakers when monetary policy is at the ZLB, Section 3 briefly describes the layout of the empirical framework as a means to analyse the implications of real rates for the economy, Section 4 provides the results of the empirical analysis and Section 5 concludes the argument with a discussion of policy prescription and implications.

2. Zero-Lower-Bound Constraint & Policy Choices

Given sufficient historic context, few ideas are genuinely original because situations recur and this is also the case for ZLB and its implications. The issue of ZLB was part of the discussion around the Great Depression in the 1930s. Keynes cautioned regarding the ineffectiveness of low-interest rates in the General Theory (Keynes, 1936). However, between the Great Depression and Global Financial Crisis of 2008, the ZLB problem disappeared from the view of policymakers and was largely limited to the academic world (Blanchard et al; 2010). For example, Reifschneider and Williams (2000) simulated ZLB. These simulations indicated that with an inflation target of about 2%, monetary policy would be constrained by the ZLB only around 5% of the time and that a ZLB situation would not extend beyond a period of one year. However, events as they have turned out in the Post-GFC world indicate otherwise. The ZLB has turned out to be a rather tenacious constraint in the formulation of policy. Perhaps, the limited attention apportioned to the issues in the pre-crisis period can be attributed to the low-risk macroeconomic environment associated with the Great Moderation (Williams, 2014). Later study based on the recalibrated model with incorporation of the risks that manifested in the Great Recession highlight the constraint imposed by the ZLB to a greater extent (e.g. See Chung et al; 2012). However, the issue of unconventional monetary policy in general and ZLB in particular have been periodically returned to from a number of perspectives within *Journal of Policy Modelling* (see, for example, Egea and Hierro, 2019; Rogoff, 2017; Kucharcukova et al, 2016; Wang, 2016; Karagiannis, 2010; Lewis and Seidman, 2008).

However, should one blame the Great Recession or periods of deep economic slumps as solely responsible for the ZLB constraint (something unforeseeable for prior simulations)? This is an open question, since the constraint may prevail even after a complete global economic recovery *if* the ZLB constraint is more structural and long-lasting (See Buiter and Rahbari; 2015, Haldane, 2015 for a detailed discussion). Nevertheless, one might just refer to experience in Japan, as the issues are evident in the Japanese case. Real interest rates have been on a downward trajectory for the last three decades, in Broadbent (2014) words, there has been a *secular decline.* On the basis of the tendency expressed in interest rates over recent decades, Haldane (2015) argued that as the Global Financial Crises approached and in the period after, monetary policy had too little room for manoeuvre[7]. The significant fall in world real interest rates is explained and quantified by Rachel and Smith (2015) to 450 basis points. The major reasons stated include lower trend growth, worsening demographic trends, low investment rates due to the falling price of capital goods, rising inequality and savings

[7] Specifically Haldane (2015) pointed that contrary to 1990s, where average world nominal rates were around 6%, the monetary authorities had plenty of room for manoeuvre and to cushion the effects of troughs in the business cycle. However, with a 2% inflation target, now there is less room for monetary policy to manoeuvre.

gluts in emerging markets[8]. Importantly, none of these factors seems to be transitory. There is no reason to expect them to alter in the medium, if not in the long-term. It seems likely that a low-interest rate environment will prevail and the ZLB constraint, as an issue, will persist in the foreseeable future. Various suggestions for monetary authorities to consider are, therefore, highly relevant. These alternative options include negative interest rates, revision of the inflation mandate/target and further and Quantitate Easing. In the following sections, we will discuss the substance and feasibility of each as policy options.

2.1 Negative Nominal Interest Rates

In the case of the ZLB constraint, a suggested remedy is to pay negative interest on currency deposits. There might be some benefits to negative nominal rates as suggested by both Rognlie (2016) and Rogoff (2017). For example, in terms of stabilizing aggregate demand. However, there is not a consensus regarding negative nominal interest rates. In some circles, they are perceived to be an unfair wealth tax, which can affect vulnerable members of society. Negative rates could lead affected groups to either retain savings or move wealth into risky assets and this may have further implications (Coeure; 2015). Ultra-low interest rates may lead to situations where agents borrow and invest in assets with limited and inflexible supply, such as real estate, which then poses risks on financial stability (Claeys and Darvas 2015 and Palley 2016).

Negative nominal interest rates can be operationalised in different ways and the basic concept for policy is not new. One hundred years ago, Silvio Gesell (1916) put forward the idea of stamping currency to avoid cash hoarding. Later, in *The General Theory*, Keynes (1936) discussed Gesell's proposal, and this is technically similar to imposing a negative interest rate. In recent contrast, Dow (2017) argues that while Keynes (1936) considered the idea behind stamped money as "sound", he dismissed the specific proposal due to the many difficulties in its implementation, particularly the availability and diversion to the alternative assets. From Keynes's (1936) perspective the notion of reforming the monetary system was not sufficient to stabilise the economy and achieve full employment through a more active role for both monetary and fiscal policy.

Despite, the limitations of Gesell's approach, debate regarding similar initiatives has become current in the 21st century. The idea of "Stamp tax" was rather more recently discussed by Goodfriend (2000) while Mankiw (2009) also proposed negative interest on loans and abolishing notes of certain serial numbers after a random draw. Buiter and Panigirtzoglou (2003) argued that something similar could be achieved by imposing a "Carry Tax" on currency, whereas Eisler (1932) and Later David (2004)[9] have proposed the unbundling of the numeraire function and medium of exchange/means of payment function of money through the creation of a parallel virtual currency. The aim was to set an explicit exchange rate between paper currency and electronic (or bank) money, where the former steadily depreciates compared to the latter, creating a negative interest rate on currency, given that electronic money is accepted by the public as the unit of account. In addition to these two discussed measures (stamp/carry tax and parallel currencies), Buiter (2009) has suggested abolishing cash, a proposal supported by Rogoff (2014, 2016)[10]. However, the case for abolishing cash has still not reached the point where it can become a practical policy measure (see, for example, Fish and Whymark, 2015)[11].

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[8] In the most recent literate, Yi and Zhang (2017) provided a detailed discussion on the global trends in the long-term real rates and associated them with the decline in the Marginal Product of Capital (MPK) and decreased total factor productivity.

[9] On the comparison between Silvio Gesell proposal and Eisler's proposal, Buiter (2005) declared former as preferable. Please See Buiter (2005) for detailed discussion.

[10] In addition to tackling the ZLB constraint, Rogoff (2014) argued that abolishing currency could overcome the illegal activities carried out using paper currency.

[11] The Bank's Chief Cashier argued that as there is a lot of life left in cash (See, Clealand, 2015). Moreover, Haldane (2015) called the currency (Government-backed) as a social convention which is definitely the unit of account and to lesser extent as a medium of exchange.

As Coeure (2015) put it, abolishing cash is more an outcome of changing technologies and social perception rather than a policy prescription.

However, considering the available options for operationalising negative interest rate policy[12], Buiter (2009) declared that "a*ll three are technically feasible, indeed operationally simple*". Furthermore, it has also been recognized that the demerits of these three options to address the ZLB on nominal interest rates should be matched against the economic cost created by the constraint on monetary policy if there is a floor imposed at zero. Buiter goes further, "*It may indeed be the case that no amount of quantitative easing or credit easing can make up for the inability of the monetary authorities to set negative nominal interest rates"* (Buiter, 2009, p. 50).

The points raised are an indication of possible consequences that Quantitate Easing and other conventional measures may ameliorate, given the constraint on monetary policy at ZLB. The same extends to fiscal policy and/or any other credit easing schemes which could be brought under the monetary policy umbrella. Ultimately, the concerns expressed by Buiter (2009) can only be addressed by observing the evidence. As it stands, nominal interest rates in the UK are still above zero and despite the increase in the Asset Purchase programme (Q.E) to £435bn and corporate bond purchases to £10bn, the policy rate has only varied between 0.25% and 0.75% and since March 2009 has mainly been set at 0.5% (Bank of England 2020). One might also note that inflation has been below target and thus conventional policy suggests an accommodative rate. The general context raises the earlier posed question regarding the benefits of keeping the nominal interest rate at ZLB and letting real interest rates vary in accordance with the dynamics of inflation. Considering this might also answer the "May or May not" questions Buiter (2009) attaches to the effectiveness of Q.Es and fiscal measures. Answers might diverge from previous theoretical and academic approaches to solving complex inter-temporal trade-offs, yet might be closer to Central Bank real practices, where monetary policy often mimics simple rules of thumb (Taylor, 2016). Gust et als (2015) simulations, may also be relevant here. They suggest that the optimal policy under discretion near the zero lower bound responds to signals about an increase in the equilibrium real interest rate by less than it would when far from the zero lower bound[13]. However, before coming to real rates we discuss the other two options available to monetary policymakers.

2.2 Revision of Monetary Policy Mandate (Inflation Target).

In addition to negative interest rates, there are also other proposals to tackle the ZLB constraint, which include revising monetary policy mandates. The inflation target in the developed economies stands at around 2% on average, whereas it is around 4% in the emerging economies. At present, inflation is undershooting those targets on average by around 1.5 percentage points (Haldane, 2015). An important implication of this is that lower inflation targets will have increased the probability of the ZLB constraint binding with lowering steady-state levels of nominal interest rates. Concomitantly, it comes with a proposal that the ZLB constraint can be loosened by simply revising the inflation targets upward, for instance from 2 to 4%. This magnitude has been discussed and found reasonable by Blanchard et al (2010) and later by Ball (2014). Similarly, while performing counterfactual policy simulation on the Japanese economy, Leigh (2009) suggested that a policy (price-targeting) rule that combined a more aggressive response to output with a higher inflation target (4%) would have achieved greater economic stabilisation.

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[12] Buiter (2009) considered all three options (1) abolishment of the currency (2) decoupling the numeraire from the currency/medium of exchange/means of payment and introducing an exchange rate between the numeraire and the currency, and (3) paying negative interest on currency by taxing currency.

[13] They also showed that the policy (Taylor-type) rules that respond aggressively to deviations of inflation and output from their target levels or consider a time-variations, perform similarly to optimal discretionary policy.

