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U.K. Monetary Policy: Observations on its Theory and Practice

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Abstract: In a dramatic change from the euphoria in the early 2000s based on a widespread belief in the "success" of the partial independence of the Bank of England, UK policymakers are now faced with great uncertainties about the future. The Coalition government responded to the financial crisis by changing the responsibilities for banking supervision and regulation and creating new institutions to deal with them. The UK was not alone in such moves and there is increased attention world-wide to greater regulatory powers and state-dependent provisioning as key to any future financial architecture. However, changes to the conduct of monetary policy are also necessary. Using the UK experience up to 2008 as a case study, we argue that the authorities here placed too much faith in the proposition that inflation-forecast targeting by an independent central bank was all that was needed. Over the previous two decades evidence accumulated that both undermined the belief that the low inflation with stable growth during the so-called "Great Moderation" was due to the new policy regime and that showed systemic risk in the financial sector was rapidly growing. We maintain that these two things were in evidence well before the financial crisis in 2008–9 and the leadership at the BoE was in error not to factor them into their interest rate decisions early on. Had this evidence been taken more seriously and had proactive action been taken based upon it, the effects of the world-wide financial crisis on the UK would very probably have been smaller. This episode highlights both the shortcomings in the DSGE paradigm favoured by the BoE and other central banks for their macroeconomic analysis as well as the very considerable difficulties in practice in creating the sort of open and transparent monetary institutions envisaged in the academic literature.

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1. Introduction

In the immediate aftermath of the world-wide financial collapse in late 2008, the question on most people's lips was obviously "What went wrong?" Possible answers came thick and fast; in the UK these largely centred on co-ordination failures of the Tripartite system responsible for financial stability, plus the presence of inappropriate incentives leading to excessive risk taking in the financial sector. Subsequently, the government's policy response has been directed at bringing together prudential supervision and regulation, with monetary policy continuing under the aegis of the MPC, but with the Bank of England (BoE) being given a central role in all these functions. There are many and serious issues with both this diagnosis and the institutional changes which are planned in response to it; some of which having surfaced in the recent exchange between the House of Commons Treasury Select Committee (HCSC) and the Court of the BoE and the Governor (HCSC, 2012). Concerns voiced by the HCSC centre on problems of "group-think" in the BoE and its lack of openness and accountability.

The present study, however, is not directly concerned with financial stability and regulation matters as such. Its focus is on the problems, past and present, with monetary policy but with the difference that our argument is that interest rate policy has financial stability implications too.[1] So, though it is now evident that there were policy co-ordination failures in the Tripartite arrangements in the crisis, other things went badly wrong too, most clearly in the BoE's mishandling of the run on Northern Rock in 2007, when the Governor refused to undertake extra liquidity support for the financial system as requested by the Chancellor, seemingly not appreciating the systemic risks inaction posed. Such problems were not confined to this episode; the rapid increase in the fragility of the financial system during the first half of the decade, for example, was sufficiently in evidence for the BoE's own financial stability section to voice major concerns about the dangers of systemic risk in 2006 (FSR, 2006).

[1] It ignores, however, possible linkages the other way, from bank regulations to their implications for monetary policy. Preliminary research aimed at filling this gap is noted in section 3.

The question addressed here is whether monetary policy was at fault in the run up to and then the onset of the crisis. Others have raised similar questions, most notably Taylor (2009) commenting on US monetary policy in the period before the crisis there and, as is discussed more fully later, there was considerable academic and other debate in the UK from the mid-2000s over the Bank's neglect of the rapid increases in UK house prices. It is also a matter of some public concern that up to and since the crisis much effort in the BoE was expended in discounting the importance of the "unbalanced "growth in the UK over much of the 2000s (with overall activity skewed to consumption underpinned by rapid increases in personal debt) and, more recently, in claiming that the BoE did all that it possibly could in the prelude to the crises (see Bean, 2008, and King, 2009).

Our central argument is that the authority's difficulties in responding to the major macroeconomic problems of the 2000s can be traced to a largely uncritical acceptance of key assumptions of the Dynamic Stochastic General Equilibrium (DSGE) paradigm, amongst which are its assumptions that there are no banks, that expectations of all agents are formed rationally with no informational asymmetries, that markets clear and that balanced growth equilibria prevail. In addition it has no explicit treatment of the fiscal side of the economy, so cannot address the thorny and very central question of monetary and fiscal co-ordination. Many others have raised serious general objections to this analytical framework as the basis for monetary policy decisions. (See two in particular from differing perspectives: Stiglitz, 2011, and Pesaran and Smith, 2011). Although we concur with these general concerns about the analytical simplifications used in the DSGE, we add other specific but crucial implications of it which appear to have governed important decisions by the leadership in the BoE over the past decade. The case made here is that these decisions were generally wrong, It led to the BoE's (in common with some independent members of the MPC and many academics) misplaced belief that its policy actions were largely responsible for the success of the "Great Moderation" of the 1990s and the early 2000s. It also underpinned the views that the rapid rise in house price inflation was a "bubble" best treated by "benign neglect"; that the increases in consumption over the period were not a matter of particular concern and were not significantly affected by the house price changes just noted and, lastly, that the huge expansion of bank balance sheets and increases in the volume of credit then underway were not a concern for monetary policy but could only be dealt with by

improvements in regulation. The BoE's belief in the validity of these propositions meant that monetary policy decisions in the UK in the period up to and including the crisis made no allowance for two crucial things: one being the possible effects of globalisation on non-increasing inflation equilibria in the UK and the other the effects of rapid and extensive financial liberalisation on the behaviour and, consequently, the financial fragility of the economy.

The argument advanced here is not a narrow technical one of whether there was a better quantitative model that the BoE should have used. Instead, it argues for the replacement of an entire intellectual framework for analysing the economy which depicts that economy as inherently self-stabilising, with one that does not necessarily have this property. The replacement recommended here rests on a fundamental but simple concern about the use or, in the BoE's case, non-use of time –series evidence, as the common characteristic of the beliefs guiding decisions at the BoE was that they largely ignored evidence that contradicted them. This was particularly the case, it seems, where that evidence was of the econometric sort. The Governor's role here may have been crucial.[2] The judgements underlying the rest of the paper are twofold ; first, that the analytical underpinnings for the sufficiency of inflation targeting in the design of monetary policy were and remain inadequate and, second, that there were limits on the extent to which the BoE was (and is) actually the open and transparent institution envisaged in the academic literature. The claim behind monetary policy thinking over recent decades that an independent central bank (ICB) with inflation forecast targeting (IFT) would ensure that monetary policy controlled inflation and would lead to output stability was, and remains, over-simplified. In line with our argument that significant change is needed in the paradigm guiding monetary policy decisions, the area for extension proposed here is to use evidence of structural economic change in it. By using evidence available at the time, it is argued that such a wider framework in the run up to the financial crisis of 2008 could have lessened the impact of the crisis on the UK. In turn, we note that the institutional arrangements giving the BoE instrument independence did not help in making the changes that were needed. What was not anticipated when the MPC was created within a partially independent BoE was

[2]The Governor's aversion to time-series econometric modelling in the UK tradition is widely known (see Giles, 2009, for example). Many of his views were summarised in a paper by Whitley (1997) which largely reproduced a critique of such macro modelling made by the Governor (then the BoE Chief Economist) at a CEPR meeting in the mid-1990s. Sadly, copies of the Governor's version appear no longer to be available.

the consequent hegemony of the BoE's own analysis in MPC deliberations in practice; BoE staff were (and remain) in the majority on that committee and, what is a major but often overlooked factor, the independent members of the MPC lacked an alternative quantitative macro and monetary analysis to that provided by the BoE itself. Although these problems were largely passed over during the mainly good times in the latter half of the 1990s and the first half of the 2000s, they have been thrown into sharp relief since. As noted at the outset, debate on these problems continues.

