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Abstract

We address the question posed in the title of this paper by investigating recent developments in the literature that estimates the NAIRU. A necessary condition for the existence of a NAIRU is dynamic homogeneity: the Phillips curve should be homogenous of degree one in lagged and/or expected inflation. But contemporary approaches to estimating the NAIRU typically *assume* rather than *test* for dynamic homogeneity, thus assuming (rather than testing for) the existence of a NAIRU. We argue that these developments remove the NAIRU from the domain of testable hypotheses and transform the concept into an article of faith. This does not constitute scientific progress.

J.E.L. Classification Codes: E10, B41, C12

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The way that modern macroeconomics tosses around the notion of a "natural rate of unemployment" is a sort of intellectual scandal ... The coarseness of the definition and the weakness of the empirical results ... suggest that we are in the presence of something that is believed for extra-scientific reasons.

(Solow, 1987, p.183)

1. Introduction

The idea of a non-accelerating inflation rate of unemployment (NAIRU) is a well-established but controversial feature of modern macroeconomics. The NAIRU codifies a pre-Keynesian vision of the economy, according to which money is neutral and aggregate demand is irrelevant for the determination of output and employment, at least in the long run. Although critics of the NAIRU question its very existence (see, for example, Galbraith, 1997; Lang, 2007), the concept has made deep in-roads into macroeconomic policy circles, and there exists an extensive empirical literature that purports to identify the precise value of the NAIRU that policy makers should incorporate into their decisions.

Our concern in this paper is with recent developments in the literature that seeks to estimate the value of the NAIRU. A necessary condition for the existence of a NAIRU is dynamic homogeneity: in the Phillips curve, the current rate of inflation must be homogeneous of degree one in lagged and/or expected inflation. But contemporary approaches to estimating the NAIRU typically *assume* rather than *test for* dynamic homogeneity, thus *assuming* (rather than *testing for*) the existence of a NAIRU. We argue that this "measurement without testing" removes the NAIRU from the domain of testable hypotheses and transforms the concept into an article of faith. In the terms of the Popper-

Lakatos tradition in the methodology of science, this makes the contemporary empirical NAIRU literature a degenerative research programme.

The remainder of the paper is organized as follows. Sections 2 and 3 review conventional and more recent methods for estimating the value of the NAIRU. It is shown that the modern empirical NAIRU literature has engaged in an implicit retreat from hypothesis testing – specifically, testing for the existence of a NAIRU – at a time when efforts directed at testing ought to have been re-doubled. This is because of the emergence of a competing (hysteresis) hypothesis that is consistent with the conditions formerly understood to denote the existence of a NAIRU, but that yields radically different implications for the role of money and aggregate demand in the economy. Section 4 then reflects on the methodological implications of the retreat from hypothesis testing in modern methods of NAIRU estimation. It is argued that this makes the contemporary empirical NAIRU literature degenerative, "elevating" the NAIRU concept into an article of faith. Finally, section 5 offers some conclusions.

2. Estimating the NAIRU using the Phillips curve

The conventional approach to estimating the NAIRU involves first estimating a reduced-form Phillips curve derived from structural wage and price setting equations. This expression can be written as:

$$p = \alpha + \beta p^e + \sum_{i=1}^{n} \gamma_i p_{-i} - \delta U + \eta \qquad [1]$$

where p is the rate of inflation, p^e denotes inflation expectations, U is the rate of unemployment and η captures transitory supply shocks.

The Phillips curve in equation [1] exemplifies what Gordon (1997, 1998) and Dew-Becker and Gordon (2005) describe as the canonical "triangular" model of the inflation process, expressing inflation as resulting from: inflation inertia and/or expectations; demand-side forces (captured by U); and supply-side forces (captured by η). It can be thought of as a useful "organizing concept" in macroeconomic theory, emerging in one form or another from a wide variety of otherwise competing traditions in macroeconomics.