The theoretical and logical basis of revising the monetary policy mandate (inflation target) stems from the argument that the inflation target should be state-dependent and this dependency includes the ZLB constraint becoming binding. The rationale for this is consistent with the argument that as the equilibrium real interest rate shifts, so should the inflation target (Reifschneider and Williams; 2000). However, evidence suggests that change in the inflation target is not costless in terms of welfare and growth through various channels (See Palenzuela et al (2003) and Schmitt-Grohé and Uribe (2010). There is substantial evidence on the negative effects of inflation on growth, nevertheless, this evidence also suggests that these negative effects only become apparent as inflation overshoots prevailing targets[14]. As such, the idea of revision of the mandate and increasing inflation targets should be treated with scepticism. Rogoff (2017), for example, describes this as "second best", preferring a focus on negative interest rates. In addition to negative effects on growth, another aspect to be considered here, which Haldane (2015) also pointed out is the evidence of a nexus between inflation and growth during a period where inflation is falling from high to low levels. There could be a crucial difference between the dynamics of inflation expectations during periods when inflation is low and suddenly rising on the one hand, and high and steadily falling on the other. Accordingly, there is a risk of asymmetric and excessive responses in inflation expectations, as pointed out by a number of studies, for instance, Kobayashi (2013), Kurozumi (2014) and Ascari et al (2014).

There is less work done on the direction of revision of the inflation mandate. In an analysis on tweaking the inflation target with a ZLB constraint, Hloušek (2016) found that although lowering the inflation target does bring economic benefits, moving the inflation target from 2 to 4% did not bring additional benefits either in terms of taming inflation and output volatility or higher levels of output and consumption. Specific to the UK economy, what is clearly evident is that inflation expectations have been tightly anchored to the inflation target. The evidence suggests that expectations have been resilient during the recent recession, which then raises the question of what would be the cost in terms of credibility if inflation expectations should become unanchored? Here, there are also issues around credibility and preferences of household, if one chooses to revise the inflation mandate (Haldane, 2015)[15]. Azariadis et al, (2015) suggest that the monetary authority may credibly promise to increase the price level in the case of a ZLB constraint. Nevertheless, their empirical findings view optimal monetary policy as one which focuses on nominal GDP targeting. Overall, if we consider all of these contributions then we might infer that an increase in inflation without revision in the mandate may bring fruitful results through the dynamics of real rates.

2.3 Conventional Quantitate Easing

The third choice in the ZLB constraint could be to have Quantitate Easing as a permanently available instrument, used not only in times of crisis but normal times. This would render QE conventional rather than unconventional (Haldane, 2015). QE is a more tried and tested policy instrument than revising inflation targets or negative interest rates. There is substantial evidence on the significant impact of QE on the financial sector, notably a decrease in uncertainty and the risk premia faced by financial markets (See Gagnon et al., (2011) and Breedon et al., (2012). There is also considerable evidence on the impact of QE on inflation and growth[16]. In this regard, Baumeister and Benati (2012)

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[15] On the point revising inflation target, Haldane (2015) referred to Hayek (1979) metaphor of controlling inflation with holding a tiger by its tale, He argued that it would be a brave step to tweak this tiger's tail at the very point we appear to have it tamed. Perhaps, with these remarks, we expect that the aspect of such revision is out of question.

[16] In the frictionless financial markets and absence of arbitrage there shall be no effects on LSAP on financial sector or economy. The LSAP affects the real economy and financial sector through two channels a) Signalling channel and b) preferred habitat channel (Williams, 2014). The evidence on the US economy by Bauer and Rudebusch (2014) showed impact of both while on UK economy Christensen and Rudebusch (2012) did repot positive affect of mainly preferred habitat channel.

and later Weale and Wieladek (2015), found positive medium-term impact of QE on inflation and growth in the US and UK economies. Although, Meaning and Warren (2015) raise concerns regarding exit strategy,[17] this is a peripheral point, since the main issue with respect to the subject matter is whether QE can be an appropriate tool whenever monetary policy confronts the ZLB constraint.

The case against making QE a permanent monetary policy instrument has been challenged on three grounds. First, the effectiveness of QE is likely to be state-contingent and therefore it comes with more uncertainty when compared to an interest rate policy focus. This uncertainty is not just the result of the limited evidence on the effectiveness of QE, but also because of the nature of the transmission mechanism for QE (see Joyce et al; 2014). There are implications for QE and its transmission mechanism due to state-contingent frictions. The risk premia would be different in different periods making QE's impact unpredictable. Second, there could also be feedback effects transmitted through reflexive agent activity. This is a highly complex issue raised by George Soros and others, but is beyond the main scope of our current work (see Morgan, 2009, 2013). However, as Egea and Hierro (2019) establish, QE has tended to be more effective in its earliest implementations, (tested in the Eurozone and US) and has exhibited diminished impact thereafter. After a review of evidence on the impact of QE reported by a number of studies, Haldane (2015) reported a significant difference in its impact on inflation and GDP in the UK, USA and Japan, which was also time-variant[18]. Hence, the transition to QE as a conventional and institutionalised instrument remains difficult due to its state-contingent and time-varying impact with respect to interest rates. The third objection to making QE a permanent instrument for monetary policy concerns its implications for fiscal policy and public debt management. Large-scale purchases of public debt affect the yield on, as well as the stock of, debt issuance, if done on a permanent basis it will also have implications for any government budget constraint. On this aspect, Kirby and Meaning (2015) and Meaning and Warren (2015) also raised concerns about fiscal-monetary coordination in relation to the Asset Purchase Facility (APF) of the Bank of England and unwinding QE. The fiscal implications of QE are paramount, even when QE entails private sector asset purchases. For instance, due to the risk and liabilities associated with those assets, which will subsequently be paid out of the public purse in case of default. Haldane (2015) emphasises the need for QE to remain temporary and limited in order to prevent a blurring between fiscal and monetary policy boundaries. This insight invokes the "*Threat of Fiscal Dominance*" (BIS, 2012) and corresponding implications in terms of price stability (Woodford (2001) and Cochrane (2011) and of course the status of independence (and thus credibility) of the monetary authority, as well as its mandate and target[19]. QE also has implications for the exchange rate and international spillovers effects which then could have implications for global financial stability. As such, according to Haldane, a permanent QE is not "*An All Seasons*" solution.

It follows, then, that *QE in a situation of ZLB constraint is not the same as a permanent QE.* Given that the ZLB constraint is an extraordinary situation QE in this situation should not be considered conventional (invoking a new and permanent normal). In general Wang (2016) makes the point that unconventional monetary policy is highly dependent on the design and context of the financial structures (institutions etc) of a given country. Kucharcuvoka et al (2016) generalise further to note that unconventional monetary policy may have spillover consequences and contexts that must also be borne in mind. More particularly, in terms of QE, the existence of *time-varying impacts is not a unique feature of QE, but a property shared by its counterpart interest rate instrument*. The impact of LSAP may vary but the central tendency reported by Williams (2014) on the bases of 15 different

[17] Meaning and Warren (2015) pointed out that the Q.E unwinding can put pressure on the interest rates as well as it has implications for the fiscal policy, debt management and expectations on the interest rates hence requires careful consideration.

[18] The impact on GDP varied between 0.5% to 5% and on inflation between No Impact to 4.2% (See Haldane, 2015 for details).

[19] In the subject case, Bank of England has been given independence with an inflation of 2% of Consumer Price Index, since 1997.

studies on UK, USA and Japan document an impact around cuts of ¾ to 1% in the policy rate. On the complementary role of unconventional measures in supporting frequently used (conventional) ones, there is some evidence from the US economy where Wu and Xia (2016) while analysing the impact of unconventional monetary policy found that shadow Fed Fund rates[20] have been effective since 2009.

Wu and Xia's (2016) findings were also complemented by Skaperdas (2016), who finds that QE substituted for the requirement of negative nominal rates to the magnitude of -2% to -5%. Although, Hakkio and Kahn (2014) argued that the use of unconventional tools (forward guidance and asset purchases) was not sufficient to fully offset the constraint due to ZLB, the benefits of the former were prima facie. Bringing that debate into the British context where unlike Fed Funds rates the instrument setting i.e. Bank Rate is explicit, the real rate is logically a better proxy than shadow rates.

Overall, regarding the effectiveness of QE and other non-interest rates measures, one can argue that monetary policy has not reached a *true lower bound* unless the entire yield curve is negative. Nevertheless, the impact on long-term interest rates and corresponding implications for the fiscal policy and the multiplier could lead to a rather more benign assessment of unconventional measures (Coeure, 2015). Importantly, if the monetary authority intends to influence interest rates beyond the medium term, it needs unconventional measures, which then can include QE or forward guidance (Quantitative or/and Qualitative). The strategy of Asset Purchases can support growth even when there is a ZLB on nominal rates (See, Bernanke and Reinhart 2004; Bernanke et al, 2004; McCallum 2000; Svensson 2001). Nevertheless, the prospect of fiscal coordination supported by Keynes and Galbraith (Down, 2017 and Sheehan, 2018) becomes rather more significant at the ZLB (See Sims, (2014 & 2010) and Schmitt-Grohé and Uribe (2014) for a detailed discussion). Such a proposal may seem to be difficult to implement in the Euro area due to its institutional framework and its basis in monetary union without fiscal union (Coeure, (2015) and Hettig and Muller (2015). However, in the UK case, fiscal-monetary coordination may not face this hurdle. On a broader context (not specific to ZLB), recent empirical evidence also provides strong support for the notion of fiscal coordination (see, for instance, Leeper (1993), page 3) argued that the "*Analysing one policy is like dancing a tango solo: it's a lot easier, but it is incomplete and ultimately unfulfilling*". Capitalising on Keynes's philosophy (though not always acknowledging it), a number of contemporary scholars emphasize the importance of fiscal coordination (for instance, see Dixit and Lambertini 2001, 2003; Leith and Lewis, 2006; Dungey and Fry, 2009; Fragetta and Kirsanova, 2010; Porqueras and Alva, 2010; Davig and Leeper, 2011; Andrew et al. 2011, Traum and Yang, 2011; Chortareas and Mavrodimitrakis 2016, Nasir et al 2017 and Chortareas and Mavrodimitrakis 2017). Specific to sluggish growth and "*Secular Stagnation*" Summers (2014) refers to the Japanese experience and argues that the preferred strategy is to raise the level of aggregate demand, whilst adopting fiscal policies to stimulate investment. Similar thoughts were expressed by DeLong (2017), who suggests that *"We should adopt appropriate fiscal policies that provide for expansionary investment*". Lewis and Seidman (2008) make complementary points regarding ZLB and counter-cyclical fiscal policy.

As it stands, looking at the Bank of England's decisions Post-Brexit, (which include an upward revision of the inflation forecast in the context of modest growth after Brexit, Bank of England; 2018), recent outbreak of coronavirus (COVID-19) and its impact on economy, and arguments put forward by the Governor of the Bank of England (Carney, 2016), there is no clear indication that the nominal interest rate will go negative. In this policy environment, a "*Lower for Longer*" strategy could be complemented by unconventional monetary measures[21] and/or enhanced fiscal coordination. Such a strategy unquestionably has important implications for real rates. Accordingly, the question we

[20] The "shadow rate is extracted from the whole yield curve" (See Wu and Xia, 2016).