The plan of the paper is as follows. Section 2 is a short literature review. Section 3 presents a critical treatment of how the standard DSGE model imposes stationarity on the so-called "Great Ratios" including the consumption to income ratio and on variables such as the natural rate of unemployment. The accumulation of evidence available by the mid part of the 2000s contradicting this assumption is reviewed in section 3. Section 4 introduces nonstationarities (where these have a plausible theoretical and empirical foundation) into an otherwise standard DSGE model and argues that this has fundamental implications for the scope of monetary policy, a proposition which it then illustrates for the UK case over the past decade. This uses the case of its monetary policy setting up to the onset of the financial crisis in 2008 and contrasts this with what they could have done had they employed an alternative using a more evidence–based approach in their deliberations. This, it should be stressed, uses evidence that was current up to 2008 only, so minimising the application of too much hindsight on our part. Apart from undermining the alleged importance of IFT by the BoE (and the MPC) in achieving the Great Moderation, this section also challenges both the widespread view that the UK house price surge was an "unpredictable bubble", treatable only by "benign neglect" and the tenet that, with inflation targeting, there is a sharp separation between monetary and financial stability functions. (For a recent restatement for the need for this separation, see Svensson, 2010). Section 5 concludes.

2. Literature Review

Starting with theoretical versions of the DSGE model typically used in expositions of optimal monetary policy, a representative version has three well-known equations: an Aggregate Demand (AD) equation derived from the Euler equation governing optimal intertemporal

consumption; an Aggregate Supply (AS) equation and some form of policy rule for interest rates. A simple version is shown next. The aggregate demand (AD) equation is

$$y_t = E_t y_{t+1} - \varphi(i_t - E_t \pi_{t+1} - r_t^W) \quad (1)$$

while the aggregate supply (AS) equation is

$$\pi_t = \beta E_t \pi_{t+1} + \kappa y_t + u_t \quad (2)$$

where r_t^W depends on the Wicksellian natural real interest rate[3] and u_t is a supply shock and each is assumed to follow a serially correlated AR(1) process, thus

$$r_t^W = \rho_r r_{t-1}^W + \varepsilon_t \quad \text{and} \quad (3)$$

$$u_t = \rho_U u_{t-1} + \nu_t \quad (4)$$

with $0 \leq \rho_{r,U} < 1$. The notation E_t refers to expectations using information available up to the present time and the variables are inflation (π_t) measured as deviations from zero (assumed for simplicity to be the target), the output gap (y_t) measured as the percentage gap between the level of output and its potential and error terms ε_t, and ν_t which are assumed to be serially uncorrelated. In the AS equation, β is the discount rate and κ depends on the elasticity of marginal cost with respect to output and of price responsiveness to changes in marginal cost. In the AD equation, φ depends on the intertemporal elasticity of substitution and the output gap y_t depends on the real interest rate gap, where this is the actual real rate minus the Wicksellian (natural) real rate of interest. Related examples to (1)-(4) abound in the literature. A few of the key ones include Clarida *et al*.(1999), Svensson and Woodford (2003) and Gali and Gertler (2007).

The model is often completed with a policy rule for the nominal interest rate responding to output and inflation deviations from desired levels and an example of a simple rule is,

$$i_t = \alpha_1 \pi_t + \alpha_2 y_t .^4 \quad (5)$$

Such theoretical, often calibrated, DSGE models are usually directed at expositing the transmission mechanism of monetary policy in a regime of ICBs which apply IFT. An

[3] Svensson and Woodford (2003) define this as the exogenous variation in the Wicksellian "natural" (real) rate of interest, the real interest rate consistent with a zero output gap. The treatment that follows simplifies theirs.

[4] Recall that from equation (1) it is the difference of the actual real (i.e. $i_t - E_t \pi_{t+1}$) from the Wicksellian real rate that determines expenditures.

important, much emphasised, by-product of the research concerns the potential gains in inflation reduction programmes from such a regime, which is seen as operating through the "credibility " effects it will have in bringing about significant (perhaps overriding) effects on expected future inflation. (See Clarida *et al*., 1999, Gali and Gertler, 2007, Svensson, 2003, Svensson and Woodford, 2003, and Woodford, 2003, as a representative but small set of examples.)

Although our partial review suggests a near orthodoxy in the analysis of monetary policy, there have been important criticisms of it. Ones that figure in sections that follow are purposely confined to research that was current up to, but not beyond, 2008 when the financial crisis struck for reasons set out in the introduction. Before the crisis some critics had challenged the alleged inclusiveness property of IFT by ICBs and put forward the alternative so-called "heterodox" approach which advocates an extra allowance for asset price changes in interest rate decisions (see, for example, Cecchetti *et al*., 2002, White, 2008, and Wadwhani, 2008). Others had objected to the concept of equilibrium used in the model together with the treatment of nonstationarities where these are evident in the data (Muellbauer 2007, McGough 2006 and Henry and Kirby 2010). Since the crisis there have, naturally, been many extensions to this list of criticisms and some of these give a context to the present study, particularly in the treatment of the AD equation used in sections 3 and 4 below. These include the major critique of the use of the REH in the DSGE by Frydman and Phelps and their associates (Frydman and Phelps 2012), extensions to the modelling of the consumption- house prices nexus to allow for portfolio decisions in a Flow of Funds framework (see Duca, Murphy and Muellbauer 2012 and 2012a) and the introduction of an embryo financial sector in the DSGE, including multiple banks with interbank lending and the possibility of bank insolvency (Dib 2010). In addition, major criticisms of the DSGE have emerged from a very different quarter, this time in the vigorous and critical response by leading UK econometricians when questioning the practice of not using empirically established nonstationarities explicitly in the model; criticisms which raise serious issues about the equilibrium concept normally used in the DSGE paradigm. These criticisms raise fundamental questions about the existence of the DSGE's postulated long-run steady-state when there are structural breaks and/or regime changes which could be expected to

affect it.[5] (See Hendry and Mizon, 2010, in particular).[6] Separately, Pesaran and his associates have proposed a conceptually and, in practice, quite different treatment to the standard interpretation of the long-run path in the DSGE model, basing their argument on the "ample evidence that most macroeconomic variables, including inflation, interest rates, real exchange rates and real output, are likely to contain stochastic trends and could be cointegrated". Where these are present, they recommend treating the steady states as long-horizon forecasts from an underlying global vector error correcting model (or VECM) (Dees *et al*., 2010). Finally, tests to date of the claim that by changing the incentives faced by the monetary authorities low and stable inflation with steady growth resulted over the mid-1990s to mid-2000s are an important background to what is done here. In the "Great Moderation" literature, both empirical and calibrated studies have been used in attempts to determine whether "Shocks" (briefly a more benevolent world environment with fewer and smaller commodity price shocks) or "Institutions" (essentially inflation targeting and moves to more independent central banks) have been the dominant determinant of the lower inflation and unemployment and their volatilities apparent in the US, and to a lesser extent in the UK since the mid-1980s. This has used single equation estimates (of New Keynesian Phillips Curves or interest rate policy rules) where, in each case, the aim is to detect changes in the parameters over sub-samples which are consistent with changes in the effectiveness of monetary policy, and complete macro models of the "Structural" VAR (SVAR) variety, which test for the relative importance of external shocks over sub periods between which it is presumed regime change has occurred. (Details from a recent conference on the issue held at the Bank of England is found in Young, 2008) The debate is still unresolved.

3. Empirical DSGEs and the Role of Nonstationarities

The common practice in DSGE models, from all locations in the New Classical–New Keynesian spectrum, either without or (more recently) with banking sectors, is to apply a long-

[5]The widespread use of statistical filters has also come in for criticism, especially the Hodrick-Prescott (HP) filter to estimate long-run trends in the model, where these filters are known to induce spurious autocorrelations in the series as noted recently in Dees *et al*. (2010). This is not discussed further here.

[6] Such as its assumed property of minimum mean-squared error (MMSE) predictors and the applicability of the law of iterated expectations which are essential to deriving inter-temporal REH solutions, a standard postulate of the DSGE model.

run equilibrium trajectory consistent with an assumed common stochastic trend in income, consumption and investment arising from the assumption made about their common driver – the productivity trend. Hence, the Great Ratios are rendered stationary. Some of the consequences of applying this property to the model are the subject of section 4. This concept of equilibrium is contrasted with that which is implied by research in parts of the UK econometrics community briefly referred to earlier. The rest of the present section is concerned with describing some previous empirical research on the probable nonstationarity of two variables that figure heavily in the DSGE.

