DOES INSTRUMENT INDEPENDENCE MATTER UNDER THE CONSTRAINED DISCRETION OF AN INFLATION TARGETING GOAL? LESSONS FROM UK TAYLOR RULE EMPIRICS

ALEXANDER MIHAILOV

Abstract. We ask whether a shift to *instrument* independence affects central bank behavior when monetary policy is already operating under the constrained discretion of an inflation targeting *goal*. Taking advantage of the unique UK experience to identify such an exogenous break, we estimate Taylor rules via alternative methods, specifications and proxies. We detect empirically two novel results: the Bank of England has responded to the output *gap*, not growth; and in a much stronger way once *more* independent. Both findings are consistent with New Keynesian theory of monetary policy, the Bank's mandate, and the evolution of the UK business cycle. Moreover, the institutional move to greater autonomy of the Bank of England, having also augmented its responsibility, accountability and transparency in achieving the delegated inflation target, has in effect increased the sensitivity of the Bank to, and the freedom to counter, inflationary pressures arising – with anchored inflation – via the output gap.

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1. The Recent UK Monetary Policy Framework as a 'Controlled Experiment'

An issue of cardinal importance in economic policy research, debates and reforms that has not yet been sufficiently studied is how institutions influence policy and economic outcomes. This paper constitutes an effort to improve our understanding in this general direction, by focusing on a particular type of institutional change that arises only rarely in economic contexts, in the sense of resembling a 'controlled experiment'. Our objective here is to address the question whether a shift to *instrument independence* affects central bank behavior when monetary policy is already operating in an inflation targeting regime, implying *goal dependence*.[1] Such has been the recent experience with monetary policy making in the United Kingdom (UK). We examine it empirically, in terms of policy reaction functions recovered from the data.[2]

UK monetary authorities moved to (flexible) inflation(-forecast) targeting in October 1992, and in May 1997 the Bank of England (BoE) was formally granted operational independence from Her Majesty's (HM) Treasury. In essence, the shift allowed the newly inaugurated Monetary Policy Committee (MPC) at the Bank to *set* interest rates (each month), earlier the task of the Chancellor of the Exchequer at the Treasury. Before this institutional change the Bank of England was one of the least independent major central banks in the world.[3] Being granted *instrument* independence, it did not receive *goal* independence, though, to use the terminology introduced by Fischer (1994) and Debelle and Fischer (1994). The responsibility for setting the primary goal of monetary policy, in terms of a numerical inflation target (every year), was kept with HM Treasury. This nuance is important, insofar the BoE has no autonomy as large as that of the European Central Bank (ECB) or the Federal Reserve System (Fed). The Bank of England still has to act under the 'constrained discretion', in the words of Bernanke and Mishkin (1997) – or 'flexible rule', according to Woodford (2003) – imposed by the inflation targeting framework. Yet the Bank's augmented *degree* of operational freedom was also accompanied by a corresponding increase of its responsibility, accountability and transparency in achieving the delegated inflation target, as, for instance, Lasaosa (2005) has emphasized.[4]

Because of the explicit public announcement of the timing of these changes, to inflation targeting and to operational independence, both could be interpreted as *exogenous*. We therefore see in that a rare opportunity to explore econometrically the effects of central bank instrument independence on policy

[1]Inflation targeting – or, more precisely, inflation-forecast targeting – is the monetary strategy that appears to have become dominant in the modern theory and practice of central banking; see, for instance, Piger and Thornton, eds. (2004) or Bernanke and Woodford, eds. (2005).
[2]An approach evaluating the outcomes of central bankers' intentions ('words') and actions ('deeds') that prevails in current applied work; see Clarida, Galí and Gertler (1998, 1999, 2000) and the subsequent literature.
[3]This has been admitted, among others, notably by Eijffinger and Schaling (1995) in a pre-independence publication of the Bank itself.
[4]See also Briault, Haldane and King (1997), for an earlier account on the relationship between Bank of England's independence and accountability, and Eijffinger and Hoeberichts (2002), for an international comparison along the lines of accountability and transparency.

responses shaped out under the goal dependence of an established inflation targeting strategy. To the best of our knowledge, this is the first paper to deal directly and through an *applied* perspective with the interesting, policy-informing issue summarized in the title.

The corresponding *theoretical* perspective appears to have been better explored, notably in recent research within the 'legislative approach to monetary policy', as labeled by Athey, Atkeson and Kehoe (2005), broadly involving issues of optimal contracts, mechanism design or principal-agent interactions. This literature extends, in fact, earlier work on optimal monetary policy in the tradition of Kydland and Prescott (1977), who established the dominance of *rules* over discretion because of the 'time-(in)consistency' problem: it leads to ex-post incentives for a government to use 'surprise inflation' to reduce the real value of any outstanding fiat money, as Calvo (1978) pointed out, and to what Barro and Gordon (1983 a) termed (average) 'inflationary bias' of a central bank acting upon discretion (and, potentially, under the influence of interfering politicians, i.e., the 'political business cycle'). With repeated interaction, Barro and Gordon (1983 b) proposed the build up of (good) *reputation* and, hence, *credibility* as a solution to the inflation bias under discretion and, thus, as an alternative to a rule-based policy. Canzoneri (1985) then showed *discretion* to be optimal when the central bank can exploit private information. Other solutions to the inflationary bias were further on suggested in the literature, the most prominent being Rogoff's (1985) central banker with *'conservative' preferences*, Walsh's (1995) *contract-theory approach*, and the still broader *institutional-design perspective* on targeting rules as a particular modern type of monetary regime. Such *inflation targeting* frameworks were initially adopted in the early 1990s by pragmatic central bankers and government officials in New Zealand, Canada, Chile, Israel, the UK, Sweden, Australia, Finland and Spain, to be somewhat later more formally justified in a growing number of academic papers and books.[5]

The theoretical arguments we sketched, supported by the findings of the parallel empirical literature,[6] summarize why a central bank should be legally and *de facto* made independent from interfering governments or parliaments with shorter-term horizons and vested interests. Simply put, a more autonomous central bank tends to lead to a lower actual inflation, on average, thus avoiding the inflationary bias. However, there are also theoretical and empirical claims against (too much) central bank independence: (i) too much independence may leave the central bank unaccountable, and this is certainly not democratic; (ii) the credibility problem of central banks may either not really exist, being merely a theoretical

[5]Following the lead of Haldane, ed. (1995), Leiderman and Svensson, eds. (1995), Svensson (1997 a, b), Bernanke and Mishkin (1997), Herrendorf (1998), Vickers (1998), and Bernanke, Laubach, Mishkin and Posen (1999), to enumerate the earliest work that concentrates explicitly on inflation targets.

[6]Beginning with Parkin and Bade (1978), Alesina (1988), Cukierman (1992) and Alesina and Summers (1993), to mention the earliest studies, all claiming desirability of central bank independence. More recent, again largely favorable, overviews are provided in Berger, de Haan and Eijffinger (2001) and Walsh (2005), among others.

artefact, or – conversely – extend as well to consolidated government entities;[7] (iii) an autonomous monetary authority may care too much about inflation and totally ignore output and employment fluctuations, and may therefore slip into a 'deflationary bias' which disrupts the financial system and economic activity.[8] That is why restrictions have been suggested to the degree of central bank independence too, which leads us to the question we pose as a title to the present empirical study.

Fischer (1994) and Debelle and Fischer (1994) have first argued that *instrument independence* coupled with *goal dependence* – specified by Svensson (1997 a) and Herrendorf (1998) as an *inflation targeting* framework, whereby the government delegates the reference interest rate setting to the central bank (or a monetary policy committee) but retains the quantification of the numerical inflation goal for itself – is the socially optimal institutional arrangement to formulate and implement monetary policy in a democratic society. This type of monetary regime is what Bernanke and Mishkin (1997) eloquently called *constrained discretion*, again in an inflation targeting context. Eijffinger and Hoeberichts (2002) have further emphasized that such a democratic approach to the conduct of monetary policy would require augmented *responsibility* of the central bank for its actions as well as *accountability* to the government and/or parliament. Accountability implies a few dimensions, one of which – with a potential to solve the private information problem identified by Canzoneri (1985) when central bank discretion is optimal – is the *transparency* of actual policy making.