[21] Unconventional measures could include keeping the existing stock of LSAP at the current levels and issuing any further Quantitate forward guidance to influence the issues of expectation formation as raised by Reifschneider and Roberts (2006) and Williams (2006) and lately by Swanson and Williams (2013) for UK and Germany.

are seeking to answer is whether keeping the nominal interest close to the zero-bound and letting real rates vary whilst managing the tolerance level to inflation (which could be done either by QE, the inflation mandate or fiscal measures) could be a constructive approach to policy. We now move on to provide a model that explores this.

3. Methodology

We employ a Time-Varying Structural Vector Autoregressive (TVSVAR), drawn on foundations laid by Primiceri (2005)[22]. In our model, a TVSVAR framework is employed in which both the coefficients and the entire variance-covariance matrix of the shocks are time-variant. The rationale of for this is that we aim to distinguish changes in the transmission mechanism of real policy rates from changes in the typical size of exogenous innovations (Primiceri, 2005). On the time variation in linear structures, there is a strand of literature which focuses on including discrete breaks with the intention to capture a limited number of switching regimes (e.g. seminal work by Sims (1999) and Sims and Zha, (2006). However, a single break model is not very suitable when accounting for the shift in the behaviour of market participant's response to a monetary policy stance. This is particularly so in a scenario where most of the changes are smoothed out by aggregation among agents (Primiceri, 2005). As such, and If we also acknowledge the existence of possible learning dynamics by market participants and real rate policy shocks, it seems appropriate to select a model with smooth and continuous drifting coefficients and heteroscedasticity innovations over a model with discrete breaks. However, in order to gain inclusive insight, in addition to considering the period as a whole, we will also apply our TVSVAR framework with discrete breaks. In doing so, we focus on the Post-GFC period, when policy rates were lowered to ZLB.

3.2 The Policy Model

The employed model possesses the novelty of both a time-varying variance-covariance matrix of the additive innovations as well as time-varying coefficients. The possible nonlinearities or time-variation in the lag structure of the model are accounted for by the drifting coefficients of association among variables. Nonetheless, the possible heteroscedasticity of the shocks and nonlinearities in the simultaneous relations among under analysis variables of interest is captured by the multivariate stochastic volatility. Considering the fact that in our modelling framework, the time variation is allowed both in the coefficients and the variance-covariance matrix, it is left to the data to determine whether the time variation of the linear structure derives from changes in the size of the shocks or they are due to the changes in the propagation/transmission mechanism. As argued by Primiceri (2005), the employed TVSVAR framework accounts for various types of shocks. This is an additional feature to the notion of incorporating a discrete break, which the applied approach to policy modelling is making an allowance for. Consider the following model as an initial specification:

$$GDP_t = \alpha_{10} + \sum_{i=1}^{n} \beta_1 GDP_{,t-i} + \sum_{i=1}^{n} \gamma_1 UNP_{t-i} + \sum_{i=1}^{n} \lambda_1 INF_{,t-i} + \sum_{i=1}^{n} \theta_1 RR_{t-i} + \varepsilon_{1i,t} \quad (1)$$

$$UNP_t = \alpha_{20} + \sum_{i=1}^{n} \beta_2 GDP_{t-i} + \sum_{i=1}^{n} \gamma_2 UNP_{t-i} + \sum_{i=1}^{n} \lambda_2 INF_{t-i} + \sum_{i=1}^{n} \theta_2 RRs_{t-i} + \varepsilon_{2i,t} \quad (2)$$

[22] See Primiceri (2005) for details.

$$INF_t = \alpha_{30} + \sum_{i=1}^{n} \beta_3 GDP_{t-i} + \sum_{i=1}^{n} \gamma_3 UNP_{t-i} + \sum_{i=1}^{n} \lambda_3 INF_{t-i} + \sum_{i=1}^{n} \theta_3 RR_{t-i} + \varepsilon_{3i,t} \quad (3)$$

$$RR_t = \alpha_{40} + \sum_{i=1}^{n} \beta_4 GDP_{t-i} + \sum_{i=1}^{n} \gamma_4 UNP_{t-i} + \sum_{i=1}^{n} \lambda_4 INF_{t-i} + \sum_{i=1}^{n} \theta_4 RR_{t-i} + \varepsilon_{4i,t} \quad (4)$$

Where the GDP, $INF(Inflation)_t$, $UNP(unemployment)_t$ and $RR(RealRates)_t$ are (n x 1) observed endogenous variables, a_{10}, a_{20}, a_{30} and a_{40} are (n x1) vector of time varying coefficients that multiply constant terms; ß$_i$, γ_i, λ_i and θi are the (n x n) matrixes of time varying coefficients, and ε_i are the heteroscedastic unobservable shocks with variance covariance matrix Ω_t. At this juncture, if we consider the triangular reduction of covariance matrix Ω_t, without the loss of generality, it can be defined as

$$A_t \Omega_t A_t' = \sum_t \sum_{t,}' \quad (5)$$

Where A_t is the lower triangular matrix,

$$A_t = \begin{bmatrix} 1 & 0 & \dots & \dots & 0 \\ a_{10} & 1 & \ddots & \ddots & \vdots \\ \vdots & \ddots & 1 & \ddots & \vdots \\ \vdots & \ddots & \ddots & 1 & 0 \\ a_{n1,t} & \dots & \dots & a_{nn-1,t} & 1 \end{bmatrix}$$

And $\sum_t$ is the diagonal matrix

$$\sum_t = \begin{bmatrix} \sigma_{1,t} & 0 & \dots & \dots & 0 \\ 0 & \sigma_{2,t} & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & 0 \\ 0 & \dots & \dots & 0 & \sigma_{n,t} \end{bmatrix}$$

Thus, it follows that the equation 1 to 4 can be modified to

$$GDP_t = \alpha_{10} + \sum_{i=1}^{n} \beta_1 GDP_{,t-i} + \sum_{i=1}^{n} \gamma_1 UNP_{t-i} + \sum_{i=1}^{n} \lambda_1 INF_{,t-i} + \sum_{i=1}^{n} \theta_1 RR_{t-i} + A_t^{-1} \sum_t \varepsilon_t \quad (6)$$

$$UNP_t = \alpha_{20} + \sum_{i=1}^{n} \beta_2 GDP_{t-i} + \sum_{i=1}^{n} \gamma_2 UNP_{t-i} + \sum_{i=1}^{n} \lambda_2 INF_{t-i} + \sum_{i=1}^{n} \theta_2 RRs_{t-i} + A_t^{-1} \sum_t \varepsilon_t \quad (7)$$

$$INF_t = \alpha_{30} + \sum_{i=1}^{n} \beta_3 GDP_{t-i} + \sum_{i=1}^{n} \gamma_3 UNP_{t-i} + \sum_{i=1}^{n} \lambda_3 INF_{t-i} + \sum_{i=1}^{n} \theta_3 RR_{t-i} + A_t^{-1} \sum_t \varepsilon_t \quad (8)$$

$$RR_t = \alpha_{40} + \sum_{i=1}^{n} \beta_4 GDP_{t-i} + \sum_{i=1}^{n} \gamma_4 UNP_{t-i} + \sum_{i=1}^{n} \lambda_4 INF_{t-i} + \sum_{i=1}^{n} \theta_4 RR_{t-i} + A_t^{-1} \sum_t \varepsilon_t \quad (9)$$

$$V(\varepsilon_t) = I_n.$$

Stacking in a vector say ß$_t$ all the ß$_{1\ to\ 4}$ coefficients (same holds for γ_i, λ_i & θi) in the equations (6-9) can be rewritten as:

$$y_t = X_t' B_t + A_t^{-1} \sum_t \varepsilon_t , \quad (10)$$

Whereas in each case, y_t is the n x1 vector of observed endogenous variables, we can rewrite equation 10 as follows

$$X_t' = I_n \otimes [1, y_{t-1}', \dots, y_{t-k}'] \qquad (11)$$

Whereas the symbol $\otimes$ denotes the Kronecker product. It is a fairly common practise to decompose the variance-covariance matrix as the one occasioned in the equation (10), particularly when one is keen on the efficient estimation of covariance matrices (Smith and Kohn (2002) or/and Primiceri, 2005). Nevertheless, on the aspect of Time-Varying VAR models, decomposition of a similar kind has been carried out in other studies, for instance, Cogley (2003) and Cogley and Sargent (2003), though they employ a time-invariant A_t matrix. However, as we emphasized earlier, for a time-varying structural VAR framework, it is vital to allow the matrix A_t to vary over time. Otherwise, if we keep the A_t constant, the innovation to the $i-th$ variable would have a time-invariant effect on the $j-th$ variable. This is definitely inappropriate, particularly when we are aiming to model the time variation in a framework in which simultaneous interactions among the under analysis variables are fundamental[23]. At this juncture, if we let the σ_t be the vector of the diagonal elements of the matrix $\sum_t$ and a_t be the vector of non-zero and non-one elements of the matrix A_t. We can specify the dynamics of our model's time-varying parameter as follows:

$$B_t = B_{t-1} + v_t, \qquad (12)$$

$$a_t = a_{t-1} + \zeta_t, \qquad (13)$$

$$log\sigma_t = log\sigma_{t-1} + \eta_t, \qquad (14)$$

Where the elements of the vector B_t are modeled as random walks, as well as the free elements of the matrix A_t[24]. Due to a general perception that the random walk may hit any upper or lower bound with probability one, the consideration of a random walk process here might be considered infeasible. However, this is an innocuous assumption as long as the equations (12 – 14) are placed for a finite period of time. Nevertheless, as Primiceri (2005) argued the random walk assumption comes with the advantage of reduced number of parameter and focusing on permanent shifts. With the following assumptions on the variance-covariance matrix, all the innovations in the model are assumed to be jointly normally distributed:

$$V = Var = \left(\begin{bmatrix} \varepsilon_t \\ v_t \\ \zeta_t \\ \eta_t \end{bmatrix} \right) = \begin{bmatrix} I_n & 0 & 0 & 0 \\ 0 & Q & 0 & 0 \\ 0 & 0 & S & 0 \\ 0 & 0 & 0 & W \end{bmatrix} \qquad 15$$

Where I_n is a n x n-dimensional identity matrix Q, S and W are positive definite matrices[25]. In each equation the coefficients of the contemporaneous relations among variables are assumed to evolve independently, this is not a vital assumption to make, however, it leads to an increase in the efficiency of estimation algorithm as well as simplifies the inference.