3.1. Equilibrium in the DSGE

Simply put, the New-Keynesian DSGE "project" so far has mainly focussed on various forms of nominal and real inertia around a steady-state growth path. The "core" AD and AS equations (see (1)–(2) above and the subsequent discussion), make up the bulk of its "endogenous" model dynamics which are mainly due to various forms of price- and wage-stickiness. Other "external" dynamics are included by the addition of "exogenous" autoregressive, but stationary, shocks (as in (3) and (4)). Empirical DSGE models include larger sets of such "shocks", especially if they allow for openness (see Smets and Wouters, 2002 and 2007, and Harrison *et al*., 2005).[7] But, in line with theoretical examples, these empirical models also impose a long-run balanced growth path. Where empirical examples differ from their theoretical counterparts is in the extensions made to the "endogenous" dynamics of the DSGE model to include richer, but still stationary, dynamics in the hope of matching the persistence generally found in the data. Examples are the addition of adjustment costs in employment as in, for example,. Chang, Doh and Schorfheide (2006), or partial indexation, exogenous habit formation effects and costs of adjustment on investment as in Smets and Wouters (2002 and 2007), Ireland (2010) and Harrison *et al*. (2005).[8] It might then be expected that there has been varied and comprehensive analysis of the DSGE model's possible dynamics. This is not true, and one source of dynamic behaviour (broadly defined)

[7] The replacement of the BoE model referred to here, the BEQM, was started using a new forecasting and analysis platform named Compass in late 2011. This is ignored in what follows as it is outside the period we concentrate on here.

[8] The responses of DSGE models already mentioned nonetheless seem fast as judged by their simulation results. Those in Smets and Wouters (2002) appear to be close to full recovery from a shock after 3–5 years. Ireland (2010) gives results at the bottom of this range and BEQM responses from interest rate or productivity shocks are complete after 2–3years.

not allowed for so far is that of structural changes to the model equations due to regime changes such as the large scale reforms to labour markets and liberalisation of the country's financial system from the mid 1980s onward. Indeed, the DSGE appears especially vulnerable on this score as we show next, arguing that, among other things, the largely common treatment of the model's equilibrium so far is highly suspect.

The most significant feature in most empirical applications is that the model used is detrended using a constant returns to scale production function for output which is subject to a technology shock assumed to follow a random-walk process often with drift. By postulating that this process is common to the main components of expenditure, the Great Ratios (for consumption to income and investment to income for example) are thereby assumed to be stationary. This imparts the equilibrium characteristics of a long-run neoclassical growth model to the DSGE. By doing so, it presupposes that regime changes, brought about by structural changes in domestic labour markets or in domestic and international financial systems, each of which are sufficiently long lasting to induce nonstationary behaviour in these ratios, cannot happen. In this light, the imposition of stationary great ratios is synonymous with assuming that, for example, in the case of the UK the labour market reforms of the 1980s had only minor transitional effects on long-run unemployment and the liberalisation of its financial markets had no lasting effects on the household consumption–income ratio even though possible effects from it had been visible for some three decades.

3.2. Nonstationarities and the Implications for Equilibrium

Even though this section shares the conclusion of Hendry and Mizon, 2010, cited earlier, it differs from their approach in using specific examples of regime change, in the labour market and the nexus of the financial and household sectors over the past three decades or so, the broad features of which were largely understood at the time even if their future evolution was not precisely predictable.[9] The examples also illustrate that the policy implications from the model are generally very different when nonstationarities in the data are included, something that has not been emphasized before. The extensions here allow for the nonstationarity of the

[9] Like most economic variables in other words. Here, the argument relies on the difference between assuming that something is predictable subject to error as opposed to being completely unknown.

unemployment rate, possible causes of which have been the subject of intensive academic research since the 1980s. In turn, developments in the housing and financial sector following the financial reforms of the 1980s, and the increasing threat these posed, were in evidence to many observers well before 2008, including economists in the BoE's financial stability section. Also, these developments had a counterpart in well publicized academic research analyzing the nonstationarity of the consumption ratio during the last decade which drew attention to these risks. Some key parts of these two areas of research are described next.

3.3. Two Nonstationarities

This paper purposely does not present new empirical results; instead it outlines econometric research in existence by the mid-2000s confirming nonstationarity in both unemployment and the consumption–income ratio. According to empirical tests reported by a number of economists at different times it was evident well before the crisis that each was nonstationary. (See, for example, Ireland, 1999, Nickell, 1998, and Henry and Nixon, 2000, for unemployment and for evidence on the consumption ratio see Barrell and Davis, 2004, and Muellbauer 2007, amongst others). We summarise the salient features of this research next as a prelude to introducing them into an otherwise typical DSGE model. Section 4 then discusses some of the principal differences these changes would have made to policy thinking had they been adopted before the crisis.

3.3.1. Long-run unemployment[10]

Recently, there have been important descriptive accounts of the possible causes of the observed flattening of the UK Phillips Curve emphasising the possible role of improved monetary policy institutions, increased deregulation of domestic labour markets, the world-wide savings "glut" and globalisation in producing the lower inflation and unemployment and their volatility that characterised the "Great Moderation" period (see Bean, 2009, and White, 2008, for example). One telling observation by White, 2008, which bears on the line adopted here, is that changes to the institutions of monetary policy or deregulation of domestic labour markets, for example, are each unlikely candidates as the sole explanation of the "Great Moderation" because

[10] The emphasis in this section is on long-run influences on labour market behaviour and it purposely ignores the important literature on the "pass-through" of nominal exchange rate changes and domestic inflation largely for reasons of space. (Important contributions include Devereux and Engel, 2002, and Monacelli, 2003).

improved inflation-growth out-turns happened across most industrial countries and these had in many cases very different institutional arrangements for monetary policy and were at very different stages in their deregulation programmes. With this in mind, this section follows with a short review of econometric labour market studies which have investigated potential determinants of long-run equilibrium unemployment. These determinants include changes in labour market "flexibility", which operate on the wage-setting side of the wage bargain (the major example here is Layard et *al*., 2005) and also effects operating on the price-setting side, which mainly emphasises the importance of external commodity price shocks and globalisation. These studies recognise that, although bounded, the actual unemployment rate appears nonstationary, hence its equilibrium rate can be assumed to be nonstationary also. Empirical studies giving behavioural explanations for possible mean shifts in unemployment are found in Layard *et al*., 2005, Nickell, 1998, Henry and Nixon, 2000, and Henry and Kirby, 2010. Briefly, these papers use the familiar model of union-firm bargains over real wages coupled with imperfectly competitive firms setting prices. The unemployment equation can be derived from these models by equating the real wage, which uses wage "push" terms as determinants of real wages, with the (inverse of) the price markup over wages which is affected by price "push" terms. This latter has a time-varying price markup μ_t over marginal cost i.e. (in logs)

$$p_t = \ln \mu_t + \ln MC_t, \tag{6}$$

where MC_t is real marginal cost. Different researchers have emphasised different channels for time-varying markups. Batini *et al*., 2005, lay stress on the effects of foreign competition, others suggest that measures of competitiveness and of openness affect margins and productivity and hence unemployment (see, e.g., Chen *et al*., 2009). The real oil price is also used as a determinant of long-run unemployment in McGough's ,2006, extension of the Sargent model. It has also figured in estimated VARs in much of the "Shocks versus Institutions" debate in the US (see Stock and Watson, 2002). Solving the wage and price equations jointly for unemployment shows it depends on both exogenous wage and price pressure variables. One important empirical question is which of these appears the more significant – wage or price pressures? Nickell, 1998, reports cointegration tests showing that wage pressure variables (such as real unemployment benefits and unionisation) account for long-run unemployment but Henry and Kirby, 2010, in line with White's conclusion quoted

earlier, argue that price pressure terms (such as real oil prices and indices of globalisation) are more important. This latter version is used below and, after simplification in the light of empirical tests, the long-run (cointegrating) unemployment equation used for illustration is[11]

$$u_t = \beta_0 + \beta_1 Glb_t + \beta_2 OIL_t + e_t \qquad (7)$$

where the unemployment rate depends on the real oil price and an index of globalisation (Glb_t). An important finding across this literature was that the UK NAIRU fell from the mid-1990s (see Nickell, 1998).This result is extended in unemployment models with an emphasis on price markups as already noted (see Batini *et al*., 2005, and Henry and Kirby, 2010, for details). The significance of these empirical results is that shifts in long-run, equilibrium, unemployment appear to be a major part of the explanation for the flat region of the simple Phillips Curve over the period of the "Great Moderation". Inflation proved quiescent as actual unemployment fell, because its equilibrium rate (here the NAIRU) fell markedly too.