There are, thus, huge applied as well as analytical literatures on both *central bank independence* and *inflation targeting*, but in isolation. One contribution of the present econometric study is to look at their *intersection*. We mostly build on the Taylor rule methodology in Clarida, Galí and Gertler (1998, 2000) and Nelson (2003) but also on other relevant studies on the UK. We detect empirically two novel results: first, throughout the inflation targeting period the Bank of England has systematically responded to the output *gap*, and not at all to output *growth*; second, it has done so in a much stronger way *once* being granted *instrument* independence. These findings are consistent with New Keynesian theory of monetary policy, the Bank's mandate, and the evolution of the UK business cycle. Yet we stress in interpreting them that the institutional move to greater autonomy of the BoE has played a major role too, reflected in the estimated *quite higher* post-independence response to the output gap: receiving operational freedom has, in effect, augmented the Bank's responsibility, accountability and transparency in achieving the delegated inflation target and has ultimately increased the sensitivity of the Bank to inflationary pressures arising – with anchored inflation – via the output gap.

[7] McCallum (1997) notably argues that (i) it is inappropriate to presume that central banks will, in the absence of any tangible precommitment technology, inevitably behave in a 'discretionary' fashion that implies an inflationary bias, and sees no necessary tradeoff between 'flexibility and commitment'; (ii) to the extent that the absence of any precommitment technology is nevertheless a problem, it will apply to a consolidated central bank-plus-government entity as well, and thus contracts between governments and central banks do not overcome the motivation for dynamic inconsistency. Forder (1998, 2000) surveys such issues in a rather similar skeptical light too.

[8] The classic example of the Great Depession and the recent one of Japan's long deflation could be invoked here.

The paper is further down structured as follows. The next section describes the data and some preliminary tests. Section 3 presents our alternative estimation methods and specifications of Taylor rules and discusses the econometric results we obtain, offering a unifying interpretation of our principal findings. The fourth section concludes.

2. Data and Preliminary Tests

2.1. **Data.** All data were downloaded from the statistical pages on the websites of the UK Office of National Statistics (ONS) and the Bank of England (BoE). Our sample consists of *quarterly* observations, starting with the fourth quarter of 1992, when inflation targeting was introduced in the UK, and ending with the fourth quarter of 2004. The second quarter of 1997, when instrument independence was granted to the BoE, splits the sample into a pre-independence and post-independence subsamples.

Following most other Taylor rule papers on the UK, in particular Nelson (2003) and Martin and Milas (2004), we assume that the short-term interest rate supposed to be the operating instrument of the Bank of England is best proxied by the *3-month Treasury bill rate*. Inflation is measured by two alternative indexes that are usual choices when working with UK data: (i) the *Retail Price Index* (RPI), as in Martin and Milas (2004) and Kesriyeli, Osborn and Sensier (2004), among others; and (ii) the same Retail Price Index but *eXcluding* the *mortgage rate* (RPIX), as, for instance, in Nelson (2003).[9] Our measure for the output gap is, alternatively, constructed out of two available time series: (i) the *final* or *revised* data for real GDP, as in the majority of studies on Taylor rules; and (ii) the *real-time* or *initially released* data for the same variable, real GDP, available to policy makers 'in real time':[10] more precisely, we use the real-time series constructed by Nelson and Nikolov (2001) and accessible on the Bank of England's website. Moreover, we have filtered each of these real GDP series in level, real-time and final, by two now standard (although not perfect) procedures to obtain respective measures for the output gap, namely: (a) by fitting a *quadratic* trend, as in Clarida, Galí and Gertler (1998, 2000) and Nelson (2003), among others; and (b) by a *Hodrick-Prescott* detrending (with a smoothing parameter equal to 1600, as recommended for quarterly data), as in Martin and Milas (2004) and Kesriyeli, Osborn and Sensier (2004), among others. These procedures have, of course, their advantages and shortcomings. To arrive at results that are not necessarily sensitive to the detrending employed, we have preferred to work with both filters.

Descriptive statistics for the two periods of interest in the present study, *pre*-independence inflation targeting (1992:4-1997:1) in Figure 1 and *post*-independence inflation targeting (1997:3-2004:4) in Figure 2 are illustrated below.

[9] The RPIX has been the officially announced measure of UK inflation and guide for UK monetary policy in the period 1992-2003, and the RPI has performed that same role before 1992.

[10] Orphanides (2001, 2003) first argued in favor of real-time data, on the grounds that they are more realistic and, hence, that they usually fit better Taylor rule regressions.

[Figure 1 and Figure 2 about here]

2.2. **Preliminary Tests.** Nominal GDP data and the GDP deflator – hence, real GDP, by construction – were available at their source as *seasonally adjusted* (sa), whereas both price levels, the RPI and the RPIX, as well as the 3-month Treasury bill rate were *not seasonally adjusted* (nsa). We thus performed seasonality tests and found both price levels and the interest rate to display seasonal patterns. Consequently, *two* versions of our Taylor rule regressions were estimated: (i) with the *raw* data; and (ii) with *seasonally adjusted* RPI, RPIX and 3-month Treasury bill rate.

In a similar study for the euro area based on the cointegration approach, Gerlach-Kristen (2003) pointed out that stationarity tests for the variables entering Taylor rule regressions were not systematically reported in most of the previous literature. In agreement with her critique, we tested our variables for stationarity, applying three alternative unit root tests. We generally found that the price levels, RPI and RPIX, could be either I(1) or I(2); hence, inflation could be stationary or not, depending on the chosen test. The 3-month Treasury bill rate and the real GDP gap obtained from quadratic-trend fitting cannot be treated definitely as stationary either. Only the real GDP gap obtained from Hodrick-Prescott detrending appeared to be most likely I(0). With no overwhelming evidence against stationarity and bearing in mind the notorious low power of unit root tests, in particular in short samples like ours, we ultimately followed the New Keynesian theory of monetary policy and performed Taylor rule estimation in the standard way, that is, relying on the procedure in Clarida, Galí and Gertler (1998, 2000). These authors defend the key assumptions in their work – stationarity of inflation and the nominal interest rate, as we shall also assume here – by stressing that they are both empirically and theoretically plausible.

3. Estimation Methods, Specifications Estimated and Key Findings

Our overall empirical strategy was to apply the most common techniques used by now in similar Taylor rule studies. These techniques relate to ordinary least squares (OLS), in the earliest literature, and to two-stage least squares (TSLS) and the generalized method of moments (GMM), in the more recent papers. Another objective we pursued was to begin from simpler specifications and move to more complicated Taylor rule versions and to econometrically better suited and justified techniques, thus basically following the chronology in which the literature evolved. We therefore started with a logical point of departure, by estimating the *original* Taylor rule with a few alternative proxies. Tests for structural breaks were then performed on it, essentially to check the validity of our split of the UK inflation targeting sample in the second quarter of 1997. Yet for theoretical and econometric reasons made clearer further down we give most weight to our findings when subsequently employing the GMM approach to estimating *forward-looking* Taylor rules popularized by Clarida, Galí and Gertler (1998, 2000).[11]

3.1. **Ordinary Least Squares: Classic and Backward-Looking Taylor Rules.**

3.1.1. *Point of Departure: The Original and Classic Taylor Rules.* We estimated *the* Taylor (1993) rule on UK quarterly data for our two subsamples both in its *original* specification and in what we would call, following Woodford (2003), *classic* version. The original Taylor (1993) rule can be written as

$$i_t^T = i^T + b_{\pi,0}\left(\pi_t - \pi^T\right) + b_{x,0}x_t, \tag{3.1}$$

where i_t^T is the nominal interest rate (NIR) *targeted* by the monetary authority (i.e., the short-term policy instrument), $\pi_t - \pi^T$ is the so-called inflation gap (that is, the deviation of actual inflation, π_t, from a constant inflation target, π^T), $x_t \equiv y_t - y_t^P$ is the output gap (with y_t being actual output and y_t^P some measure of *potential* output). i^T is the *desired* constant NIR target when both gap measures are zero; more precisely, $i^T \equiv r^* + \pi^T$, where r^* is interpreted in a Wicksellian manner[12] as the constant equilibrium 'natural' real interest rate. $b_{j,l}$ denotes the coefficient to the respective *variable* of interest (expressed by the relevant *letter* according to our notation) $j = \pi, x, i$ ($j = 0$ stands for some compound intercept terms made explicit in the formulas that follow) at a respective *lag*$(-)$/*lead*$(+)$ (expressed by an integer *number*) $l = ..., -2, -1, 0, +1, +2, ...$ ($l = 0$ designates, of course, a current-period response). We can estimate (3.1), as specified with contemporaneous response parameters, directly from the data (for i_t^T, π_t and x_t) if we *know* the inflation target π^T. We did so with $\pi^T = 2.5$, as is most appropriate for our particular country case and sample period (which will become evident a little bit later, when describing potential structural breaks). If we do *not* know the inflation target, (3.1) can be rewritten as

$$i_t^T = \underbrace{\left(i^T - b_{\pi,0}\pi^T\right)}_{\equiv b_{0,0}=const} + b_{\pi,0}\pi_t + b_{x,0}x_t \tag{3.2}$$

and estimated in the form of (3.2) as a *classic* Taylor rule.