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[23] The modelling strategy entails modelling the coefficient process in equation (10) and one-to-one mapping from 1 to 9 provides justification this approach.

[24] Classified as stochastic volatility, the σ_t (standard deviations) are assumed to be evolved as geometric random walks (Shepherd (1996) and Primiceri, 2005).

[25] Note: As all the zero blocks could be substituted by non-zero blocks, with only small modifications of the estimation procedure, none of restrictions on the structure of V are essential. Furthermore, choice of V as described in the equation (13) is also appropriate as a) adding all the off diagonal elements of V would require the specification of a sensible prior which can prevent cases of ill-determined parameters b) any structural interpretation of the innovations would be precluded by allowing for a completely generic correlation structure among different sources of uncertainty.

3.3 Bayesian Estimation

The Bayesian approach is employed for the estimation of our model and evaluation of posterior distribution of the parameters of interest, specifically, B^T A^T Σ^T and the hyperparameters of the variance covariance matix V. The choice of a Bayesian approach is also appropriate in a situation where the demarcation between shocks and parameters is not very obvious and we have to deal with unobservable components. Furthermore, the Bayesian approach is preferable over classical estimation in a model such as the one we have chosen since in case of too small variance of (time-varying) coefficients, the classical maximum likelihood estimator may lead to a point mass at zero i.e. pile-up problem[26]. Nonetheless, in terms of practicality, the Bayesian approach is very efficient in dealing with nonlinearities, as well as the high dimension of the parameter space. For the posterior numerical evaluation of the parameters of interest, we are employing Gibbs Sampling which is a variant of the Markov Chain Monte Carlo (MCMC) method. Instead of drawing from the high dimensional joint posterior of the whole parameter set, this entails drawing from lower dimensional conditional posteriors. The MCMC yields smoothed estimates of parameters which are based on the complete dataset. In this regard, Primiceri (2005) emphasised that the smoothed estimates are more efficient and preferable for the investigation of the true evolution of the unobservable states over time[27].

3.4 Selection of Priors

To begin with, it is intuitive to assume that the initial states of the coefficients, covariances, log volatilities and the hyperparameters are independent of each other. The priors for the hyperparameters,Q, W and the blocks of S, are assumed to be distributed as independent inverse-Wishart. It is also assumed that the priors for the log standard errors $p(B_0)$, $p(a_0)$, and $p(log_{\sigma 0})$, simultaneous relations and initial states of the time varying coefficients are normally distributed. Together with equations (10) to (12), these assumptions imply normal priors on the entire sequences of the B's, α's and log σ's (conditional on Q, W and S). The choice of normal priors is a standard practice, due to their tractability and the feature of not being too conjugate (See, Smith and Kohn 2002; Sims and Zha 1998; and/or Primiceri, 2005). As we discussed earlier, in order to generate a sample from the joint posterior of B^T A^T Σ^T and V, we used a MCMC algorithm. Specifically, to exploit the blocking structure of the unknowns the Gibbs sampling is employed which entails four steps: i) drawing in turn, time varying coefficients B^T, ii) simultaneous relations A^T, iii) volatilities Σ^T and iv) hyperparameters$V$, conditional on the observed data and the rest of the parameters[28]. This empirical framework is applied on the dataset, details of which follow.

3.5 Dataset

The dataset includes the series on real rates, Real GDP growth, unemployment rate and inflation rates in the United Kingdom. We have chosen the date of analysis from January 1989 till September 2016. This provides the longest data set available on measures of inflation and also includes the volatile periods of the early 1990s (Exchange Rate Mechanism), the Great Moderation and GFC (2008). Hence, it includes periods of both financial-economic tranquillity and oscillations, which consequently make the analysis more informative (see Williams (2014) for an interesting discussion on encompassing periods of crises). The model is first employed on the whole dataset from January 1989 to September 2016. Thereafter, a discrete break is included in the analysis for the ZLB period. The series is subsampled to expedite this. This is in accordance with practice established by Tsai (2015) and Reboredo and Ugolini (2016). The Pre-ZLB and Pre-GFC period is chosen from 1989 to August 2008, while for the discrete break we choose the period November 2008 to September 2016. Limiting the Pre-ZLB period to August 2008 excludes the immediate effects of the GFC. Although

[26] See e.g. Shepherd and Harvey (1990) and Stock and Watson (1998).
[27] Considering the whole sample and then discrete break will give us further insight.
[28] Please see Primiceri (2005), for details on structural interpretation and identification.

the date of onset of the GFC is debatable (see Reboredo and Ugolini 2016), we choose the Pre-ZLB period before the collapse of Lehman Brothers and the financial upheaval of September-October 2008. The details on each variable and proxy are as follows:

Real (Policy) Rates: Inflation-adjusted monthly observations of the Bank of England (BoE)'s base rate (commonly called the Bank Rate) are obtained from the BoE. The Bank rates are the official policy rates set by the BoE's Monetary Policy Committee.
Inflation Rates: Monthly estimates of the Consumer Price Index (CPI), the choice is based on the fact that the 2% CPI is the official target of the Bank of England, the data series obtained from the BoE's database BankStats.
Unemployment Rate: The unemployment rate is based on estimates from the Labour Force Survey (LFS) as a proportion of the workforce. The data series is obtained from the Office for National Statistics. The data used is the quarterly observations on the rate of unemployment. However, we convert this into monthly by linear interpolation and from end to end of quarters. Doing so gives insight into the development of the labour market during each quarter.

Real GDP Growth Rates: The quarterly data on real GDP growth rate, quarter on quarter % change, Chained Volume Measured CVM and seasonally adjusted was used. The observations were obtained from the Office for National Statistics and converted into monthly by linear interpolation.

4. Analysis & Findings

To gain some insight into the statistical properties of the data series, we conducted two tests prior to the application of our TVSVAR framework. First, we performed a Unit-root test, using the Augmented Dickey-Fuller (ADF) with a structural break. Although Sims (1989) and Fanchon and Wendel (1992) have argued that the Bayesian approach is not dependent on the requirement of stationarity and hence testing for unit-roots may not be required, we chose to do so to gain a deeper insight into the features of our dataset. The employed ADF test incorporates structural breaks in the data series, providing a permeable over simple ADF test[29]. Beside empirical grounds, on theoretical and logical grounds, a very important aspect we must elaborate here is that the under analysis series of data on economic growth, unemployment, inflation and real rates exhibit a structural change from their usual trend due to a number of reason which we can categorise into business and financial cycles. Instead of giving the exogenous date of the break, we let the data speak and determine the date of the break endogenously. We employed the ADF test in the presence of a break with both *Additive Outliers* and *Innovative Outliers*. The results are presented in the Table-1 as follows:

Table 1: ADF Unit-Root Test With Structural Break (Additive & Innovative Outliers)

	Variable	*ADF Test Statistic*	*Critical Value at 1% level*	*Critical Value at 5% level*	*Probability*
Level	GDP	-5.451	-4.949	-4.443	< 0.01*
	Unemployment	-3.555	-4.949	-4.443	0.356
	Inflation	-5.018	-4.949	-4.443	< 0.01*
	Real Rates	-3.879	-4.949	-4.443	0.201
1st Difference	GDP	-7.988	-4.949	-4.443	< 0.01*
	Unemployment	-4.496	-4.949	-4.443	0.043**
	Inflation	-17.265	-4.949	-4.443	<0.01*
	Real Rates	-15.517	-4.949	-4.443	0.001*

** 5% level of significance, *1% level of significance using Vogelsang (1993) asymptotic one-sided p-values.

[29] The critique by Perron (1989) led to successful efforts in development of various unit root tests which accounted for the structural break (Hansen, (2001) and Perron (2006).

The results show that all the series except inflation and GDP had a unit root at the level of the ADF test statistic, with the structural break lower than the critical value at the 5% level[30]. However, the data series was found to be stationary at the 1st difference and thus we integrated of order *I* (1) implying that there wasn't much of an explosive behaviour to cause concern. After testing for the unit-root, an optimal lag selection test was performed. For this purpose, we used a number of information criteria (Akaike Information Criterion, Hannan-Quinn Information Criterion and Schwarz Information Criterion) and each criterion suggested two as an optimal number of lags[31].

4.2 Time Varying Structural Vector Auto-Regression (TVSVAR) Model

In terms of ordering of the variables the real rates are ordered last. This is due to the identification assumption that implies that monetary policy shocks affect with lags as well as due to the exogenous nature of real rate shocks. The simultaneous interaction between real GDP, unemployment and inflation is arbitrarily modelled in a lower triangular form with real GDP growth rate first. This is not an identification condition but for the sake of normalisation, although arbitrary normalisation may have the potential to make a difference. However, in this setting the ordering of the GDP growth block did not affect the results. A total of 10000 iterations of Gibbs Sampling with a burn rate of 20% i.e. (2000 iterations) was chosen. For the training sample, we choose 36 initial observations i.e. 3 years period. To start with, it is important to look at the time varying standard deviation of the real rates shocks. Figure 1(c) presents the plot of the posterior mean and the 16th and 84th percentiles of the time-varying standard deviation of the monetary policy shocks. The percentiles correspond to the bound of a one standard deviation confidence interval.

The Figure 1 (A to D) presented below, gives some interesting insight into the behaviour of the under-analysis series. The periods of the early 1990s and then 2008 showed higher variance due to the macro-financial events i.e. Black Wednesday and the Global Financial Crises respectively. The Post-GFC period also shows a rather smooth period for interest rates and unemployment, which is an era of low-interest rates and inflation. However, GDP growth showed consistent oscillation.

[30] Schwarz information criterion (SIC) is used to determine the number of lags. This is due to the reason that the SIC performs best in the presence of structural breaks (See Asghar and Abid (2007).

[31] The results are not presented here to conserve the space, however are available on request.