3.3.2. The Consumption-Income Ratio

This section gives an overview of the debate about the changes in the consumption ratio over the two decades preceding the crisis and their economic significance. The interpretation adopted in the paper is that the ratio was non stationary for reasons that were largely understood at the time and in which house price inflation played a key role and these have implications for policy which differ markedly from those implied by the widespread assumptions that consumption was not affected by house price inflation and that the surge in house prices was a bubble due to self-fulfilling expectations. The account that follows interprets the two episodes of house price inflation in the UK since the mid-1980s as the result of changes to banks, their lending and borrowing behaviour and household borrowing, each of which were due to the very substantial financial liberalisation which started in the first half of the 1980s. According to this account, a judgement about the causes of the house price surges observed at the time needs to be made in the context of changed behaviour in banks and households, where the underlying driver of these changes was the process of financial liberalisation. (The following section below spells out the modelling context for these

[11] Note that most of the subsequent policy analysis in section 4 is unaffected by which of these different interpretations of the source of the change in the Phillips Curve is used.

statements in more detail). This treatment is in contrast to the explanation for asset price increases in most DSGE models that these were sunspot solutions (see Lubik and Schorfheide, 2003, for example).[12] The presence of multiple solutions to the standard linear rational expectations macro model implies that such sunspot equilibria can emerge due to non-fundamental (by definition) stochastic disturbances which produce model dynamics different from those of the unique rational expectations equilibrium. The question posed then is whether the increases in UK house prices, together with the connected changes in credit, the huge expansions in banks' balance sheets and the changes in the consumption ratio were due to recognisable and forecastable effects of structural changes in the financial system as argued here, or were they due to self-fulfilling but unpredictable asset price bubble behaviour as assumed in many DSGE models? What follows opts for the former account of a regime induced change in the fundamental determinants of house prices. Speculative effects on these and other asset prices are not ruled out but are relegated to having only transitory effects, including the possibility that some prices might "overshoot" their longer -run path.[13]

3.3.2.1. Collateral, credit and the consumption ratio

So far our attention has focused largely on the behaviour of the consumption ratio but it is clear that over recent decades this cannot be seen as an isolated issue. Behind its changes there were massive changes in the financial system and, while the changes in consumption were very significant, they were only one part of what was happening. Starting from the mid 1990s, there were changes in the entire nexus; huge increases in bank lending, their leverage and their scale and sources of banks' funding and, finally, equally large increases in household's borrowing and consumption coupled with rapid house price inflation. In terms of the extensions needed to the DSGE model to include these developments, research since the crisis has made important initial steps. Two which give some contextual basis for what we consider later, are those extensions incorporating an active financial sector which is undergoing financial liberalization, where there are multiple banks and an interbank market with the possibility that some banks

[12] Very recently, others have advanced an RBC version which stresses the role of the nature of the shocks to the tfp as the key source of the expansion and subsequent collapse of house prices and consumption (see Davidson *et al*., 2010, and Ireland, 2010).

[13] This general line of argument follows that set out by Krugman (1996) on the 1990s currency crisis which emphasised changes in fundamentals as the primary explanation in contrast to speculative attacks based on self-fulfilling expectations.

can default on a fraction of their interbank borrowing. Such a model is described by Dib, (Dib 2010).[14] Liberalisation effects in these models entail changes in the competitive structure of the financial system and consequent increases in credit offered by banks and reductions in its terms. Another part of this general model relevant for interpreting what follows are models of the interface between banks and households and the consequent easing of the financial constraints facing the household sector due to financial liberalisation. Part of this was anticipated in the important early strand of research by Goodfriend and McCallum (2007) on bank lending behaviour where changes in house prices are used when banks monitor the credit worthiness of borrowers, suggesting that rapidly increasing house prices could lead to large scale credit expansion at reduced terms via this "collateral" effect. More recent and extensive research by Duca et al. concentrate on the household part of this using estimated joint models of consumption and housing liquidity indicators, where the latter is derived as a latent variable in a Flow of Funds model. (See Duca, Muellbauer and Murphy 2012 and (2012a).

A general equilibrium model satisfactorily incorporating all of these elements still remains at the top of the research agenda. In what we describe as an interim analysis (in Section 4) the emphasis is restricted to having indices of the effects of financial liberalisation on consumption only. The main reason for this lies in our intention to "rerun" history, so using only empirical research available before 2008. That said, the consumption equation used later is intended to be consistent with a general equilibrium model in which some of the recent developments described above would be an important part but, as will be clear, it simplifies them considerably. In what follows, we assume that the AD equation (1) refers to aggregate consumption only (treating all other components of demand as exogenous). Then, the interpretation of the effects of the changes to the financial system employed here is that they had the effect of lowering the "effective" interest rate in the credit market. This was due to both the effects of increasing competition in the financial sector and to the banks' "search for yield" which saw them taking on greater risk in a global environment where interest rates were already low. This "effective" rate includes effects due to changes in loan to

[14] In such extensions, as in the other DSGE examples reviewed earlier, the model is linearised and solved for a steady state where the "Great Ratios" apply. This treatment places a major constraint on the model's medium–long-term behaviour since it means a much reduced variation in these ratios compared with what has happened to them in the data. Estimates of the marginal properties of the model and thus evaluation of the transmission mechanism of monetary policy and other shocks are likely to be contaminated.

income and loan to value ratios, an increased percentage of the house price allowed in the mortgage, changes in the number of individuals counted in the household income assessment and the increasing use of self assessment. At its most simple these differences, acting in combination, drive a wedge between the policy interest rate (in real terms) and the natural real rate in equation (1), and we index this wedge by the term F_t which is composed of these changes in the terms on which credit is available. (It is treated as a scalar measure in what follows for simplicity). In short, F_t is intended to include the overall effect of liberalisation; the progressive reduction in credit constraints on households when consumption smoothing. An influential example, broadly in line with this interpretation is given in a paper by Muellbauer[15], with a consumption equation which may be described schematically as

$$c_{t-1} = \lambda_1(CCI_t) + \lambda_2.Z_{t-1} \qquad (8)$$

where c_{t-1} is the consumption ratio, CCI_t is an estimated time-varying credit conditions index and Z_t is the vector of the other determinants of the consumption ratio including income, disaggregated financial wealth and housing wealth (Muellbauer 2007).[16] In Section 4, a near relative to the standard Euler equation for the AD equation is used, in which the consumption ratio depends on the real interest rate as in (1) but is there augmented by the F_t term just described, which is meant to act like the credit conditions index in the more elaborate consumption equation such as that of equation (8).

Thus, to sum up, empirical research on UK consumption up to 2008 just briefly reviewed contained strong evidence that the consumption-income ratio depends, amongst other determinants, on measures of credit market conditions. The interpretation of these results given here is that these single equation (consumption function) regressions can be seen as being part of a general-equilibrium framework, such as that indicated above, linking together bank-household credit decisions with banks using house price changes to index credit worthiness.[17] The house price surge is then an outcome of these joint effects of liberalisation (assuming a relatively fixed supply of housing services) and these effects have also altered over time. (See

[15] The Muellbauer model includes intercept and interaction effects of CCI so is non-linear. Equation (8) is a linear approximation to this, used here for expositional convenience only.
[16] For an estimated CCI index see see Fernandez- Coregedo and Muellbauer, 2006..
[17] It needs to be made clear at this point that this is our interpretation, and it is not attributed to any of the authors of the research on consumption cited in the paper.

Barrell and Davis, 2004, Aron and Muellbauer, 2006, Muellbauer, 2007 and Muellbauer and Murphy, 2008, for empirical evidence on the consumption ratio.) . Before moving on, we note some of the diverse messages on consumption coming from the BoE and MPC in the mid 2000s.

3.2.2.2. Diverse messages from the BoE

A clear account of growing systemic risk in the UK the Financial Stability Report (FSR) of 2006, which highlighted the rapidly increasing dangers posed by any reassessment of risk premia and the evidence of enhanced amplification channels.[18] It also drew attention to banks' increased reliance on wholesale funding, and the large growth in Collateralised Debt Obligations (CDOs). Putting these together with the growth in the indebtedness of the household sector and what was then understood about the very large increases in the amplification mechanisms in the financial system, they pointed to there being a very substantial systemic risk of a major financial and real collapse in the UK. Very significantly, it also noted that although the growth in CDOs offered diversity against idiosyncratic risks, it left the system highly vulnerable in the event of a general macroeconomic shock. Equally, the increasing reliance by banks on wholesale funding, and the increasing interbank and counterparty exposures between banks and Large Complex Financial Institutions (LCFIs), meant larger risks at the system-wide level. The FSR added to this list its own concerns about the very high levels of indebtedness in the household sector.