Our results are presented in the first pair of columns in Table 1.

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[11]Another recent estimation technique was implemented by Muscatelli, Tirelli and Trecroci (2002). They apply the *structural time series* (STS) approach proposed by Harvey (1989) to *generate* series of the *expected* inflation rate and output gap. By contrast, the Clarida-Galí-Gertler (1998, 2000) GMM approach essentially consists in using the *errors-in-variables* method to *model* rational expectations: in it, instead of forecasting inflation and output – e.g., by Kalman filter methods, as in Muscatelli-Tirelli-Trecroci (2002) – future *actual* values replace as regressors *expected* values, as we explain later on.

[12]Woodford (2003), chapter 1, traces the intellectual history of policy reaction functions back to the works of Wicksell (1898, 1907).

[TABLE 1 ABOUT HERE]

The *original* (or *classic*, if estimated transformed) Taylor rule performs quite impressively during our *post*-independence subsample. All variables are (i) statistically significant and have (ii) the expected (from theory) sign and (iii) magnitudes that seem quite reasonable. Furthermore, the coefficients $b_{\pi,0}$ and $b_{x,0}$ are found practically the same, 0.85, as Taylor (1993) argued (however, he quantified them both at 0.5 instead, without attempting econometric estimation). The only major problem with the regression results in Table 1 is *serial correlation* (reflected in the value of the Durbin-Watson statistics). Lagrange multiplier Breusch-Godrfrey tests have established a likely positive autocorrelation of the residuals of the regression of order 1. When an $AR(1)$ correction in the error process is introduced in the equation, with no any other modification, our results do not change qualitatively (although in quantitative terms policy responses become twice weaker), as can be seen in the second pair of columns in Table 1. In the *pre*-independence subsample another problem is that the *output gap* is statistically indistinguishable from zero, no matter which measure we use for it. However, when using more complicated Taylor rule specifications and more sophisticated econometric techniques, as reported further down, we obtain results of a similar spirit. One interpretation may be in the sense that the Bank of England has not (systematically) considered the output gap in designing its monetary policy during 1992-1997 but has (consistently) reacted to it, as well as to inflation, during 1997-2004. Moreover, the estimated coefficients on inflation do not unambiguously indicate that the response to it by the BoE has increased or decreased in magnitude in the post-independence period relative to the pre-independence one. We return with more analysis and a plausible interpretation to these initial findings in the later parts of the present section.

3.1.2. *Structural Break Tests.* To check for structural breaks in our sample and, in essence, to see if our sample split could be confirmed econometrically, we performed Chow *breakpoint* and *forecast* tests on the classic Taylor rule (3.2). The *dates* we selected for the tests were potentially the most likely ones to have resulted in structural instability in UK monetary policy throughout the 1990s and until 2004. All these changes have been implemented following *official public announcements*, as discussed by Nelson (2003), among others, and can thus be considered as *exogenous*:

(1) Membership of the British sterling in the *Exchange-Rate Mechanism* (ERM) of the European Community, as from October 1990;
(2) Sterling crisis and suspension of the ERM in the UK, in September 1992, followed by the instauration of an *inflation targeting* framework for monetary policy as from October 1992;
(3) Target inflation reformulated in June 1995 from a target *band* (or *range*) of 1% to 4% (implying a *mid*-point of 2.5% p.a.) to an explicit medium-term *point* target of 2.5% p.a.;

(4) The Bank of England granted *operational independence* from HM Treasury in May 1997, and in June 1997 the 2.5% point target announced to become *symmetrical*: i.e., to give *equal* weight to circumstances in which inflation is higher or lower than the target rate;

(5) In December 2003, target inflation *lowered* from 2.5% p.a. to 2% p.a., and *expressed* as from January 2004 in terms of the Harmonized Index of Consumer Prices (HICP), instead of the RPIX.

The breakpoint and forecast Chow tests we performed confirmed that the structural breaks delimiting our sample, (2) and (4) above, are the most supported by the data. We, therefore, continued to estimate over our two subsamples and to compare the results across them.

3.1.3. *Backward-Looking Taylor Rules.* One way to address the problems of endogeneity and, potentially, serial correlation usually encountered in classic Taylor rule equations while still applying the OLS method is to estimate them with all regressors *lagged* and by also adding an additional *lagged* dependent variable. Such backward-looking Taylor rules can be written in the form:

$$i_t^T = b_{0,-n} + \sum_{n=1}^{N} b_{\pi,-n}\pi_{t-n} + \sum_{n=1}^{N} b_{x,-n}x_{t-n} + \sum_{n=1}^{N} b_{i,-n}i_{t-n}^T, \tag{3.3}$$

with the dynamic structure truncated at some relevant lag length N. Most papers have found that lags of 1 or 2 are often sufficient to capture the dynamics of such equations. Another common finding, in addition to the problems of a theoretical nature in ignoring forward-looking rational expectations,[13] has been that backward-looking Taylor rules are weak in terms of econometric output. This is what our results confirmed indeed.

3.2. **Two-Stage Least Squares: Classic and Backward-Looking Taylor Rules.** A second way to address the problems of endogeneity and, potentially, serial correlation in classic Taylor rule equations is to replace OLS by TSLS. Such is the main estimation strategy in Nelson (2003). It is also what we did next.

3.2.1. *The Original and Classic Taylor Rules Again.* Our TSLS results enhanced, as a matter of fact, those from the OLS estimation outlined above.

[Table 2 about here]

[13] On the other hand, a view has emerged that backward-looking rules contribute to protecting the economy from embarking on expectations-driven fluctuations. Yet Benhabib, Schmitt-Grohé and Uribe (2003) oppose this view in noting that a common characteristic of the existing studies that arrive at this conclusion is their focus on local analysis. Conducting global analysis instead, they find that backward-looking interest-rate feedback rules do not guarantee uniqueness of equilibrium.

Table 2 indicates that there is no any important difference in our conclusions, even in a quantitative aspect, regarding the policy responses of interest. First, such equations for the UK perform amazingly well and can be sensibly interpreted in the *post*-independence period of inflation targeting. Second, they suggest that the output gap has not mattered *before* operational independence but has mattered afterwards – even *more* than inflation, if we judge by the magnitude of the respective coefficient estimates – in monetary policy decisions at the Bank of England.

3.2.2. *Backward-Looking Taylor Rules Again.* Our TSLS estimation confirmed further what the OLS method had found earlier concerning *backward*-looking Taylor rules. That is why we would conclude that the poor performance of such equations is most likely due not to the particular econometric technique implemented but rather to their problematic justifiability from the perspective of economic theory.

3.3. **Generalized Method of Moments: Forward-Looking Taylor Rules.**

3.3.1. *Forward-Looking Specifications: Theoretical Rationale and Econometric Estimation.* As a third method to quantify Bank of England's feedback, in addition to OLS and TSLS, we finally turn to the popular Clarida-Galí-Gertler (1998, 1999, 2000) approach to estimating forward-looking Taylor rules. We do so because this recent methodology is appealing – and superior to both OLS and TSLS – in at least two respects, a theoretical one and an econometric one. By deriving from microfoundations monetary policy reaction functions within the set-up of the currently dominant and rather consensual paradigm of the New Keynesian macromodel, the approach provides a solid *theoretical* rationale for similar empirical work. The latter model, first derived by Yun (1996) and King and Woolman (1996), is also known – in a broader context – as the New Neoclassical Synthesis (NNS) model, after Goodfriend and King (1997). Such sticky-price analytical frameworks have by now been well explored, e.g., in Walsh (2003), later chapters, and Woodford (2003). For that reason, we would only sketch below the 'core' equations and relate them to the forward-looking feedback rules we estimated next, thus briefly clarifying the second major appeal of the Clarida-Galí-Gertler (1998, 1999, 2000) methodology, namely its *econometric* rationale. It follows from both the underlying economic model, NNS, and the corresponding estimation method, GMM. GMM essentially implies that some moment condition, or conditional expectation, should equal zero in equilibrium from theory (e.g., a consumption Euler equation or an orthogonality condition like the one we exploit later).