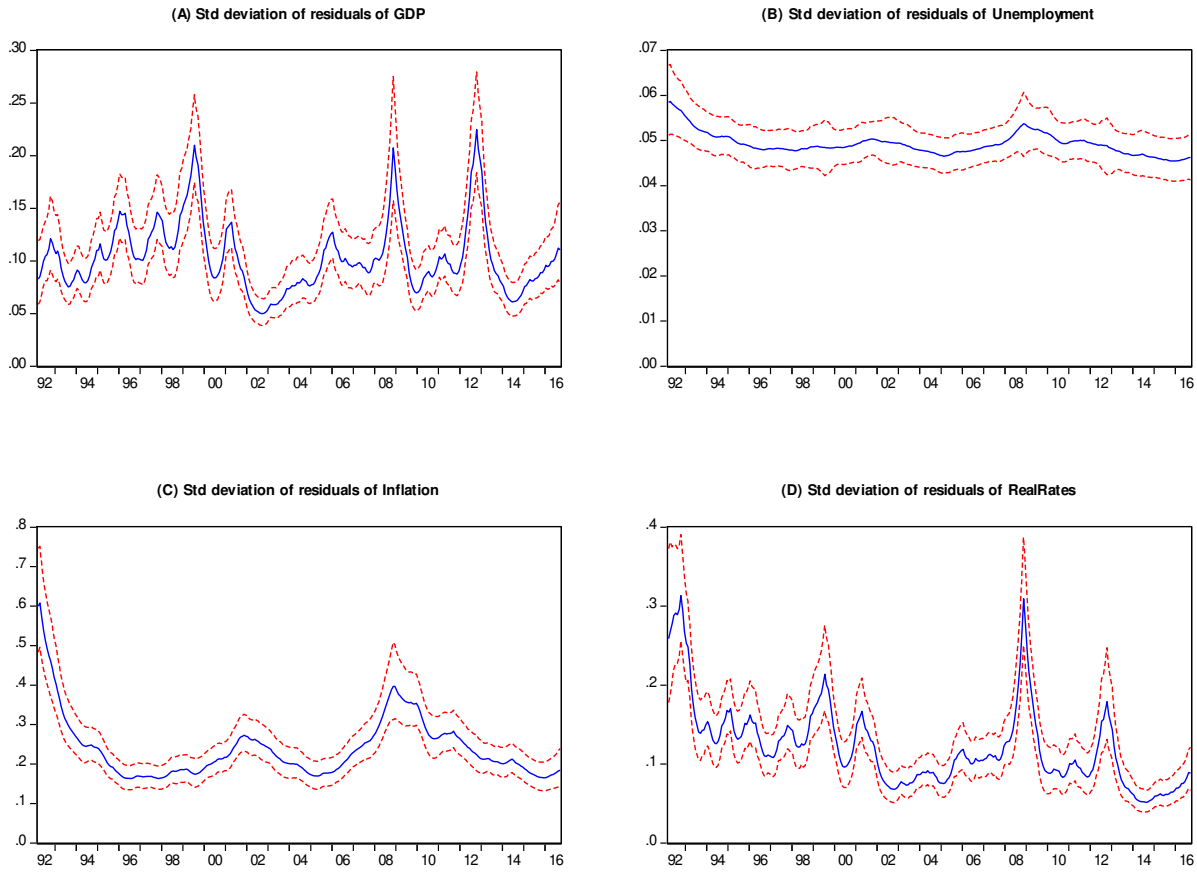

Figure 1: Posterior mean, 16th and 84th percentiles of the standard deviation of (A) residual of the GDP (B) residual of the Unemployment Rate (C) residuals of the Inflation equation and (D) residuals of the equation for Real Rates equation or policy shocks

The dynamics of the real rate shocks are summarised in Figure 2. It presents the impulse responses of the GDP, unemployment and inflation to real rates shock in four different dates of the under analysis sample. The following figures 3-5 represents the pairwise difference between the impulse responses at different dates with the 16th and 84th percentiles. The dates chosen for the comparison are August 2008, April 2009, May 2016 and August 2016. The choice of dates is due to the corresponding macro-financial events and environment of prevailing periods. August 2008 is just before the collapse of Lehman Brothers and the associated turmoil in the global financial markets and economies. The April 2009 date is the point of time when interest rates were reduced to the then all-time low level of 0.5%. The choice of May 2016 and August 2016 is based on the reason that these are the most recent periods and epoch when the UK voted to leave the European Union in the "Brexit" Referendum. The results show positive shocks to real rates leading to a fall in real GDP growth.

An important point we would like to emphasise here is that a recent study by Lee and Werner (2018) did find a positive relationship between the interest rate and GDP (in the US, UK, Germany and Japan), which led them to argue that "*the conventional monetary policy as operated by the central banks for the past half-century is fundamentally flawed* (p. 26)". However, our analysis using real rates suggests that in fact, that is not the case if you consider real rather nominal rates. Interestingly, there was heterogeneity in the response of GDP growth, which was persistently negative in the later periods, implying negative consequences for high real rates in the Post-GFC and Brexit periods. Similar shocks led to a fall in the unemployment rate in all the periods, which persisted into medium term. We did not find initial heterogeneity in the intensity of response in any period, although, there was a difference in the persistence of response, as unemployment recovered rather more quickly in the

later periods i.e. May and August 2016. On the other hand, the inflation responded positively to a similar shock. In the later periods, the response of inflation was rather more pronounced, which can be associated with the increase in inflation due to increase in real rates in a period which is different from the 2008-09, which was dominated by the Global Financial Crisis. One might interpret this finding through the lens of the prize puzzle or Fisher effect[32] (See Williamson, 2016 for a very insightful discussion on Fisher effect in US and low inflation policy trap)[33], though the situation is not quite that, since we are using real rather than nominal policy rates. Most notably, our findings indicate an important silver lining in context of policy setting. Put simply, it implies that low real interest rates do not harbour high inflation and so concern with future high inflation may be overstated.

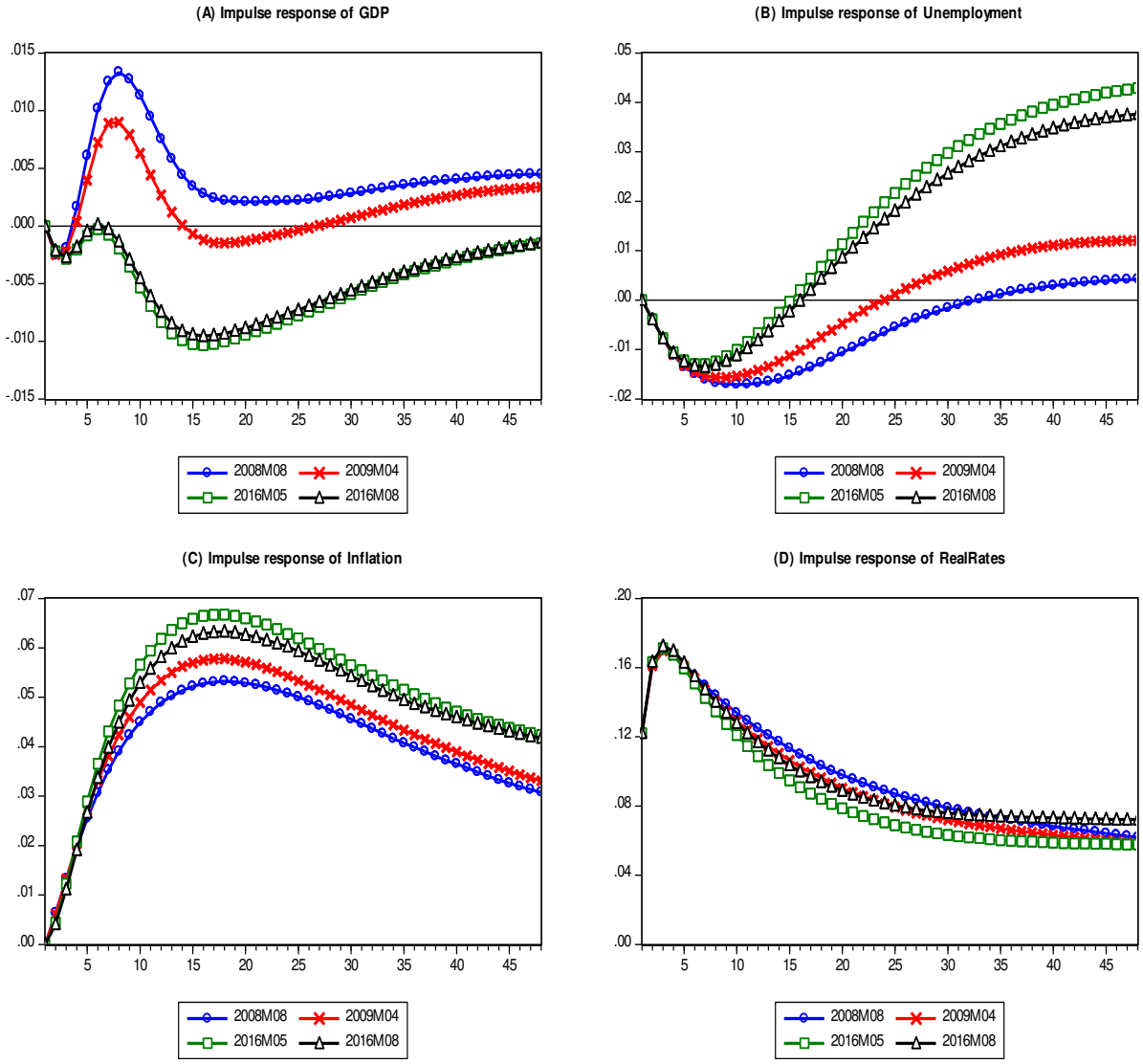

Figure 2: Real Rates shocks in August 2008, April 2009, May 2016 & August 2016

[32] According to Fisher Effect (named after Irving Fisher) the increase inflation by increase the nominal interest rates (Williamson, 2016).

[33] One can also refer to Cochrane (2016), Rupert and Sustek (2016), and Williamson (2018) for evidence of Fisher effect which then may ignite a debate on the contemporary monetary policy wisdom and central bank practice and response to inflation. However, that debate is beyond the scope of this study.