On the monetary analysis side of the BoE, however, it appears that some senior economists in the Bank and on the MPC had a very different account of the mechanisms at work in the 2000s; not apparently accepting that there were links between consumption and house price increases or that bank lending decisions used house price increases in judging collateral at a time when banks themselves had become increasing exposed to risk of liquidity shortage and possible insolvency. In the monetary analysis part of the BoE the "in-house" argument was that house price inflation did not have wealth effects and this appears to have been thought a sufficiently strong argument for monetary policy not to factor in any special allowance for the increases in house prices then in evidence. And,

[18] Principally increased exposure to potentially illiquid instruments and, in the face of the need to unwind these, there being large falls in asset prices.

although the Bank's model (BEQM) had a collateral effect from house prices in its consumption equation, this was small and statistically insignificant. It is worth remembering that this model was probably used for most of the simulation and monetary policy analyses presented to the MPC and would have been giving misleading accounts of house price effects according to us.

It was also the case that, over the first half of the 2000s, speeches from both BoE and MPC economists reviewing some of the changes in house prices, consumption and consumer debt mainly argued that, in the light of these, there was no need for monetary policy to be amended. Thus MPC member, Steve Nickell in his Keynes lecture reviewing UK monetary policy over 2000-2005, argued that consumption growth had not been unusually rapid and that the consumption ratio had remained relatively stable because household debt accumulation rose at about the same rate as household's accumulated assets and both were a result of rising house prices over the period (Nickell 2005). He concluded there was no strong relationship between changes in consumption and debt accumulation and that the trends in the mortgage and the household debt ratio were set to continue providing house prices continued their increase. From a policy perspective, he concluded that whilst it was possible that any shock causing house prices to fall substantially would indeed lead to effects on the wider economy, the scale of this would depend on whether creditors continued to treat their loans as secure or not. It they did, the effects of the shock would obviously be less. While this general proposition is obviously true, there is no hint here that the sort of shock he had in mind was one that resulting from any increased risk of systemic bank failure. Notably, his key example instead was the 1999 collapse in house prices which was due to the 15% interest rates then in place as the UK sought to keep sterling in the ERM. A similar hike in rates he thought highly unlikely, correctly, as it turned out. What was much more likely at the time, and which he did not allow for, was the huge increase in UK banks' exposure to risk revisions in their holdings of poor quality UK household debt and, even more so, in their holdings of securitised tranches mainly originating from the US. This second line in particular made the both the nature and the scale of the risks posed by financial fragility in the UK by the mid 2000s completely different from the risks posed by the financial fragility of the late 1980s.

A brief comment is also in order on the regular judgement from the BoE and MPC to the effect that because growth in consumption in the early 2000s was not out of

line with earlier episodes, they could be ignored. (See Nickell, 2003 and 2004, and Dale, 2009. Thus, Dale opined that "since the start of this century and the onset of the financial crisis, consumer spending has increased no faster than it had done on average over the past 40 years".[19] Given that overall activity was not that strong over this period, it would have been surprising if consumption growth had been unusually rapid in this sense. But something of greater significance in this context, which he ignored, was that the question of "high" or "low" consumption was (and is) fundamentally concerned with the consumption ratio, as this is assumed to be stationary in the standard DSGE. Highly persistent deviations away from this would suggest that consumption behaviour was "unusual" according to the tenets of the BoE's accepted paradigm.

The next section sets out a DSGE model which incorporates explicit nonstationarities attributable to regime changes in both the labour market and in the interface between the household and financial sectors in the credit market. The aim is to illustrate what policymakers, particularly the BoE (MPC), could have done had they made allowance for important features evident in the macroeconomic data in the run-up to the financial crisis in 2008/9. Hence, the section concentrates on research material and evidence available before then.[20]

4. A DSGE with explicit nonstationarities[21]

4.1. The Policy Model with nonstationarities

This section aims to bring together the themes of earlier sections by outlining a model that is recognisably in the DSGE framework but which accommodates econometric evidence of changes in the non-accelerating inflation rates of growth the economy can sustain with, simultaneously, evidence of the effects on aggregate demand of large-scale changes in financial markets due to financial reforms dating from the 1980s. What follows is similar to

[19] He notes, in a footnote, that growth in real consumption spending was "unusually strong" in the 1996–2000 period.

[20] There were examples of DSGE models with elements of banking sectors before this time. See Goodfriend and McCallum (2007) and Goodhart *et al.* (2004) for example. It is, however, historically accurate to say that most DSGE models at this date precluded these extensions.

[21] I am grateful to Malcolm Pemberton for comments and advice on this section. Responsibility for its contents remains my own.

Krugman's (1996) financial crisis model, where predictable changes in fundamentals play a central role, but it also builds on the extension to the DSGE model to allow for cointegrating relations as advocated in the important paper of Pesaran and Smith (2011). That said, the most that is claimed for the present study is that it is intended to be broadly consistent with the implications of a general equilibrium model that includes a banking sector where substantial structural changes to the financial sector could play a major part in creating financial crisis conditions. It also implies that active monetary policy can and should be used as one of the weapons to control undue leverage in the household and financial sectors that result from wide-reaching financial liberalisation as part of the efforts to ameliorate the effects of these crises.

4.2. An Interim nonstationary model

In contrast to their assumed behaviour in the DSGE, this section outlines nonstationary counterparts for unemployment and the consumption–income ratio based on econometric evidence that are used to replace the assumption of a stationary equilibrium value for both unemployment and, hence, output, together with substantial changes to the DSGE's treatment of the real interest rate gap. Initially, the model is couched as a vector error correction model (VECM), and then reformulated as a DSGE such as (1) – (2).

Henceforth, we use a changed version of the AS equation where (y_t^n, u_t^n) refers to differences of actual from time-varying non-accelerating inflation level of output and the rate of unemployment respectively. The interpretation is that these NAIRs incorporate evidence-based nonstationary movements in unemployment from its orthodox natural rate so, in keeping with this, the output gap used here (y_t^n) includes these nonstationary effects in addition to what is assumed in the standard definition of potential output (y_t^T) used in the DSGE. As the NAIR for output is defined as potential output where unemployment is at the NAIRU, and as the estimated nonstationary part of the NAIRU summarised in (7) depends on globalisation and commodity price effects, this implies that revised definition of potential output defined as its NAIR will also depend on these too. Thus, for simplicity, letting G_t be a single index of the vector of the two effects (Glb and OIL) used in equation (7), we define the output gap as the

difference of actual output from the standard measure of its potential augmented with the nonstationary effects as follows,[22]

$$y_t^n = y_t - \lambda_Y G_t \qquad (9)$$

where y_t is measured as output deviations from the orthodox definition of potential output as in (1), but with the addition of a time-varying nonstationary vector (G_t) due to the effects that globalisation and other real persistent shocks such as oil prices exert on price margins as described earlier in the model for long-run unemployment (7).[23] Its interpretation is that globalisation lowers, whereas oil price shocks increase, inflation at given rates of output over and above that due to standard productivity effects already included in y_t^T.

Turning to our treatment of the AD equation, the earlier summary described the effects of extensive financial liberalisation on credit conditions and the effects of this mainly on household spending, inducing significant nonstationary changes to the consumption–income ratio and hence aggregate demand. We argue that this property is in keeping with the implications of a general equilibrium model, where this includes a behavioural sub-model of the financial system with multiple financial intermediaries, undergoing major financial liberalisation. Solutions of such a model would show falls in the effective real interest rate due to this liberalisation.[24] Over the past two decades, real interest rates in the UK have fallen for two reasons. One was the effects of changes in global saving, principally originating in China, which led to lower world real rates (as discussed most notably in Bernanke, 2006).[25] The other was due to the channel emphasised in this paper and was the large-scale structural change in the domestic financial system following liberalisation from the mid-1980s.[26] As described earlier, the effects of this second (domestic) channel acted to reduce the effective rate on borrowing in the UK. In this interim model, this is the principal

[22] There are a number of steps involved in making this connection, omitted for the sake of brevity, but which need to be recognised. Although we do not assume a simple or stable form of link between unemployment and the output gap (Okun's law), nevertheless there is no allowance made here for changes in participation rates, changes in labour supply (including that due to net inward migration) or labour hoarding. Finally, a further key omission is any reference to capital stock and investment decisions.