After log-linearization around a zero inflation steady state, the equilibrium conditions of the baseline NNS model are embodied in four equations. Following Clarida, Galí and Gertler (2000) in ignoring certain constant terms, but using our notation here, these can be written as:

$$\pi_t = \delta E\left[\pi_{t+1} \mid \mathcal{I}_t\right] + \lambda\left(y_t - \xi_t\right), \tag{3.4}$$

$$y_t = E\left[y_{t+1} \mid \mathcal{I}_t\right] - \frac{1}{\sigma}\left(i_t - E\left[\pi_{t+1} \mid \mathcal{I}_t\right]\right) + \zeta_t, \tag{3.5}$$

$$i_t^T = \beta_{\pi,+1} E\left[\pi_{t+1} \mid \mathcal{I}_t\right] + \beta_{x,0} x_t, \tag{3.6}$$

$$i_t = \beta_{i,-1} i_{t-1} + \left(1 - \beta_{i,-1}\right) i_t^T. \tag{3.7}$$

Equation (3.4) is a forward-looking Phillips curve, also known as a forward-looking aggregate supply (AS) curve. $\mathcal{I}_t$ is the information set at time t. δ is the discount factor from the utility function, and λ the output elasticity of inflation. $y_t \equiv \ln Y_t$ is the current-period level of output, and ξ_t is the natural rate of output, defined as the level of output that would obtain under fully flexible prices and assumed to follow an AR(1) process. This AS curve can be derived by aggregation of optimal price-setting decisions by monopolistically competitive firms under Calvo (1983) individual price adjustment.

(3.5) is a forward-looking IS curve, derived as a combination of a standard consumption Euler equation and a market clearing condition. σ denotes the coefficient of relative risk aversion (CRRA) embedded in the utility function. ζ_t is an exogenous demand shock, assumed an AR(1) process similarly to ξ_t.

Equation (3.6) is a forward-looking monetary policy rule of the usual Taylor type.

(3.7), finally, is an interest rate smoothing equation, where i_t is the *actual* NIR.

A more realistic, empirical counterpart of (3.6) is a commonly used linear instrument rule of the Taylor type:

$$i_t^T = i^T + \beta_{\pi,+k}\left(E\left[\pi_{t+k} \mid \mathcal{I}_t\right] - \pi^T\right) + \beta_{x,+q} E\left[x_{t+q} \mid \mathcal{I}_t\right]. \tag{3.8}$$

Adding and subtracting $E\left[\pi_{t+k} \mid \mathcal{I}_t\right] - \pi^T$ to the RHS of (3.8) and rearranging, implies an ex ante *real* interest rate *target* that can be written as:

$$r_{t,+k}^T = \underbrace{\left(i^T - \pi^T\right)}_{\equiv r^* = const} + \left(\beta_{\pi,+k} - 1\right)\left(E\left[\pi_{t+k} \mid \mathcal{I}_t\right] - \pi^T\right) + \beta_{x,+q} E\left[x_{t+q} \mid \mathcal{I}_t\right]. \tag{3.9}$$

Clarida, Galí and Gertler (1998, 2000) point to some insights embodied in (3.9); it clearly shows that (i) attaining the target 'on average' and assuming that the real interest rate is determined by non-monetary factors in the long run implies a constraint on i^T which should be set equal to the exogenously given long-term 'equilibrium' real interest rate r^* plus the inflation target π^T (as noted earlier); (ii) interest rate rules characterized by $\beta_\pi > 1$ – an inequality known as the 'Taylor principle', after Taylor (1999) – and $\beta_x > 0$ will tend to be stabilizing, to the extent that lower real interest rates boost economic activity (these properties have not, however, been without controversy in the literature[14]).

Incorporating further a more general specification of interest rate smoothing behavior, both evident in the practice of central banks and suggested by theory, and allowing for exogenous interest rate (i.e., here also monetary policy) shocks extends (3.7) to its usual empirical counterpart:

$$i_t = \beta_i(L)\, i_{t-1} + \left(1 - \beta_{i,-1}\right) i_t^T + \nu_t. \tag{3.10}$$

In (3.10), L denotes the lag operator, $\beta_i(L) \equiv \beta_{i,-1} + \beta_{i,-2}L^1 + ... + \beta_{i,-n}L^{n-1}$ where $\beta_{i,-1} \in [0,1)$ measures the degree of smoothing of interest rate changes and ν_t is a zero mean interest rate shock.

Now plugging the Taylor rule target (3.8) into the partial adjustment model (3.10), representing the expected values as realized values minus forecast errors, and rearranging yields an equation for the *actual* (not target) nominal interest rate of the form

$$i_t = \left(1 - \beta_{i,-1}\right) \left\{ \underbrace{\left[r^* - \left(\beta_{\pi,+k} - 1\right)\pi^T\right]}_{\equiv \beta_{0,+k}} + \beta_{\pi,+k}\pi_{t+k} + \beta_{x,+q}x_{t+q} \right\} + \underbrace{\beta_i(L)}_{\equiv \beta_{i,-1}} i_{t-1} + \varepsilon_t, \tag{3.11}$$

where

$$\varepsilon_t \equiv -\left(1 - \beta_{i,-1}\right)\left\{\beta_{\pi,+k}\left(\pi_{t+k} - E\left[\pi_{t+k} \mid \mathcal{I}_t\right]\right) + \beta_{x,+q}\left(x_{t+q} - E\left[x_{t+q} \mid \mathcal{I}_t\right]\right)\right\} + \nu_t. \tag{3.12}$$

ε_t in (3.12) is a linear combination of *forecast errors* and the exogenous disturbance to the interest rate, ν_t: it is, thus, orthogonal to any variable in the information set $\mathcal{I}_t$. Letting $\mathbf{z}_t$ denote a vector of variables within the central bank's information set at the time when the decision on the interest rate is made, that is, $\mathbf{z}_t \in \mathcal{I}_t$, with elements of $\mathbf{z}_t$ (and, therefore, instruments in the econometric sense) any lagged variables that help forecast inflation and output as well as any contemporaneous variables that are uncorrelated with ν_t, one can write $E\left[\varepsilon_t \mid \mathbf{z}_t\right] = 0$. (3.11) then implies the set of *orthogonality* conditions

[14]The Taylor principle has not always been found to hold empirically, see, e.g., Clarida, Galí and Gertler (1998) for the UK or Mehra (2002) for the US. Theoretically, this principle is usually a necessary and sufficient condition to guarantee determinacy of rational expectations equilibrium, in the sense of unique stationary solution assuming stationary disturbance processes, as Woodford (2001) has discussed, among others. More recent research, e.g., Davig and Leeper (2005) or Carlstrom, Fuerst and Ghironi (2006), has modified or generalized the Taylor principle in various ways, depending on the underlying model structure.

(3.13)

$$E\left[\left\{i_t - \left(1-\beta_{i,-1}\right)\left(\underbrace{\left[r^* - \left(\beta_{\pi,+k}-1\right)\pi^T\right]}_{\equiv \beta_{0,+k}} + \beta_{\pi,+k}\pi_{t+k} + \beta_{x,+q}x_{t+q}\right) - \beta_i\left(L\right)i_{t-1}\right\}\mathbf{z}_t\right] = 0,$$

which provide the basis for GMM estimation of the parameters of interest,[15] collected in the vector $\boldsymbol{\beta} \equiv \left(\beta_{0,+k}, \beta_{\pi,+k}, \beta_{x,+q}, \beta_{i,-1}\right)'$. To the extent that the dimension of vector $\mathbf{z}_t$ is *higher* than the number of parameters to estimate, 4 in our case, (3.13) implies *over*identifying restrictions that can be tested in order to assess the validity of the specification estimated and of the set of instruments used.[16] We present and discuss such test statistics further down.

3.3.2. *Summary of Estimates of Forward-Looking Taylor Rules.* Equation (3.11) can be rewritten as

$$i_t = \underbrace{\left(1-\beta_{i,-1}\right)\beta_{0,+k}}_{\equiv b_{0,+k}} + \underbrace{\left(1-\beta_{i,-1}\right)\beta_{\pi,+k}}_{\equiv b_{\pi,+k}}\pi_{t+k} + \underbrace{\left(1-\beta_{i,-1}\right)\beta_{x,+q}}_{\equiv b_{x,+q}}x_{t+q} + \underbrace{\beta_{i,-1}}_{\equiv b_{i,-1}}i_{t-1} + \varepsilon_t, \quad (3.14)$$

from where we obtained direct GMM estimates of what may be called – following, e.g., Surico (2004) – the 'reduced-form' parameters (the b's above). Then the corresponding 'structural-form' parameters (the β's above) were recovered using the definitions in (3.14). Approximate standard errors for the policy responses of interest here, the β's, were finally calculated by an application of the delta method. We estimated specifications where the *lead* for inflation varied from 1 to 8 quarters ahead, $k = 1, ..., 8$, and that for the output gap from 0 to 4, $q = 0, ..., 4$. The leads of $k = 2, 3$ for inflation and of $q = 0, 1$ for the output gap were strongly supported by the data from the viewpoint of both econometrics and economics.[17] Due to space limitations, we would focus on the results from our preferred, or 'benchmark', specifications reported in Table 3.