Under the equilibrium conditions $p = p^e = p_{-i} = p^*$ (for all $i = 1, \ldots, n$) and $\eta = 0$, we obtain the long run Phillips curve:

$$p^* = \frac{\alpha - \delta U}{1 - \left(\beta + \sum_{i=1}^{n} \gamma_i \right)} \qquad [2]$$

In general – i.e., when the denominator in [2] is non-zero – equation [2] implies a trade-off between inflation and unemployment. The idea of a NAIRU (or alternatively, a natural rate of unemployment) emerges as a specific form of the equilibrium solution to [1] associated with "dynamic homogeneity" in the inflation process – or in other words, when:[1]

$$\beta + \sum_{i=1}^{n} \gamma_i = 1 \qquad [3]$$

Given dynamic homogeneity, imposing the equilibrium conditions $p = p^e = p_{-i} = p^*$ (for all $i = 1, \ldots, n$) and $\eta = 0$ on equation [1] yields:

[1] It is common to reserve use of the term "natural rate of unemployment" to refer to an equilibrium solution of [1] consistent with [3] that is *also* associated with labour market clearing. In this paper, however, we do not differentiate between the NAIRU and the natural rate of unemployment (NRU) This is because there is no analytical difference between the way that these concepts are derived from equation [1], and because the empirical techniques that are used to measure these concepts are exactly the same. As such, we refer exclusively in what follows to the concept of the NAIRU.

$$U = \alpha / \delta = U_n \qquad [4]$$

where U_n is the NAIRU. The long run Phillips curve in equation [4] now implies that there is *no* long-run relationship between unemployment and inflation. Instead, regardless of the observed rate of inflation, the long run rate of unemployment is always consistent with the NAIRU, which is understood to be a unique equilibrium rate of unemployment determined independently of the actual rate of unemployment on the supply side of the economy. A corollary of all this is the accelerationist hypothesis: that sustained departures of the actual rate of unemployment from the NAIRU result in ever increasing or decreasing inflation. This is evident from equation [1] which, with dynamic homogeneity (and assuming $n = 1$, $p^e = p_{-1}$, and $\eta = 0$), suggests that:

$$\Delta p = \alpha - \delta U$$

so that only with $U = \alpha / \delta$ do we observe $\Delta p = 0$. Note that given equation [4], it is a straightforward matter to establish the precise value of the NAIRU using the estimation coefficients $\hat{\alpha}$ and $\hat{\delta}$ as approximations for the parameters α and δ, respectively.

The preceding analysis reveals the advantage of the conventional Phillips curve approach to estimating the value of the NAIRU. The process begins with a "generic" Phillips curve that nests competing hypotheses about the precise relationship between *p* and *U*, of which the "NAIRU hypothesis" (NAIRUH) – that there is *no* long run relationship between *p* and *U* – is just one. The concept of a NAIRU then emerges under specific conditions that are *testable*. In short, the approach taken above renders the NAIRUH a testable hypothesis. Certainly, the power of the resulting test of $\mathrm{H}_0 : \hat{\beta} + \sum_{i=1}^{n} \hat{\gamma}_i = 1$ is open to question. Hence Setterfield and LeBlond (2003), using

contemporary US data, show that failure to reject the null hypothesis of dynamic homogeneity is associated with large Type II errors. Nevertheless, the methodological point remains that the procedure for estimating the NAIRU outlined above keeps the NAIRUH firmly within the realm of testable hypotheses.

3. Recent developments in NAIRU estimation

More recently, the preferred approach to estimating the value of the NAIRU has moved away from the practices outlined above. The contemporary NAIRU estimation literature utilizes more or less sophisticated statistical methods designed to extract the trend rate of unemployment from an unemployment time series. These practices do have a purpose. Specifically, the procedure described in the previous section produces a single point estimate of the NAIRU (from equation [4]) for the entire range of data used to estimate equation [1]. It has long been claimed, however, that the value of the NAIRU can change over time. Allowing for this time variation in the value of the NAIRU is an important motivating factor in the new empirical NAIRU literature. But unfortunately, as will become clear in what follows, the contemporary literature has – unwittingly or otherwise – undermined the status of the NAIRUH as a testable hypothesis, elevating it instead to the status of an article of faith.

There are two strands of the contemporary literature referred to above. The first, and much less sophisticated, strand – which is evident in undergraduate macroeconomics textbooks such as Mankiw (2006, figure 6.1, p. 160) – involves calculating a moving average of the actual unemployment rate and simply calling this trend a NAIRU.[2]

[2] This approach is not altogether confined to materials designed for undergraduate instruction. See, for example, CEPR (1995, n.20).