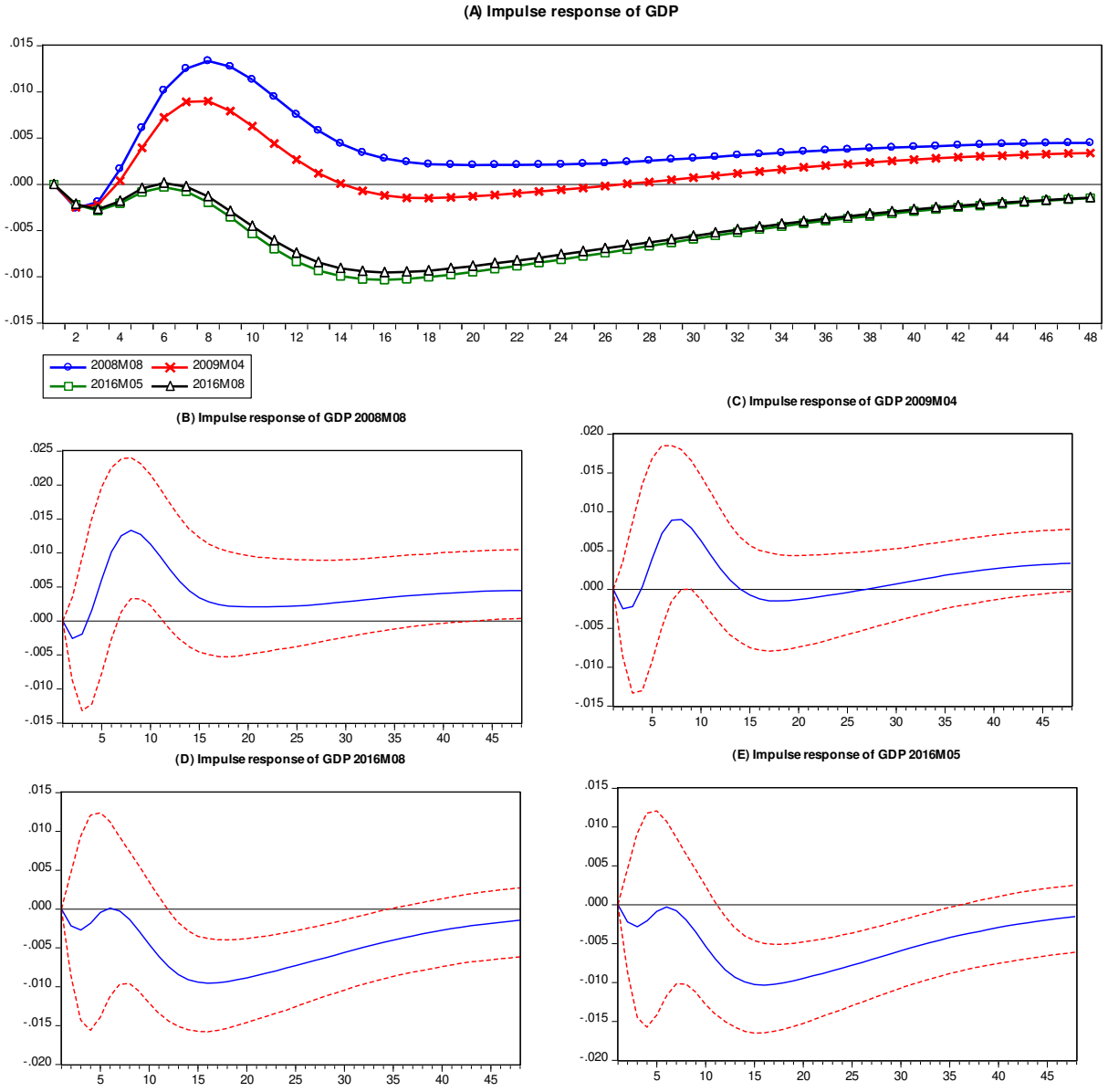

Figure 3: (A) Impulse responses of the GDP rate to real rate shock Aug 2008, April 2009, May 2016 & August 2016, (B-E) difference between the responses in corresponding periods with 16th and 84th percentiles.

Figure 3 also depicts the pairwise differences between the impulses in different dates with 16th and 84th percentiles. As is obvious in the representation, the responses show significant variation, implying that the increase in real rates in the later periods have rather more pronounced negative effects on GDP as we have already witnessed in Figure 2. This finding has significant implications in terms of policy setting targeting the real rates seem to be an effective instrument for influencing nominal income.

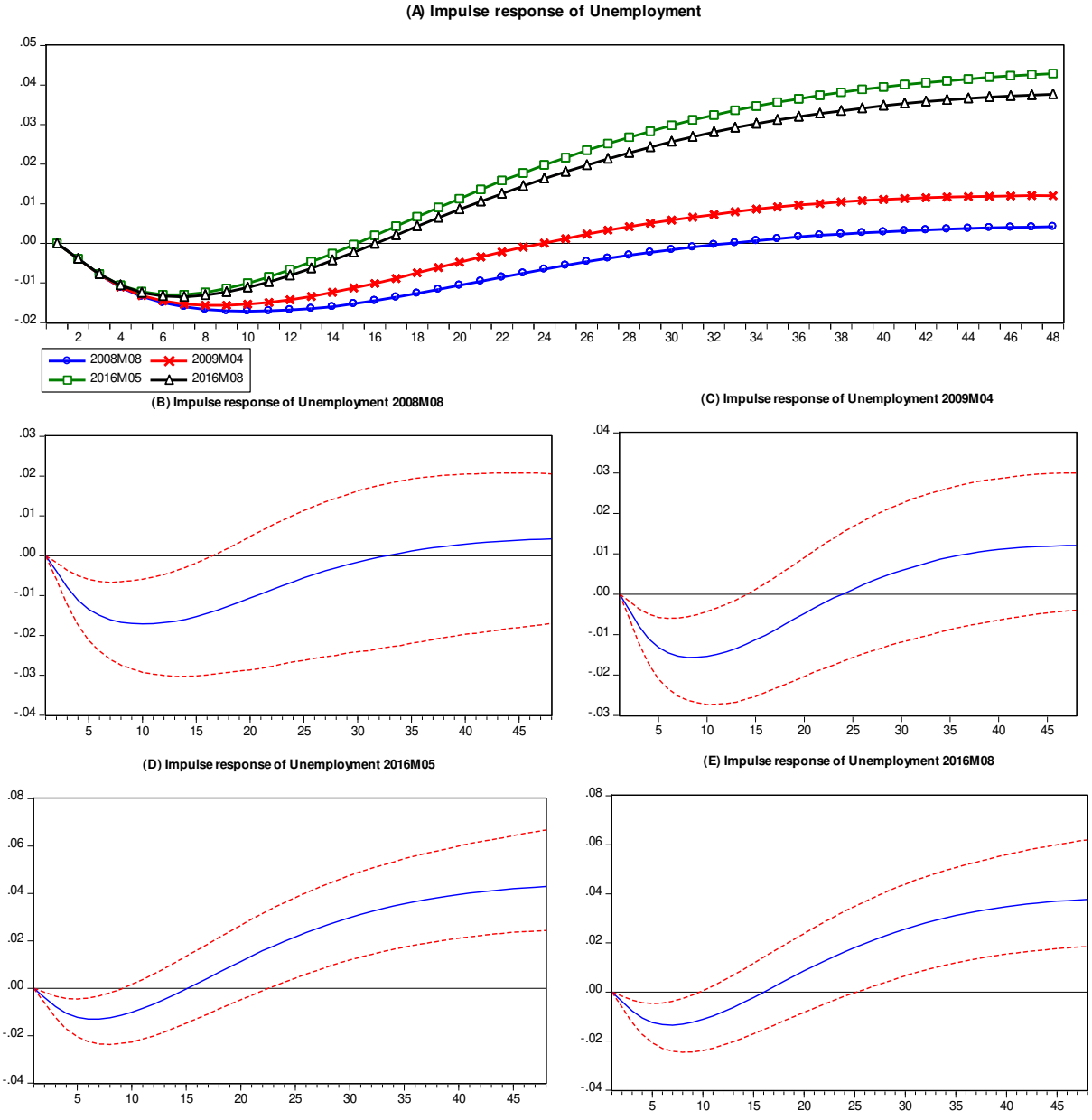

Figure 4: (A) Impulse responses of the unemployment rate to real rate shock Aug 2008, April 2009, May 2016 & August 2016 (B - E) difference between the responses in corresponding periods with 16th and 84th percentiles.

The pairwise differences between the impulses of the unemployment rate on different dates with 16th and 84th percentiles are presented in Figure 4. The responses exhibit a subtle variation implying the short-term robustness of the relationship between real rates and unemployment through time, as we have already witnessed in Figure 2. The findings on the initial response are in line with the Primiceri (2005) analysis of unemployment in the US economy. However, a close comparison suggests that in the later periods (May & Aug 2016) which correspond to the ZLB, unemployment recovered rather more quickly and became significantly positive in the medium term. In policy setting, this has important implications. It implies that the dynamics of real rates are vital for the labour market, even when in the nominal sense monetary policy is constrained at the ZLB.