[TABLE 3 ABOUT HERE]

Panels A and B in the table compare the policy response coefficients from an identical forward-looking Taylor rule estimated via GMM over the *pre-* and *post-*independence subsamples, respectively, using the

[15]Clarida, Galí and Gertler (1998, 2000) note that, by construction, the first component of $\{\varepsilon_t\}$ follows an $MA(a)$ process, with $a = \max\{k, q\} - 1$ and will thus be serially correlated unless $k = q = 1$. GMM estimation should then be carried out with a weighting matrix that is robust to autocorrelation (and heteroskedasticity), which we do.

[16]See, e.g., Clarida, Galí and Gertler (1998), pp. 1040-1041.

[17]In the former case, the econometric characteristics of the regressions such as statistical significance of most relevant parameters, higher adjusted R-squared, lower standard error of regression (SER) and higher probability value of the Hansen J-test for the validity of overidentifying restrictions have mattered overall. In the latter case, the signs and magnitudes of the statistically significant monetary policy feedback coefficients to inflation and to the output gap and the value of the interest rate smoothing parameter that make most economic sense and allow reasonable interpretation have been the major criteria of judgement.

RPI to calculate inflation and both final and real-time GDP gap data.[18] As can be verified in the last row of each panel, the validity of our overidentifying restrictions and of the set of our instruments cannot be rejected for all equations, and the goodness of fit is also very high. Then, the parameters of interest are statistically significant at all conventional levels in all specifications. Moreover, the positive expected signs of the response to both inflation and the output gap and the bounds between 0 and 1 of the smoothing parameter are everywhere satisfied.

We next turn to the magnitudes of the reaction coefficients in our 'benchmark' forward-looking Taylor rules in Table 3. Discussing any other of the alternative specifications we experimented with will not modify the *quantitative essence* of our key conclusions. A major result that we find robust across our numerous forward-looking regressions is a *much stronger* response of the Bank of England to the output gap *after* it became more autonomous. Thus, Table 3 reports always (i) *statistically significant* and (ii) *positive* estimates for the coefficient to the contemporaneous output gap, $\beta_{x,0}$, which, most importantly, (iii) indicate a *unanimous and considerable rise* in its magnitude in the *post*-independence period. An exact quantification of this magnitude is, unfortunately, not possible, as numbers vary across specifications. Nevertheless, we would conclude that the increase in BoE's reaction to the output gap under operational independence is anyway *quite high*, for two empirically inferred reasons. First, no matter whether our final or real-time data GMM estimates from forward-looking Taylor rules are taken into account, the increase of the output gap coefficient is substantial indeed (see, e.g., Table 3); as a matter of fact, it is likely to be of the order of 2 to 3 times, if we also consider the most frequently observed significant values across our forward-looking specifications with alternative proxies (not reported here, to save space). Second, another indication for a large increase in the response of the Bank to the output gap after it began setting interest rates itself was captured by the classic Taylor rules we estimated via OLS and TSLS earlier, as noted, with this response only becoming statistically significant in the post-independence subsample. Our econometric results, supportive of quite a big change in BoE's reaction to the output gap, lead us to believe that the institutional shift to greater central bank autonomy has also played a role. We return with more interpretation to these points below.

By contrast, we cannot say much as to whether the response to inflation or the degree of interest rate smoothing, reflected in our alternative estimates for the coefficients $\beta_{\pi,+2}$ and $\beta_{i,-1}$, have become stronger or weaker after the Bank of England was granted operational independence. Evidently, any conclusion in this sense would rest on a restrictive interpretation of a subset of our Taylor rule specifications and proxies, which we would not wish to force on the data.[19] For instance, *final* data indicate an increase in the response to inflation as well as in the degree of interest rate smoothing, irrespective of the particular

[18]We present our results with RPI inflation instead of RPIX inflation mostly because of the much higher variation of the former relative to the latter in both estimated subsamples, as can clearly be seen in figures 1 and 2, which suggests a likely higher precision of the slope estimates of BoE's reaction function when the RPI is used to measure inflation.

[19]Likewise, our results are inconclusive on the empirical validity of the Taylor principle by subsample.

output detrending used; whereas *real-time* data reverse this conclusion (see again Table 3). It might also well be that, with respect to both inflation and interest rate smoothing, the post-independence behavior of the Bank has not changed much, for one reason or another, to be definitely detected by our data.

This leads us to the question: Why should a central bank in an inflation targeting regime increase its reaction to the output gap *after* receiving instrument independence, with its reaction to inflation at the same time most likely not much changed (or, if increased, not at a comparable degree)?

Mihailov (2006) argued that this is exactly what the Bank of England – whose priority is to keep inflation low, the more so under flexible inflation targeting – should have done once the evolving UK business cycle is taken into consideration. The easiest way to understand this is to look at the dominant phase of the business cycle before and after operational independence. Comparing the respective descriptive statistics in figures 1 and 2, one can see that the output gap was characterized by a considerably negative mean (and by much more volatility) according to *all* our four gap measures during the pre-independence subsample and by a slightly positive mean (plus lower variability) during the post-independence one. It is, then, clear that the Bank of England has reacted in a much stronger way to the output gap when aggregate demand has, on average, been closer to potential supply, thus creating inflationary pressures, i.e., (mostly) during the post-independence period when inflation was, moreover, credibly anchored at the Bank's target.

However, the magnitude of the increase in BoE's response to the output gap appears econometrically quite too large, as we already claimed, to be due only to the evolving UK business cycle. One contribution of the present paper is, therefore, to complement and make more realistic the above explanation by adding a second, *institutional* factor in the picture: namely, the move in May 1997 to central bank instrument independence, but with goal dependence, in the UK monetary policy framework. The Bank's augmented autonomy has, in fact, implied a corresponding increase of its responsibility, accountability and transparency in achieving the delegated inflation target. Lasaosa (2005), among others, illustrates compactly our main point here by stressing that: (i) the *Minutes* of the MPC monthly meetings (introduced with operational independence in mid-1997 and containing the individual votes of the nine MPC members, four of which external) are published two weeks after each meeting; (ii) the average number of pages of the Bank of England's quarterly *Inflation Report* (introduced with inflation targeting in late 1992) has increased since 1997 from around 45 to 65, including a new section entitled "Monetary Policy since Latest MPC"; and (iii) the Governor has to write an *open* letter to the Chancellor of the Exchequer on behalf of the MPC if inflation deviates more than one percentage point from the inflation target. All these three institutional arrangements (and some other of a lesser importance, of course) accompanying the increased autonomy of the Bank of England definitely enhance the accountability as well as the transparency of UK monetary policy, hence the Bank's responsibility when deciding on short-term interest rates every month, conditional on the available economic data and forecasts. BoE's *much* stronger reaction to the output gap post-independence is, therefore, not surprising. It is a logical consequence: (i) in part of the evolving UK *business cycle*, as claimed in Mihailov (2006); (ii) in part of the *institutional shift* in the UK framework for monetary policy making, as we emphasize in the present paper; and (iii) in part of the *anchored inflation* that characterizes the UK inflation targeting data (figures 1 and 2) and, hence, anchored inflationary expectations. Without instrument independence for the central bank, it is very likely that the government, wishing to support economic activity, would have exerted influence through power to alleviate or prevent such a strong monetary policy feedback to the output gap, itself intended as a forward-looking, preemptive response to rising inflationary pressures. Given our short sample, containing roughly one full cycle of contraction and recovery of the British economy within the inflation targeting period on which we focus here, we are not in a position to separate out the individual contribution of each of the above *three* principal factors largely explaining the estimated change in Bank of England's reaction function. Future research could, of course, address this issue.

Real GDP Growth Instead of Real GDP Gap? We next subject our key result and its interpretation offered thus far to what may be called a theory-consistency empirical test for monetary policy under inflation targeting. Mostly because of the well-known problems in measuring in 'real time' the *true* output gap, which cannot be observed, the use of the rate of real GDP *growth* (or some combination of it and other variables) instead of the real GDP *gap* has sometimes been proposed as desirable, for pragmatic reasons, when estimating central bank policy reaction functions.[20] But while responding to an output gap measure is theoretically required in a flexible inflation targeting regime like the one in the UK, reacting to real output growth is not expected: neither from the viewpoint of conventional theory, nor because of BoE's delegated inflation target. So, has the Bank also reacted to real GDP *growth*, in a way similar to its asymmetric response to the output gap across the business cycle? To check whether BoE's behavior has been theory- and goal-consistent – not erratic – under instrument independence, we proceeded to estimation of the same Taylor rule specifications but with real GDP *growth* replacing real GDP *gap*.