[23] The model could be expressed in terms of the unemployment gap (actual unemployment deviations from the NAIRU) without losing any essentials in what follows, but the output gap is easier to relate to standard practice.

[24] Henry and Kirby (2010) discuss problems in identifying global and domestic effects on long-run real interest rates in a VECM framework in order to satisfy the necessary weak exogeneity restrictions.

[25] This global effect may be closely related to the globalisation variable (G_t) above, but that possibility is not explored here and is left for further research.

[26] The major changes in risk taking which ensued are largely ignored here.

mechanism through which financial liberalisation measures have their effects; driving a nonstationary "wedge" between the real interest rate and the standard natural rate.

To incorporate these effects, the definition of the long-run real interest rate gap used later is amended to be

$$i_t - \pi^e_{t+1} - r^n_t \text{ ,where}$$

$$r^n_t = r^W_t + \lambda_R F_t \qquad (10)$$

where r^W_t is the standard Wicksellian real interest rate, usually assumed to be stochastic and possibly persistent but stationary and the equation includes the variable F_t, which is an I(1) nonstationary vector of indices of increasing competition among financial intermediaries and the consequent easing of restrictions on domestic lending in the UK. In the light of the earlier comments, λ_R is < 0 so having the effect of lowering the equilibrium real interest rate. It is the case that r^n_t was affected by changes in global saving too but, for simplicity, this is ignored in what follows. In effect, the subsequent discussion then centres on the effect of monetary policy where interest rates are purged of global savings effects.

Again, as with our simplified treatment of nonstationarities in the AS equation, there are serious caveats in order in this section too. Thus, in the absence of a fully articulated financial sector, our treatment leapfrogs many of the steps in the links between structural changes to the financial system introduced in the 1980s and their effects on the behaviour of financial intermediaries and on the spectrum on interest rates. Our account essentially postulates a relationship between a time-varying effective interest rate (changing according to the wedge) and the nonstationary consumption ratio that it led to.

In the model that follows, each of these regime changes – that in the labour market and that in the financial-household nexus – is treated as an additive, "exogenous" shift for analytical convenience, as will become clear later. In summary, the cointegration evidence described earlier can be expressed in the VECM

$$\Delta y_t = \Gamma_1(L)\Delta x_{t-1} - \Phi_{11}(y_{t-1} - \lambda_Y G_{t-1}) \qquad (11)$$

$$\Delta r_t = \Gamma_2(L)\Delta z_{t-1} - \Phi_{22}(r_{t-1} - \lambda_R F_{t-1}) \qquad (12)$$

where the first error-correction term is in terms of a NAIR value for potential output which augments standard natural rate with the nonstationary G_t, the effect of which is a downward

shift in the standard AS curve. In turn, the corresponding real interest rate (as measured as a deviation from the Wicksellian natural rate) is shifted down by variation of the nonstationary term F_t, which then leads to an upward shift in the AD equation. As y_t and r_t are defined as deviations of the actual from the orthodox natural rate for output and for the real interest rate, equations (11) and (12) determine the adjustment of the familiar output and the real interest rate gap to the difference between these and their now augmented longer-run levels. These additional deviations are nonstationary, contrary to their assumed behaviour in the DSGE and, in our extension, we explain these nonstationary deviations from the standard balanced growth path by allowing for the effects from G_t and F_t. The vector x_t is the set of conditioning variables (which includes lagged changes in y_t and lagged changes in G_{t-1}) and z_{t-1} has a similar definition for variables conditioning real interest rates[27].

4.3. Some Simple Solutions for the Standard and NS models

To relate (11) and (12) to a typical DSGE model as illustrated by (1) – (4) earlier, the cointegrating vectors in (11) and (12) replace the usual gap terms for output and the real interest rate in the AS and AD equations as follows [28]

$$\pi_t = \tilde{\beta} E_t \pi_{t+1} + \tilde{\kappa} y_t^n + \varpi_t \qquad (13)$$

$$y_t^n = E_t y_{t+1}^n - \tilde{\sigma} r_t^n + \xi_t \qquad (14)$$

Where the parameters in the two equations are now different from those in (1) and (2) in recognition of the change in the meaning of these gaps compared with their measurement in the standard model. Moreover, they are not intended to have the sharply defined micro-theoretical interpretations of the original. The model (13) – (14) is labelled the nonstationary DSGE (NSDSGE) from here on, and its properties contrasted with a DSGE one. To clarify the differences between the two versions, the standard model uses quite elaborate dynamics on its disturbance terms as is clear from (3) and (4). The disturbance in the AS equation (u_t) is sometimes interpreted as a forecastable cost shock which could be due to a time-varying

[27] For further detail on some of the econometric problems in identifying a model like (11) – (12), see Henry and Kirby (2010) and references there to the wide econometric literature on this subject.

[28] Reparameterising Euler equations governing the DSGE model to accommodate cointegrating equations between the endogenous and conditioning variables is described in Callen *et al*. (1990). Typically, in moving from ECM equations to a forward-looking model will involve a mixture of leads and lags .We restrict attention to a simple led version for ease of making the comparisons that follow.

markup between retail over wholesale prices (for example see Clarida *et al*., 1999, and Svensson and Woodford, 2003). The shock to the AD is variously interpreted as due to the forecastable part of exogenous variation of the Wicksellian natural real interest rate attributable to disturbances affecting the desired timing of expenditures in the Svensson-Woodford model, though Cochrane (2009 and 2011), in simplified versions of the DSGE model, interprets the AR (1) shock as a generalised monetary policy disturbance made up of the variables "inevitably" left out of regression models of central bank behavior, including responses to financial crises, changes in exchange rates, and mistakes in estimating potential output: a list that extends over a considerable range in other words. The nonstationary model has simple i.i.d errors but with the added ingredients of the nonstationary terms G_t and F_t, assumed here to be exogenous. Next, using the different parts of the determinants of potential output and the real rate of interest, this NSDSGE model can be related to the standard stationary model using the following decomposition (after substituting for the definition of the actual real interest rate in (13) and (14))

$$\pi_{t+1} = \frac{1}{\tilde{\beta}}\pi_t - \frac{\tilde{\kappa}}{\tilde{\beta}}y_t - \frac{\varpi_t}{\tilde{\beta}} + \frac{\tilde{\kappa}}{\tilde{\beta}}\lambda_Y G_t \qquad (15)$$

$$y_{t+1} = y_t + \tilde{\sigma}r_t - \xi_t + \lambda_Y \Delta G_{t+1} + \tilde{\sigma}\lambda_R F_t \qquad (16)$$

The first part of each equation is similar in its general form to that of the standard model (1) – (2) above but the each have the important difference now of nonstationary terms in the driving variables G_t and F_t at the end of each equation.

The rest of this section uses this decomposition to review the properties of solutions of two models: a stationary DSGE one using (1) and (2) and that of the NSDSGE given by (15) and (16) above. Its attention is on two prominent features of policy analysis in the literature: the central role of a sufficiently strong interest rate reaction to inflation to deliver a determinate solution to the DSGE model, and the policy implications of aggregate demand as opposed to aggregate supply shocks. On this last point, the standard result is that the interest rate should fully offset any aggregate demand shocks, whereas it should accommodate supply shocks to potential output by keeping nominal interest rates constant. We

offer further comments on these features in the light of the events in the recent crisis, concentrating on examples with simple policy rules[29].