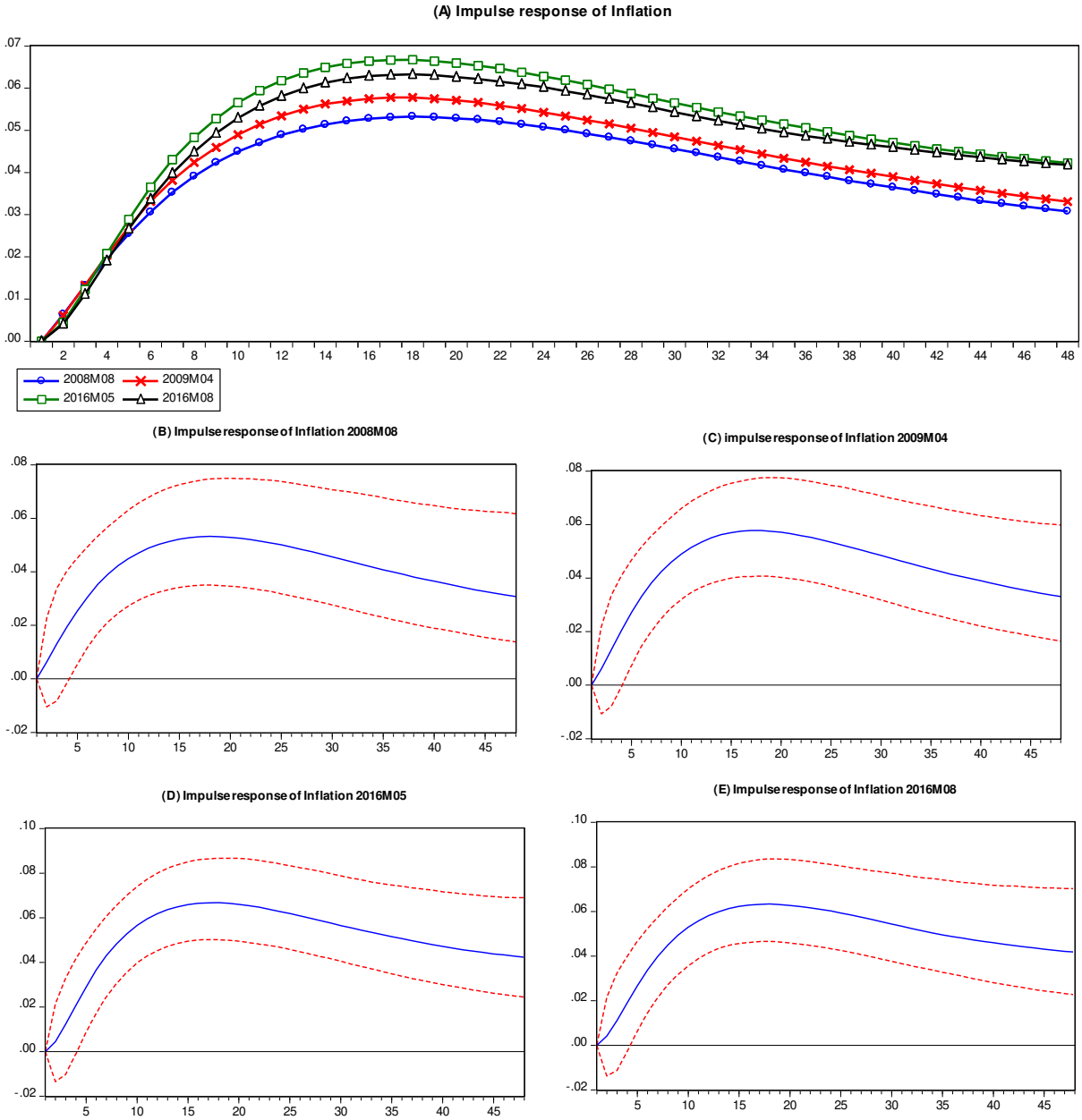

Figure 5: (A) Impulse responses of the Inflation to real rate shock Aug 2008, April 2009, May 2016 & August 2016, (B - E) difference between the responses in corresponding periods with 16th and 84th percentiles.

Figure 5 also depicts the pairwise defences between impulses in different dates with 16th and 84th percentiles. The responses did not show a great amount of variation implying the robustness of the relationship between real rates and inflation as we have already witnessed in Figure 2. However, with regard to policy, it shows that real rates are a vital instrument for price stability. Overall, it appears that positive shocks to real rates while nominal monetary policy is constrained at the ZLB can decrease real growth, increase unemployment and inflation in the medium term. This provides a rationale to exploit the relationship between real rates, growth, unemployment and inflation, through unconventional monetary and fiscal measures.

4.3 Discreet Break & ZLB

So far, we have considered the period spanning over 27 years and included the era of the Great Moderation as well as the Great Financial Crisis. At this point, we opt to apply a discrete break in the data series. This follows Sims (1999) and Sims and Zha (2006), who use discrete breaks to capture a limited number of switching regimes. In addition to Primiceri's (2005) position, which favours smooth and continuous drifting coefficients and heteroscedasticity innovations, we introduce an innovation in the form of discrete breaks in the analysis. This includes the Post-Global Financial Period, which is associated with the low inflation, low growth and low-interest rates. This provides further insight, as the training sample will also be drawn on the Post-GFC period. Our point of departure is the aftermath of the GFC, and this addresses matters of instrument choice and provides robustness to our results.

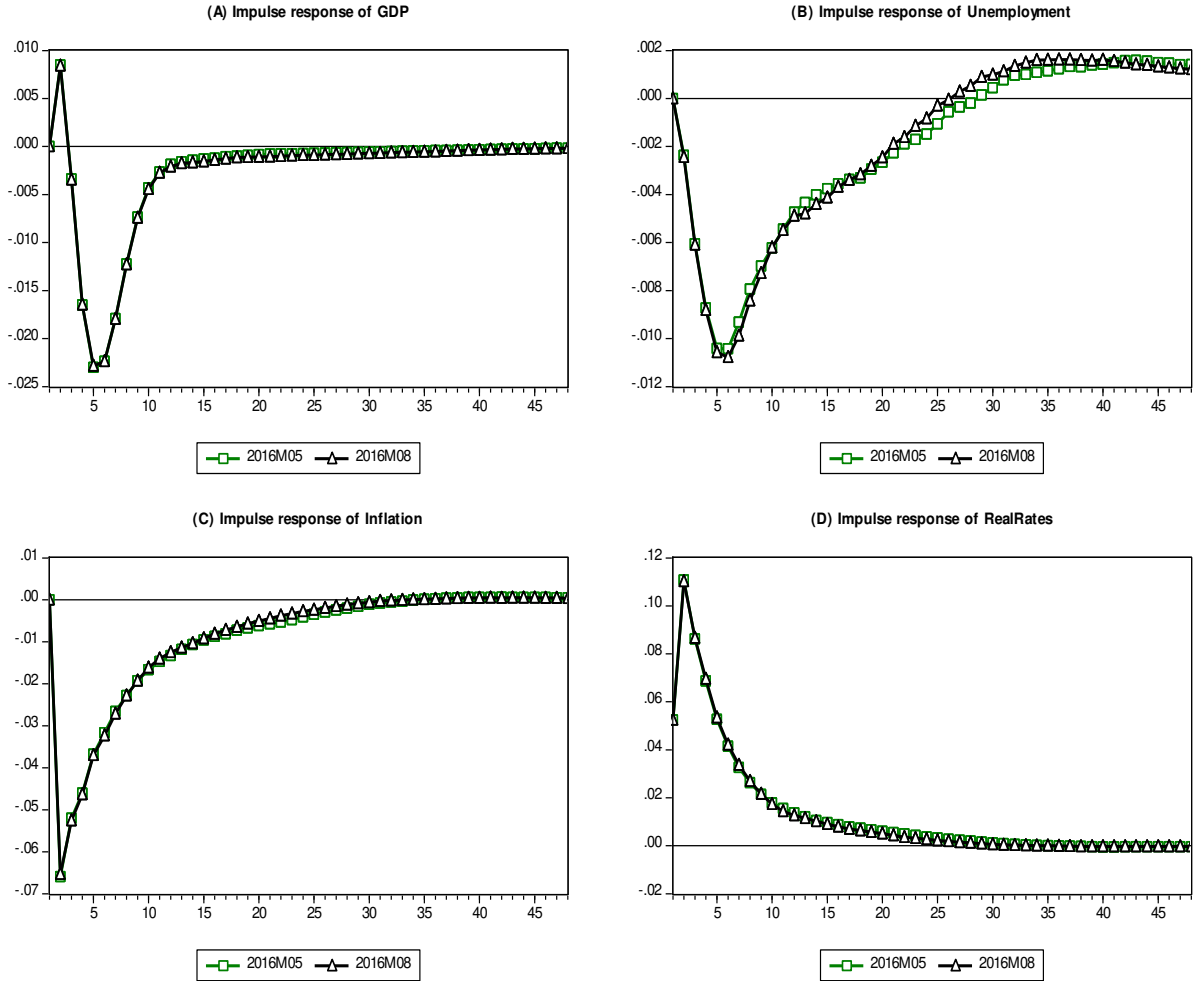

Figure 6: Real Rates shocks in May & August 2016

We opt for 10000 iterations of Gibbs sampling with a burn rate of 20% i.e. (2000 iterations). The 24 observations (2 years period) were chosen for training sample. Before discussing results, we acknowledge the limitations of a comparatively small sample size in the Post-GFC as well as loss of information due to including the periods of crisis and a break after the crisis. However, we still choose to perform this exercise to witness the consequences and see both "worlds". The results presented in Figure 6 based on the data from November 2008 to September 2016 show a slight shift in the response of real GDP growth, the unemployment rate and inflation rate to real rates shock. This shows that after an initial surge GDP dropped and did not recover in the medium term. Similarly, the unemployment rate fell but then increased in the medium term in response to the real rate hikes. By contrast, inflation showed a sharp and consistent drop in response to the real rates shocks.

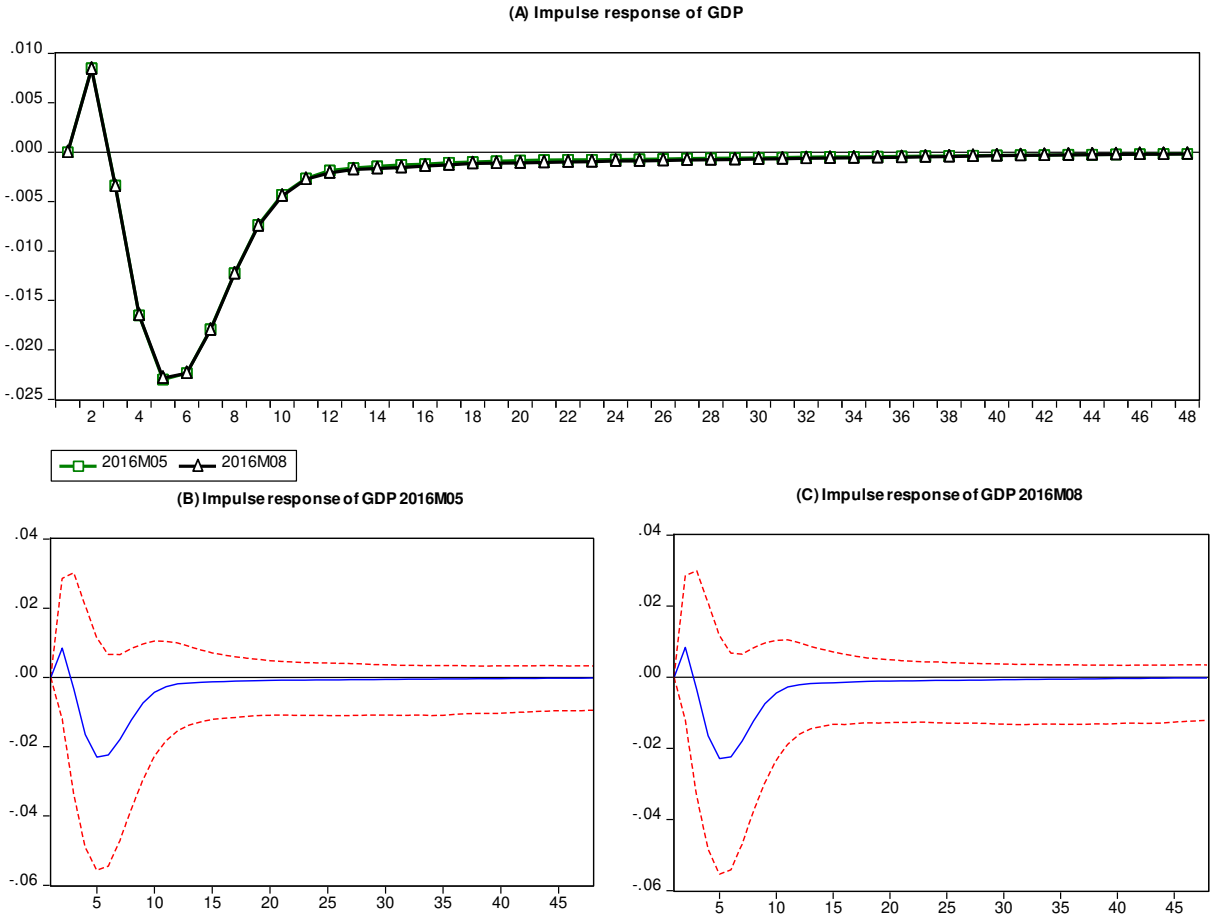

Figure 7: (A) Impulse responses of the GDP rate to real rate shock May 2016 & August 2016, (B - C) difference between the responses in corresponding periods with 16th and 84th percentiles.