[Table 4 about here]

Table 4, featuring our benchmark specifications but now with real GDP *growth* (in % p.a.) as explanatory variable, presents evidence that what the Bank of England has really cared about throughout the *entire* inflation targeting period is the output *gap*, and not the rate of *growth* of real output: nowhere in this table, before as well as after operational independence, is the coefficient on real GDP growth

[20]See, in particular, Orphanides et al. (2000), McCallum (2001), Orphanides (2003), and Carare and Tchaidze (2005).

statistically significant at all. According to our forward-looking Taylor rule GMM regressions, the UK inflation targeting data thus clearly reject the idea that real GDP *growth* has guided BoE's monetary policy instead of the output *gap*.

There is good economic rationale, conventional as well as New Keynesian, behind such a finding. It can be summarized in the following way. There is no need for a central bank to (aggressively) react to any change in the rate of *growth* of real GDP *per se*; for example, real expenditure may grow in a depressed economy and there is no reason to overhastily abort such a (stabilizing) tendency. It is only with respect to a benchmark *potential* output (although controversial to estimate) that the increase in aggregate demand should matter for inflationary expectations, and hence for an inflation-targeting central bank. But once aggregate expenditure comes close to the estimated capacity of an economy to produce output and threatens to surpass it, thus creating inflationary pressure and affecting unfavorably the (rational) expectations of economic agents about future inflation, the central bank should respond (aggressively), the more so under a flexible inflation targeting framework. Such interpretation constitutes another important aspect in logically explaining the empirical findings in the present paper. It confirms that the Bank of England has reacted in a justified and consistent way to the changing business cycle conditions in the period of its operational independence relative to the pre-independence inflation targeting period, as also envisaged by its broader mandate and in agreement with its increased responsibility and accountability.

3.3.3. *Additional Robustness Checks and Avenues for Further Research.* We finally point out to a few dimensions of interest for further research into the topic, which constitute potential limitations of the present study.

Exchange-Rate Augmented Taylor Rules. Part of the literature on Taylor rules estimates specifications that *explicitly* include one or more (contemporaneous and lagged) exchange rate terms. This has been considered appropriate especially for small open economies. However, Taylor (2001) argues that there is no need to do so. The reason is that even if the exchange rate may matter a lot for a small open economy, its dynamics will be reflected (almost immediately) in the dynamics of the price level, that is, in inflation as well. So, once an inflation term is included in the Taylor rule, the exchange rate is always *implicit* in the equation, via its pass-through onto import and consumer prices. Leitemo and Söderström (2005) also claim that an explicit exchange rate term adds little to the performance of simple monetary policy rules under exchange rate uncertainty. Yet as another robustness check of our findings we, nevertheless, performed Taylor rule regressions with the nominal effective exchange rate (NEER) index added to the standard variables in (3.14). A general conclusion from this exercise was that the NEER came out as statistically significant but of a very negligible magnitude, practically close to zero, and with an uncertain – that is, switching across specifications – sign. More importantly, the inclusion of the NEER also made all policy responses unrealistically low, the more so during the operational independence period, while at the same time pushing the interest rate smoothing parameter and, especially, the adjusted R^2 for the regressions conspicuously high, which is indicative of a likely misspecification. For this reason, we do not report estimates and avoid here any further discussion of forward-looking Taylor rules with an explicit exchange rate term.

Nonstationary Taylor-Type Policy Rules. As pointed out by Gerlach-Kristen (2003) and mentioned earlier, the empirical literature on policy reaction functions has usually ignored the issue of *stationarity* of the variables taken into account. She explores the econometric properties of the traditional Taylor rule model using euro area quarterly data for 1998-2002 and finds signs of instability and misspecification. She then estimates interest rate rules using the *cointegration* approach and claims that such rules are stable in sample and forecast better out of sample. The findings of Gerlach-Kristen (2003) are, certainly, of interest. Moreover, nonstationarity may be relevant for part – if not all – of the UK time series we included in our Taylor rule estimation, as was duly discussed. In this sense, a cointegrated approach may deserve attention in future research.

Nonlinear Taylor-Type Policy Rules. The literature has also turned to explore potential *nonlinearities* in feedback rules. For example, Martin and Milas (2004) and Kesriyeli, Osborn and Sensier (2004) have directly addressed such issues with UK data, and Surico (2004) with US data. We would agree that this is another, perhaps promising, avenue for further work.

Hybrid Monetary Policy Rules. So-called *hybrid* rules, which include *both inflation* and the *price level* as policy response variables in addition to the output gap, have also been investigated.[21] Jääskelä (2005) has recently argued that it does not make sense to include the price level in a policy rule when inflation expectations are backward-looking. But when they are forward-looking, the price level rule and the hybrid rule are superior to the standard (inflation-based) Taylor rule under *certainty* about the *structural* parameters of the model. However, he also admits that the standard (*optimized*) Taylor rule is more robust to *model uncertainty* than both those alternatives. This feature of a higher robustness to model uncertainty was another reason to focus our initial analysis here on the simplest case of commonly employed Taylor rules, rather than hybrid, nonlinear or nonstationary ones. Potentially extending it in ways to incorporate the more complex aspects briefly discussed in the last few paragraphs remains thus for further research.

[21]The debate on price level and inflation targeting, triggered by Fischer (1994), gave rise to a substantial literature in the last decade. Nessén and Vestin (2005), for instance, show that the performance of a hybrid target can be superior to a price level target and to an inflation target, taken separately, if commitments of an inflation targeting central bank are not feasible. Batini and Yates (2003), on the other hand, study the pros and cons of (*non-optimized*) hybrid rules in an open-economy context when policy makers are able to commit.

4. Concluding Comments

This paper posed and investigated empirically a novel question: does a shift to central bank *instrument independence* matter for the conduct of monetary policy that already operates under the 'constrained discretion' of an established *inflation targeting* regime, implying *goal dependence*? We took advantage of the unique experience in that sense of the United Kingdom, where the Bank of England was granted operational independence from HM Treasury only in May 1997, while flexible inflation-forecast targeting had been effective since October 1992. Our econometric strategy concentrated on estimating forward-looking Taylor rules using the GMM approach, theoretically consistent with the New Keynesian monetary policy model popularized in similar contexts by Clarida, Galí and Gertler (1998, 1999, 2000). Yet we also applied OLS and TSLS to classic and backward-looking Taylor rules, for the purpose of comparability with earlier work as well as across alternative econometric techniques.

Answering in summary to our title, we would conclude that the move to instrument independence of the Bank of England has augmented the responsibility, transparency, accountability and the *marge de manoeuvre* of monetary policy in achieving the delegated inflation target. This institutional shift has, consequently, increased the Bank's sensitivity to inflationary pressures, as captured by the much higher policy reaction coefficients to the output gap we estimated during post-independence. Without instrument independence for the central bank, the government – wishing to support economic activity – could have exerted influence to alleviate such a strong, anticipating feedback to the output gap. We also presented evidence that the BoE has systematically responded to the output *gap*, and *not* at all to output *growth*, which is consistent with both conventional theory and the flexible inflation targeting mandate of the Bank: the monetary authority should care (for theoretical reasons), and did seem to care (in our empirical results), not whether aggregate demand grows *per se*, but whether such growth implies – as would be in a stage of the business cycle *above* or *near* potential supply – increasing inflationary pressure.

Overall, the monetary strategy adopted in the UK in October 1992 and enhanced by the granting of operational independence to the Bank of England in May 1997 seems to have been successful in simultaneously avoiding three major policy problems known from the literature (and reflected in real-world experiences): the inflation bias of full discretion with or without political pressure (e.g., many high-inflation developing countries in a floating exchange rate regime), the lack of democratic accountability under complete central bank independence (e.g., some critiques on the ECB), and the time inconsistency of rigid rules (e.g., the currency board failure in Argentina). Our paper therefore brings partial evidence in favor of the hypothesis first proposed by Fischer (1994) and Debelle and Fischer (1994) that monetary policy under *instrument independence* with *goal dependence* would generally tend to produce low average inflation; as well as in favor of the now wide-spread claims of theoretical and empirical studies – in the spirit of the early work of Bernanke and Mishkin (1997), Svensson (1997 a) and Herrendorf (1998) – that inflation targeting may well be close to optimal monetary policy and best central bank practice (given the current economic circumstances in the world).