4.3.1. Determinacy and the "Taylor principle"[30]

We start with a preliminary exercise centring on the issue of determinateness of the stationary model (1) – (4) which, after substituting for the real interest rate, is

$$X_{t+1} = AX_t + Bs_t \qquad (17)$$

where $X_{t+1} = \begin{bmatrix} \pi_{t+1} \\ y_{t+1} \end{bmatrix}$, $A = \begin{bmatrix} \frac{1}{\beta}, & \frac{-\kappa}{\beta} \\ \frac{-\varphi}{\beta}, & (1+\frac{\kappa\varphi}{\beta}) \end{bmatrix}$, $B = \begin{bmatrix} -\frac{1}{\beta}, 0, 0 \\ 0, -\varphi, \varphi \end{bmatrix}$ and $s_t = \begin{bmatrix} u_{t+1} \\ r^W_{t+1} \\ i_{t+1} \end{bmatrix}$

This version of the DSGE model is fully forward-looking in that both of its endogenous variables, inflation and output, are not predetermined. It is has long been known that this sort of model is indeterminate in the absence of control, i.e. where the interest rate is taken to be exogenous. In the light of this it has been argued that, by adding an appropriately designed simple interest rate rule of the form

$$i_t = \alpha_\pi \pi_t + \alpha_Y y_t \ , \qquad (18)$$

determinacy may be achieved providing the response to inflation (α_π) or output deviations (α_Y) is sufficiently strong (see Svensson and Woodford, 2003).[31] But, in turn, this result has been disputed recently on the grounds of the implausibility of the resulting determinate solution (see the exchange between McCallum and Cochrane in McCallum, 2009, and Cochrane, 2009 and 2011). Without commenting further on this aspect of the issue, another concern about determinacy is raised here; one based on the appearance of nonstationary terms in the model, such as those already described. Intuitively, it appears unlikely that using a rule like (18) for the nonstationary model (15) and (16) will lead to determinacy, as the rule

[29] Further detail on theses exercises, including some extension to the fully optimal case are given in a short Annex to the paper available from the author.

[30] I am grateful to Malcolm Pemberton for advice and comments on this section. Final responsibility for its contents remains my own

[31] The precise requirement is $\alpha_R + \frac{(1-\beta)}{\kappa}\alpha_Y > 1$. On the importance of the "Taylor principle" of which this is an example, see Woodford (2003) and Lubik and Schorfheide (2003).

depends only on deviations of inflation and output from natural rate targets so does not make any allowance for the nonstationary ingredients in the model. Generally, this intuition is correct. Even so, the exercise does produce one useful insight, as is described below, and the section also serves as an introduction to the basic features these nonstationarities introduce into these models and their solution under simple rules.

4.3.2. Solving the NSDSGE

Solving the nonstationary model (15) and (16) using the same simple policy rule (18) applied to the stationary model gives the dynamics of the nonstationary model under this special assumption about the policy rule as

$$X_{t+1} = \tilde{A}_C X_t + D\varsigma_t + \tilde{B}\tilde{\xi}_t \qquad (19)$$

where the $\tilde{A}$ matrix with active control is the matrix $\tilde{A}_C$, defined as

$$\tilde{A}_C = \begin{bmatrix} \frac{1}{\tilde{\beta}}, & \frac{-\tilde{\kappa}}{\tilde{\beta}} \\ \frac{-\tilde{\sigma}}{\tilde{\beta}} + \tilde{\sigma}\alpha_\pi, & (1 + \frac{\tilde{\kappa}\tilde{\sigma}}{\tilde{\beta}} + \tilde{\sigma}\alpha_Y) \end{bmatrix}, \text{ and } D = \begin{bmatrix} 0, & \frac{\tilde{\kappa}}{\tilde{\beta}}\lambda_Y L, \\ + \tilde{\sigma}\lambda_R L, & (\lambda_Y(1-L) + \tilde{\sigma}\frac{\tilde{\kappa}}{\tilde{\beta}}\lambda_Y L), \end{bmatrix}, \ \varsigma_t = \begin{bmatrix} F_t \\ G_t \end{bmatrix}$$

where L is the lag operator. The form of the $\tilde{A}_C$ matrix is evidently that of the stationary model (17) above, but with different parameters in both the AD and AS equations. But, more importantly, the decomposition of (15) and (16) shows that the nonstationary model is a non-homogeneous system. The standard DSGE avoids this non-homogeneity by defining the DSGE in terms of deviations from a balanced growth path, where this path is assumed, *a priori*, to be bounded. Where there are additional exogenous terms such as (3) and (4) in the stationary model, these give only temporary deviations away from the equilibrium path, by assumption. In contrast, solving (19) under a simple policy rule needs a two part solution where each part is of importance. That is, the solution is one part for the homogeneous part plus a particular solution for the additive exogenous terms which are now nonstationary and so non- trivial. In general, the problem this leads to is that the specific time-form of the nonstationary variables (F_t, G_t) will determine the time-form of any particular solution, and hence the kind of interest

rate equation needed to achieve, for example, a bounded solution to the model. Again, it can be expected that this extended policy rule will have to include feedback from the nonstationary part of the model.

To illustrate this, we assume there is only one nonstationarity, which affects the AD equation only and this is a simple form of Markov switching effect, of a unit step form over a given interval. Thus let the AD equation (16) be of the form

$$y_{t+j+1} = y_{t+j} + \bar{\sigma} r_{t+j} - \bar{\sigma}\lambda_R \chi q_{t+j} - \xi_{t+j} \qquad (20)$$

where the variable q_{t+j} is the scalar version of the nonstationary wedge variable in the effective real interest rate described earlier and the parameter χ is a switching variable defined below. . To illustrate the effect of the nonstationarity the simplest form for it is taken, assuming it is constant, e.g. $q_{t+j} = k, (j = 1,2,....)$ and, without loss of generality, setting this to unity. The parameter χ takes the value zero (no effect) or unity over a known period (indexed by j). The effect of these assumptions is that the nonstationary departure from the balanced growth path has the unit step form. Although the duration of this asset price effect is assumed to be finite, it could be long- lasting; the UK house price inflation preceding the crisis of 2008 was over a decade long for example. It is also assumed (unrealistically) that the unit form for the q_{t+j} shock and the duration of its period is known with certainty. Hence, for the period when the nonstationarity operates, $t + j$, (j=1,…N), the AD equation is

$$y_{t+1} = y_t + \bar{\sigma} r_t - \xi_t - \bar{\sigma}\lambda_R \qquad (21)$$

since χq_t =1 according to our assumptions.. The NSDSGE model under the control of rule (18) as before, is now

$$X_{t+1} = \tilde{A}_C X_t + \tilde{D}^T \chi E_t q_t \qquad (22)$$

where $\tilde{A}_C$ matrix is as defined above and the $\tilde{D}^T$ vector is the transpose of $(0, -\bar{\sigma}\lambda_R)$. Then the particular solution for the finite period where there is a non-zero χ (taken here to be for the period $t + j, j = 1,....., N$) is (dropping the E operator as it is redundant)

$$X^*_{t+j} = (I - \tilde{A}_C L)^{-1} \tilde{D}^T \chi q_{t+j} \qquad (23)$$

Letting $B(L) = (I - \tilde{A}_c L),$ this gives

$$(\det B(L))X^*_{t+j} = (adjB(L))\tilde{D}^T \chi q_{t+j} \qquad (24)$$

Providing the characteristic equation of $\tilde{A}_c$ has distinct roots, λ_1, λ_2 both greater than one, a fully forward-looking solution to (24) is,

$$X^*_{t+j+1} = \frac{1}{(\lambda_1^{-1} - \lambda_2^{-1})}[\frac{\lambda_1^{-1}}{(1-\lambda_1^{-1}L^{-1})} - \frac{\lambda_2^{-1}}{(1-\lambda_2^{-1}L^{-1})}](adj(B(L)L)\tilde{D}^T \chi q_{t+j} \quad (25)$$

for the period j = 1,…,N.

In detail, the solution for inflation and output over this period is

$$\pi^*_{t+j+1} = \frac{\tilde{\kappa}\bar{\sigma}\lambda_R}{\beta(\lambda_1^{-1} - \lambda_2^{-1})}\sum_{j=1}^{N}(\lambda_1^{-j} - \lambda_2^{-j})q_{t+j} \qquad (26)$$

$$y^*_{t+j+1} = -\frac{\bar{\sigma}\lambda_R}{(\lambda_1^{-1} - \lambda_2^{-1})}\sum_{j=1}^{N}(\lambda_1^{-j} - \lambda_2^{-j})(1-\frac{L}{\tilde{\beta}})q_{t+j} \qquad (27)$$

and these are the particular solution to the nonstationary part of the model, weighted by the roots of the stationary system (the inverses of λ_1, λ_2). The form that these take depends on the specific form of the liberalisation term; a unit step over a finite period, so the movements away from the orthodox solution due to allowing for this particular solution will also be that of a finite fixed amount (akin to a mean shift). Actual output changes mainly in the first quarter only, as the shock enters (27) in something close to a first difference, but as its level then remains above potential afterwards in the absence of any policy correction, inflation rises. This happens in spite of the interest rate rule following the Taylor principle as normally construed. An amendment to rule, to allow for a response to the shock will offset these effects if the extra tightening is a similar unit step form too. In spite of this example being a relatively trivial one, it nonetheless serves to show the principal involved. For this very special form of shock, under the Taylor principle, the solution departs from the orthodox one by a factor uniquely determined by the shock. Clearly, an amended "simple" policy rule can be derived that would offset these effects and this can be expected to imply that interest rates be increased over and above what the Taylor principal requires by an amount and a form dictated by the assumed size and timing of the shock. Other more realistic and complex forms for the q_{t+j} shock will yield the same conclusion if the same informational assumptions about it are made. For this, quite but obviously not completely general, reason, the Taylor principle would not give determinacy, and an additional requirement for extra interest rate changes to offset the effects of the shock in

the model of (26) and (27) is needed, where the extra interest rate change depend directly on the time-form of the nonstationarity (or nonstationarities) in the model. We comment further on how more plausible extensions to this framework might be made, after a special case of the solution is briefly noted.