The pairwise differences between impulses on different dates with 16th and 84th percentiles are presented in Figure 7. The dates chosen for comparisons are May 2016 and August 2016 as these are the latest dates encompassing the Brexit referendum. The responses did not change much indicating no significant time variation around the referendum event. This implication should be taken with a pinch of salt as we have applied this to a very limited Post-Brexit period and the wider outcome of the Brexit and its long-term implications can only be witnessed as they materialise.

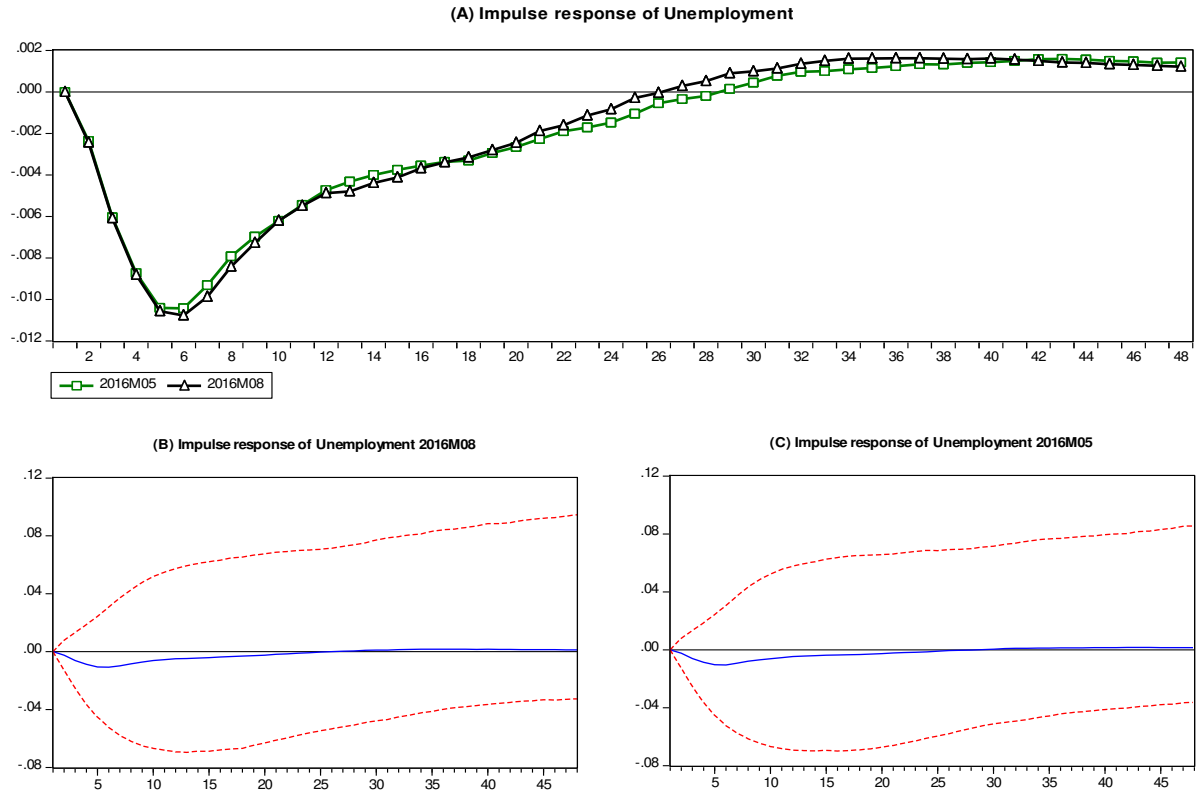

Figure 8: (A) Impulse responses of the unemployment rate to real rate shock May 2016 & August 2016, (B - C) difference between the responses in corresponding periods with 16th and 84th percentiles.

The pairwise differences between impulses for unemployment on different dates with 16th and 84th percentiles did not show much variation and showed insignificant results.

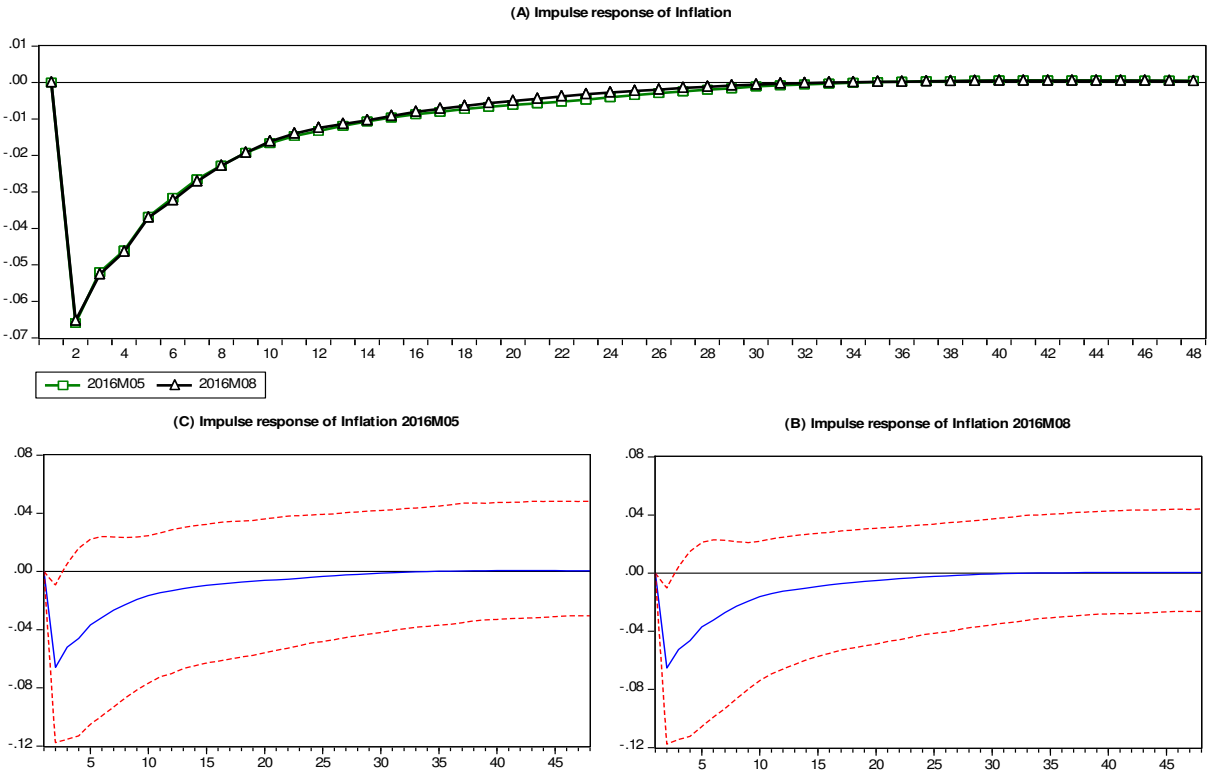

Figure 9: (A) Impulse responses of the Inflation rate to real rate shock May 2016 & August 2016, (B - C) difference between the responses in corresponding periods with 16th and 84th percentiles.

The pairwise differences for the response of inflation on different dates with 16th and 84th percentiles are also presented in Figure 9. Similar, to GDP growth and unemployment they did not show much of a variation around the Brexit. On the whole, we witnessed a shift in the association among real rates, growth, inflation and unemployment with the introduction of the discrete break in the data series. We conclude in the next section.

5. Conclusion & Policy Implications

In the context of the debate on the ZLB and choices available regarding monetary policy, we have discussed the merits of each monetary policy option when faced with a ZLB constraint. There are considerable limitations regarding negative interest rates, revision of the inflation target mandate and performing QE as a standard or conventional instrument. This provides some justification for focusing on real rather than nominal policy rates as a policy relevant instrument. With this in mind, we have modelled aspects of real policy rates for the UK economy. On the basis of the findings from our empirical exercise, we conclude that, historically, an increase in real rates has had positive implications for growth and the labour market. Nevertheless, real rates have also led to an increase in inflation. However, in the Post-GFC period and when monetary policy is constrained by the ZLB a surge in real rates seems to have negative effects on growth and employment in the medium term. Given that real interest rates have been effective even when nominal rates are at ZLB, one might, therefore, infer that *monetary policy is not constrained in this real sense*. Perhaps, keeping a low constant policy rate can be better described as *smooth sailing at a constant velocity*.

In terms of policy, our findings have major implications, particularly in the context of modest growth outlook, Brexit and the recent outbreak of coronavirus (COVID-19). Although at the ZLB nominal rates are locked, real rates are free to move to sub-zero to affect growth, employment and prices with some degree of management based on inflation dynamics. Our application of a discreet break provided further analytical insight. An increase in real rates in the Post-GFC period where ZLB applies leads to falling GDP and falling inflation. However, the labour market effects indicate rather mixed results. Notably, an initial fall in unemployment but then some increase, reflecting a trade-off between inflation and unemployment. This implies some scope for choice based on broader policy priorities. In any case, we can conclude that real rates are a potentially effective tool in an era where a nominal rate ZLB constraint applies. There is scope for policy to exploit real rates, and this could be achieved through a variety of measures, including coordinated fiscal efforts, further asset purchases, and qualitative and quantitative forward guidance schemes to push lower rates through to end users of credit. In the UK case, for example, Post-Brexit one might expect some inflationary pressure based on disruption to current supply lines and as new trading relations emerge based on some degree of friction in comparison to the current situation. If a ZLB applies then there is limited scope for revision of the Bank rate from the current level, and yet real rates may still vary and this will have implications for the British economy. The recent outbreak of coronavirus (COVID-19) is also a manifestation of dilemma monetary policy is facing at ZLB. A nominal negative interest rate is not the only choice in the toolbox. It seems reasonable to suggest that at the ZLB fiscal coordination is needed more than ever before.

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