Panel A: Pre-Independence Subsample: 1992:4 – 1997:1 (18 observations)				
Real GDP Filter:	Quadratic	Hodrick-Prescott	Quadratic	Hodrick-Prescott
i^T	5.77*** (0.15)	5.76*** (0.09)	6.03*** (0.23)	5.78*** (0.13)
$b_{0,0}$	3.88*** (0.49)	3.68* (0.41)	5.00*** (0.68)	4.58*** (0.66)
$b_{\pi,0}$	0.75*** (0.16)	0.83*** (0.15)	0.41* (0.21)	0.48* (0.42)
$b_{x,0}$	−0.03 (0.10)	−0.12 (0.10)	0.27 (0.23)	0.20 (0.33)
$AR1$ term			0.44*** (0.15)	0.42*** (0.21)
Adj R^2	0.63	0.66	0.75	0.72
SER	0.35	0.34	0.29	0.31
DW	0.90	1.07	$AR1$ correction	$AR1$ correction
F p-v	0.000224	0.000118	0.000046	0.000101

Panel B: Post-Independence Subsample: 1997:3 – 2004:4 (30 observations)				
Real GDP Filter:	Quadratic	Hodrick-Prescott	Quadratic	Hodrick-Prescott
i^T	4.95*** (0.14)	5.01*** (0.17)	4.56*** (0.75)	4.18*** (1.22)
$b_{0,0}$	2.81*** (0.45)	3.38*** (0.56)	3.55*** (0.81)	3.22** (1.27)
$b_{\pi,0}$	0.86*** (0.17)	0.65*** (0.21)	0.40*** (0.14)	0.38*** (0.14)
$b_{x,0}$	0.85*** (0.16)	0.38** (0.43)	0.37 (0.24)	0.37 (0.23)
$AR1$ term			0.90*** (0.08)	0.93*** (0.06)
Adj R^2	0.61	0.39	0.92	0.91
SER	0.75	0.94	0.35	0.35
DW	0.39	0.22	$AR1$ correction	$AR1$ correction
F p-v	0.000001	0.000520	0.000000	0.000000

Table 1. Classic Taylor Rules: OLS Estimates on RPI and Final Real GDP Gap

Explanatory Note to Table 1: All data are quarterly and for the United Kingdom; the method of estimation is OLS; the estimated equations are (3.1) and (3.2), with intercepts i^T and $b_{0,0}$, respectively, and all other parameters the same, as explained in the main text; standard errors for the directly estimated coefficients (i^T and the b's) are in parentheses; ***, **, * = statistical significance at the 1, 5, 10% level, respectively; $AR1$ = correction for an autoregressive process in the error of the regression of order 1; Adj R^2 = adjusted R^2; SER = standard error of regression; DW = Durbin-Watson statistic (for testing first-order serial correlation in the error process when there is no $AR1$ correction for it or lagged dependent variable in the regression specification); F p-v = F-statistic probability value (for the joint significance of all estimated parameters).

Panel A: Pre-Independence Subsample: 1992:4 – 1997:1 (18 observations)				
Real GDP Filter:	Quadratic	Hodrick-Prescott	Quadratic	Hodrick-Prescott
i^T	5.74*** (0.16)	5.75*** (0.09)	6.20*** (0.38)	5.78*** (0.13)
$b_{0,0}$	3.76*** (0.53)	3.51*** (0.44)	5.62*** (1.13)	4.42** (1.58)
$b_{\pi,0}$	0.79*** (0.17)	0.89*** (0.16)	0.23 (0.32)	0.54 (0.61)
$b_{x,0}$	−0.05 (0.11)	−0.16 (0.11)	0.48 (0.45)	0.13 (0.75)
$AR1$ term			0.52** (0.19)	0.39 (0.48)
Adj R^2	0.63	0.66	0.73	0.72
SER	0.35	0.34	0.30	0.31
DW	0.94	1.16	$AR1$ correction	$AR1$ correction
F p-v	0.000228	0.000106	0.000067	0.000108
Panel B: Post-Independence Subsample: 1997:1 – 2004:4 (30 observations)				
Real GDP Filter:	Quadratic	Hodrick-Prescott	Quadratic	Hodrick-Prescott
i^T	4.94*** (0.14)	5.00*** (0.18)	4.66*** (0.62)	4.23*** (1.15)
$b_{0,0}$	2.77*** (0.45)	3.43*** (0.57)	3.63*** (0.70)	3.40*** (1.22)
$b_{\pi,0}$	0.87*** (0.17)	0.63*** (0.22)	0.41*** (0.15)	0.33** (0.15)
$b_{x,0}$	0.89*** (0.17)	1.24*** (0.42)	0.56 (0.33)	0.65* (0.32)
$AR1$ term			0.88*** (0.10)	0.92*** (0.07)
Adj R^2	0.61	0.38	0.91	0.91
SER	0.75	0.96	0.36	0.36
DW	0.40	0.24	$AR1$ correction	$AR1$ correction
F p-v	0.000001	0.000402	0.000000	0.000000

Table 2. Classic Taylor Rules: TSLS Estimates on RPI and Final Real GDP Gap

Explanatory Note to Table 2: All data are quarterly and for the United Kingdom; the method of estimation is TSLS; the estimated equations are (3.1) and (3.2), with intercepts i^T and $b_{0,0}$, respectively, and all other parameters the same, as explained in the main text; standard errors for the estimated coefficients are in parentheses; ***, **, * = statistical significance at the 1, 5, 10% level, respectively; $AR1$ = correction for an autoregressive process in the error of the regression of order 1; Adj R^2 = adjusted R^2; SER = standard error of regression; DW = Durbin-Watson statistic (for testing first-order serial correlation in the error process when there is no $AR1$ correction for it or lagged dependent variable in the regression specification); F p-v = F-statistic probability value (for the joint significance of all estimated parameters).

Panel A: Pre-Independence Subsample: 1992:4 – 1997:1 (18 observations)				
Real GDP Data:	Final /Revised/		Real-Time /Initial/	
Real GDP Filter:	Quadratic	Hodrick-Prescott	Quadratic	Hodrick-Prescott
$b_{0,+2}$	1.53*** (0.13)	2.02*** (0.21)	1.13*** (0.16)	1.29*** (0.18)
$\beta_{0,+2}$	3.52 (0.31)	4.48 (0.47)	2.73 (0.40)	3.13 (0.43)
$b_{\pi,+2}$	0.38*** (0.03)	0.21*** (0.04)	0.45*** (0.04)	0.37*** (0.05)
$\beta_{\pi,+2}$	0.88 (0.08)	0.47 (0.09)	1.09 (0.09)	0.91 (0.11)
$b_{x,0}$	0.11*** (0.04)	0.21*** (0.03)	0.07*** (0.02)	0.12*** (0.02)
$\beta_{x,0}$	0.60 (0.08)	0.48 (0.07)	0.47 (0.05)	0.29 (0.06)
$b_{i,-1}$	0.56*** (0.01)	0.55*** (0.02)	0.59*** (0.01)	0.59*** (0.01)
Adj R^2	0.75	0.76	0.83	0.71
SER	0.29	0.28	0.31	0.31
J-stat	0.302956	0.288247	0.282935	0.289121
OvId p-v	0.79	0.82	0.82	0.82

Panel B: Post-Independence Subsample:				
	1997:3 – 2004:4 (28 observations)		1997:3 – 2001:4 (18 observations)	
Real GDP Data:	Final /Revised/		Real-Time /Initial/	
Real GDP Filter:	Quadratic	Hodrick-Prescott	Quadratic	Hodrick-Prescott
$b_{0,+2}$	0.11 (0.11)	−0.07 (0.15)	2.82*** (0.22)	2.14*** (0.20)
$\beta_{0,+2}$	0.43 (0.44)	−0.38 (0.76)	4.62 (0.37)	3.72 (0.34)
$b_{\pi,+2}$	0.46*** (0.02)	0.38*** (0.03)	0.30*** (0.03)	0.42*** (0.04)
$\beta_{\pi,+2}$	1.79 (0.08)	1.96 (0.14)	0.48 (0.05)	0.73 (0.06)
$b_{x,0}$	0.21*** (0.04)	0.17*** (0.05)	0.92*** (0.10)	1.06*** (0.13)
$\beta_{x,0}$	0.71 (0.16)	0.88 (0.25)	1.38 (0.16)	1.85 (0.23)
$b_{i,-1}$	0.74*** (0.02)	0.81*** (0.02)	0.39*** (0.03)	0.42*** (0.03)
Adj R^2	0.92	0.92	0.94	0.92
SER	0.35	0.35	0.24	0.29
J-stat	0.217969	0.224985	0.159138	0.264661
OvId p-v	0.73	0.71	0.97	0.85