A special case of the type of solution just described may be used to shed some light on the Great Moderation in the UK. This reverts to the two nonstationary effects case; one on the AS the other the AD equation as described earlier. If it is then assumed that the authorities believe they inhabit the environment of the standard stationary model (1) – (4), whereas they are actually in that of the nonstationary one given by (19) then, arguably, this broadly represents the situation in the UK and its monetary policy stance over the last half of the 2000s. In this scenario, policymakers believe, mistakenly, that by controlling deviations of output and inflation from their standard natural rates and providing they apply the Taylor principle, their actions are fully adequate. This policy action would clearly be wrong in general, but there is at least one case where a bounded solution to equation (19) of the same type as that of the simple stationary example exists. This is where the overall effects of the two nonstationary vectors in $D\varsigma$ (that is, each shock multiplied by its weighting coefficient) are of opposite sign but are equal in absolute value. Then the dynamics of this model are essentially the same as the stationary model of (1)–(2). In words, this says that the expansionary stimulus in the AD equation due to financial liberalisation has its effects offset by the reductions in the NAIR rate of output in the AS equation, due in turn to the effects of globalisation[32]. This is not simply a curiosity as it captures some of what seems to have happened over the late 1990s and the first half of the 2000s in the UK if, as we (and some others) believe, the effect of global changes was to lower the rate of inflation in the UK at given activity levels while, at roughly the same time, financial liberalisation acted to increase aggregate demand largely by its effect on increasing consumption.

The conclusions to this section note some of the important limitations to the model it has used and relates these to its shortcomings for policy analysis.[33] The major limitation in the model is that it treats the nonstationary term in the AD equation as exogenous.

[32] Other factors played a part in this supply improvement including the effects of inward migration on the labour supply and possible improvements in labour productivity, but are ignored here for simplicity.

[33] In what follows, extensions to the social welfare function to allow for the risks of potential bank runs and systemic collapse are ignored. Attention is directed purely on lessons for the economic model to use in the light of the recent crisis.

As we have already stressed, behind the lowering of the effective real interest rate following the changes to the financial sector there were major changes in banks' leverage and growing systemic risk in the financial and the household sectors, neither of which is explicitly included in the present partial model. Put simply, the illustration above takes the growth in financial fragility as given, so its policy implications are limited to treating the consequences of this excess demand once it has emerged. Among extensions which can try to cope with this shortcoming the most important, in our judgement, would be extended DGSE models with multiple banks such as those noted in section 3. Our judgement is that such an extension is critical, because the 2008 crisis was, at root, a banking crisis brought about by excessive risk taking by the banks combined with a failure by the authorities to take proactive moves to ward of its systemic consequences. In the meantime, further extensions to some of the analytics of the interim model used here (i.e, without an articulated banking system) are clearly desirable. These include both having more elaborate time-series model for the exogenous labour market and financial liberalisation shocks, as well as using explicit learning models of expectations formation; both about the expected time–form of the shocks but also about their expected duration.

To end this section, in the light of its simplifications it needs to be stressed that the results above are best thought of as illustrative only. They suggest that liberalisation effects could shift the AD upwards possibly for extended periods of time. Although, this was not extended explicitly to the case of a nonstationary mean shift in the AS equation occurring at the same time, the discussion mentioned possible combinations of these two shifts which could mask growing threats of financial instability. Two things follow from this it seems. One is that in our examples the "standard" transmission mechanism is used via the output gap and hence inflation. Hence, even in the example it uses, it would be changes in inflation only that would trigger a policy response. But secondly, it might be hoped that, in the light of evidence that the consumption ratio was nonstationary - as postulated in the model and in the light of what the BoE's financial stability experts were advising them - the monetary authorities might realise that there were problems in the banking system and so act to curtail bank's lending. Unfortunately, the leadership at the BoE at the time showed, and subsequently has shown, little willingness to make those connections.

5. Conclusions

The theme of this paper has been to interpret UK monetary policy over the past decade as seen through the lens of the DSGE model. It has argued that not allowing for globalisation effects and commodity price shocks on inflation and unemployment was a crucial omission in official assessments probably to the belief that the "success" of the Great Moderation was due largely to monetary policy up to the mid-2000s. The BoE's judgement on this may not simply have been wrong, but may also have played a part in inhibiting them from proactive action when financial fragility was in evidence in the second half of the 2000s. On the issue of regime change in the financial sector, the case made here is that the econometric and descriptive analysis available in the first half of the 2000s provided clear evidence of very considerable systemic risk in the household and banking sectors. Singling out one of the elements emphasised here, the consumption–income ratio, at the end of 2006 this stood at just above its level in the second half of 1990, immediately before the crash then. This evidence, and its probable connections with house price increases, together with the likelihood that this was interwoven with the large-scale expansions of bank lending to households, was dismissed by the BoE and some independent members of the MPC in spite of persuasive evidence in its favour made by outside experts and the descriptive account of emergent systemic risk made by its own financial stability section. The paper has used a counterfactual exercise where the authorities incorporate broad features of time-series evidence available in the mid-2000s and use the resulting "interim"framework to set monetary policy. The aim has been to illustrate the possible benefits of extending the equilibrium model which appeared to underpin the BoE's deliberations. Its conclusion is that, far from being a technical detail, an allowance for effects on the economy due to ongoing regime changes in their preferred model would have had major implications about what caused the observed changes in UK unemployment and inflation over the past two decades or so, as well as defining what policy changes would be appropriate in the presence of major monetary regime change.. Had it been used in this way from the mid-2000s onwards it is probable that the scale of the first-round effects of the financial crisis in reducing UK GDP would have been smaller, as proactive monetary tightening to curb excessive bank leverage and lending to households would have reduced the country's exposure to the world financial crisis, and reduced the first-round effects of the crisis on UK GDP, moving it down from its high ranking in those countries most damaged by the world recession. In comparison,

Canada, which openly used monetary policy in the way advocated here, had an output fall of –2.4% in 2009 followed by growth of 3.4% in 2010, compared with the UK's fall of –4.0% and then growth of 1.8% over the same period. Although other factors were at work here it seems that their active use of interest rates did have some effect in reducing the effects of the world recession on the Canadian economy. One other consequence of the "benign neglect" adopted by the authorities in the face of house price inflation, fast rising credit and other evidence of growing financial fragility was, that by accepting these price increases, the authorities reinforced markets' beliefs that these trends would continue and were sustainable. In effect, loose monetary policy confirmed the (erroneous) market judgment that downside risk in the housing and interbank markets were minimal.

Since the crisis, senior BoE staff on the MPC have, on several occasions, rejected the argument that the active use of monetary policy could have been used to ease the fragility of the financial sector. One argument they have made is that of having insufficient tools to deal with the apparent build-up of the financial stresses in the financial system and that proactive interest rate increases would "merely" have lowered UK growth and risked undershooting the inflation target (see in particular Bean, 2008, and King, 2009).[34] There are two omissions underlying such claims. One is that had alternative "macro-prudential" tools been available before the crisis, and had they been used, this would undoubtedly have reduced growth. The other is that the BoE's argument ignores the possibility of there being any economic gains to any proactive interest rate increases. Given the scale of the first-round falls in UK GDP in 2009 noted above, this was a surprising underestimate of the risks incurred by inaction.

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[34] Bean (2009) suggests that since the crisis the balance of the argument has moved in favour of extra allowance for asset price inflation in interest rate decisions.

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