Table 3. Forward-Looking Taylor Rules: GMM Estimates on RPI and Real GDP Gap

Explanatory Note to Table 3: All data are quarterly and for the United Kingdom; inflation is computed using the RPI; the method of estimation is GMM; the instrument set includes 4 lags of all (3) variables in the estimated equation, (3.14), with $k = 2$ and $q = 0$; standard errors for the directly estimated (reduced-form) coefficients (the b's) in parentheses are calculated using a Newey-West weighting matrix robust to error autocorrelation and heteroskedasticity of unknown form; ***, **, * = statistical significance at the 1, 5, 10% level, respectively; standard errors for the indirectly estimated (structural-form) coefficients (the β's) are computed via the delta method; Adj R^2 = adjusted R^2; SER = standard error of regression; J stat = J-statistic: equals the minimized value of the objective function in GMM estimation and is used, following Hansen (1982), to test the validity of overidentifying restrictions when there are more instruments than parameters to estimate, like in our case here (we have $3 \times 4 + 1 = 13$ instruments, including the constant, to estimate 4 parameters, and so there are $13 - 4 = 9$ overidentifying restrictions: under the null that the overidentifying restrictions are satisfied, the J-statistic times the number of regression observations is distributed asymptotically $\chi^2(m)$ with degrees of freedom m equal to the number of overidentifying restrictions, 9 in our case); OvId p-v = probability value of the above-summarized Hansen test for $m = 9$ overidentifying restrictions.

Panel A: Pre-Independence Subsample: 1992:4 – 1997:1 (18 observations)		
Real GDP Data:	Final /Revised/	Real-Time /Initial/
$b_{0,+2}$	0.81*** (0.14)	1.13*** (0.29)
$\beta_{0,+2}$	1.95 (0.33)	2.53 (0.65)
$b_{\pi,+2}$	0.57*** (0.04)	0.49*** (0.05)
$\beta_{\pi,+2}$	1.36 (0.09)	1.11 (0.12)
$b_{y,0}$	−0.01 (0.02)	0.01 (0.02)
$\beta_{y,0}$	−0.02 (0.04)	0.02 (0.04)
$b_{i,-1}$	0.58*** (0.01)	0.56*** (0.03)
Adj R^2	0.68	0.67
SER	0.33	0.33
J-stat	0.283959	0.290898
OvId p-v	0.82	0.81

Panel B: Post-Independence Subsample: 1997:1 – 2004:4 (28 observations)		
Real GDP Data:	Final /Revised/	Real-Time /Initial/
$b_{0,+2}$	−0.08 (0.08)	1.61*** (0.25)
$\beta_{0,+2}$	−0.64 (0.61)	2.88 (0.45)
$b_{\pi,+2}$	0.30*** (0.04)	0.56*** (0.04)
$\beta_{\pi,+2}$	2.27 (0.29)	1.00 (0.08)
$b_{y,0}$	0.01 (0.04)	0.12 (0.07)
$\beta_{y,0}$	0.08 (0.37)	0.21 (0.13)
$b_{i,-1}$	0.87*** (0.01)	0.44*** (0.05)
Adj R^2	0.93	0.88
SER	0.33	0.36
J-stat	0.199089	0.262429
OvId p-v	0.78	0.86

Table 4. Forward-Looking Taylor Rules: GMM Estimates on RPI and Real GDP Growth

Explanatory Note to Table 4: All data are quarterly and for the United Kingdom; inflation is computed using the RPI; the method of estimation is GMM; the instrument set includes 4 lags of all (3) variables in the estimated equation, (3.14), with $k = 2$ and $q = 0$; standard errors for the directly estimated (reduced-form) coefficients (the b's) in parentheses are calculated using a Newey-West weighting matrix robust to error autocorrelation and heteroskedasticity of unknown form; ***, **, * = statistical significance at the 1, 5, 10% level, respectively; standard errors for the indirectly estimated (structural-form) coefficients (the β's) are computed via the delta method; Adj R^2 = adjusted R^2; SER = standard error of regression; J stat = J-statistic: equals the minimized value of the objective function in GMM estimation and is used, following Hansen (1982), to test the validity of overidentifying restrictions when there are more instruments than parameters to estimate, like in our case here (we have $3 \times 4 + 1 = 13$ instruments, including the constant, to estimate 4 parameters, and so there are $13 - 4 = 9$ overidentifying restrictions: under the null that the overidentifying restrictions are satisfied, the J-statistic times the number of regression observations is distributed asymptotically $\chi^2(m)$ with degrees of freedom m equal to the number of overidentifying restrictions, 9 in our case); OvId p-v = probability value of the above-summarized Hansen test for $m = 9$ overidentifying restrictions.

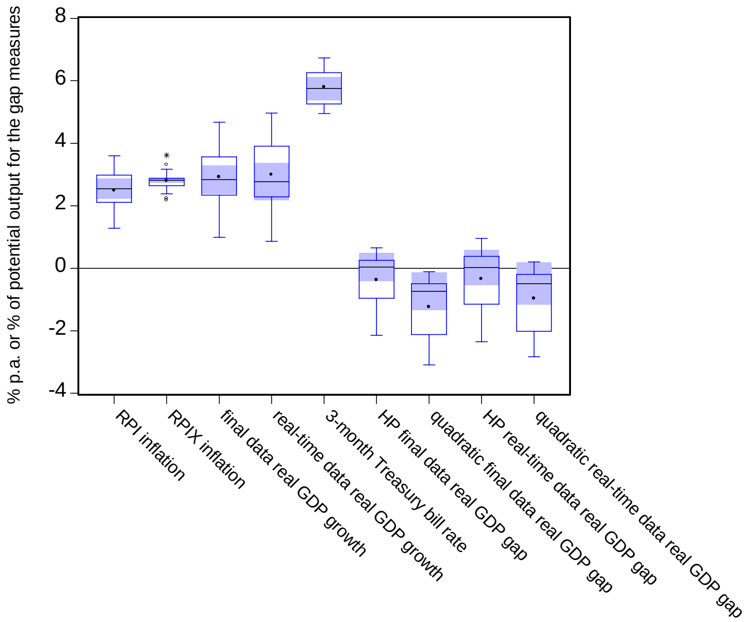

FIGURE 1. Descriptive Statistics of the Data: Pre-Indepencence Boxplot (1992:4-1997:1, 18 observations)

DATA SOURCE: Office of National Statistics (ONS), website.

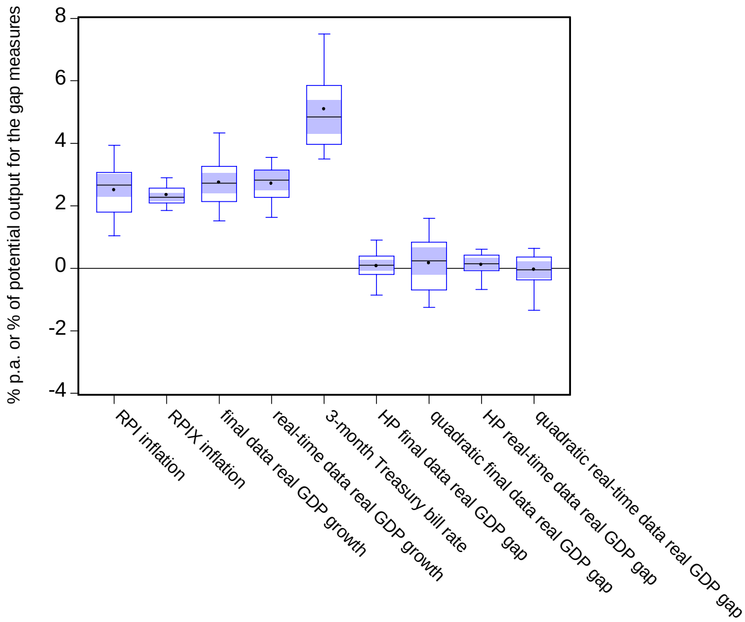

FIGURE 2. Descriptive Statistics of the Data: Post-Indepencence Boxplot (1997:3-2004:4, 30 observations or 1997:3-2001:4, 18 observations for the real-time data output gap measures)

DATA SOURCE: Office of National Statistics (ONS), website.

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Department of Economics, University of Essex, Colchester CO4 3SQ, United Kingdom

E-mail address: `mihailov@essex.ac.uk`

URL: `http://www.essex.ac.uk/economics/people/staff/mihailov.shtm`