Although this exercise may serve to inculcate undergraduates with the language of "modern macroeconomics", the problem with the approach is obvious: it must be *assumed* that the unemployment data generated by actually existing economies represent transitory movements of the unemployment rate away from a NAIRU, so that any procedure that extracts the trend from this data is, indeed, measuring the NAIRU. In other words, both the concept and the value of the NAIRU emerge by definitional fiat, and not as the result of any identifiable *behavioural hypothesis* that can be subject to testing.

The second, more sophisticated, strand of the contemporary empirical NAIRU literature employs univariate or multivariate statistical filters to extract trend rates of unemployment from time series data associated with statistical models of the inflation process.[3] The use of a univariate filter is exemplified by Ball and Mankiw (2002). Ball and Mankiw begin by estimating an equation of the form:

$$\Delta p = \alpha - \delta U + \eta \qquad [1a]$$

Under the equilibrium conditions $\Delta p = \eta = 0$, the now familiar NAIRU result in equation [4] emerges from [1a]. This, in turn, can be re-written as:

$$\alpha = \delta U_n$$

Substituting this last expression into Ball and Mankiw's original estimating equation and re-arranging, we arrive at:

$$U_n + \eta / \delta = U + \Delta p / \delta$$

[3] Univariate filters can be applied directly to unemployment data and their output labelled the NAIRU, as in Staiger, Stock and Watson (1997a) and Chouliarakis (2009). According to the latter, this method has "the advantage of imposing very little structure on the problem at hand" (i.e., that of estimating the NAIRU) (Chouliarakis, 2009, p.484). Unfortunately, so little structure is imposed that even the *opportunity* of testing for dynamic homogeneity is lost – an opportunity that is at least present in the work surveyed in what follows. Hence although the statistical methods used by Chouliarakis (2009) are more advanced than those employed by Mankiw (2006), this work suffers exactly the same shortcomings as the "less sophisticated" approach to measuring the NAIRU discussed previously.

The right hand side of this expression can easily be calculated using time series data for U and Δp and by using $\hat{\delta}$ as an approximation for δ. Ball and Mankiw (2002) then contend that since η/δ will exhibit high-frequency variation while U_n will exhibit low-frequency variation, it is possible to extract the (time-varying) value of U_n from the calculated series $U + \Delta p / \hat{\delta}$ using any standard statistical method for extracting a trend from a time series. Their preferred method of extracting this trend is a Hodrick-Prescott (HP) filter.[4] On this basis, Ball and Mankiw (2002) calculate what they identify to be the value of a time-varying NAIRU for the US economy for the period 1960—2000. They claim that this time-varying NAIRU first rose (between 1960 and 1980) and has since fallen, much as the actual rate of unemployment first rose and then fell during the period of their investigation. The implication is that the "evolution" of the time-varying NAIRU explains changes in the actual rate of unemployment over several successive business cycles in the US economy.

The problem with this approach to "estimating the NAIRU" is at once simple but important: by estimating [1a] (in which the dependent variable is Δp) rather than [1], the dynamic homogeneity in equation [3] that was revealed in the previous section as a necessary condition for the existence of a NAIRU has been imposed upon the estimating equation from the outset. In other words, Ball and Mankiw *assume* rather *test for* the dynamic homogeneity necessary to empirically validate the Phillips curve in equation [1a] that they estimate, and in the process they assume rather than test for the existence of a NAIRU. The trend they extract from the time series $U + \Delta p / \hat{\delta}$ is *labelled* a NAIRU,

[4] The HP filter is the most popular univariate filter employed in the contemporary empirical NAIRU literature. It is not, however, the only univariate filter employed in this literature. See, for example, Chouliarakis (2009, pp. 483-4), whose univariate filter NAIRU estimates are based on both HP and low-pass filters.

but the authors provide no statistical evidence to suggest that this interpretation is consistent with the underlying data.[5]

The approach developed by Ball and Mankiw (2002) has also been adopted by Hsing (2009) in a study of the time-varying NAIRU in Germany. Hsing (2009) modifies the Ball and Mankiw model by replacing $\Delta p = p - p_{-1}$ in equation [1a] above with $\Delta p = p - \overline{p}$, where $\overline{p}$ denotes a measure of the average rate of inflation in the recent past. Note that this achieves little more than producing a Phillips curve similar to that found in equation [1] with $\beta = 0$ and equation [3] satisfied by assumption. Hsing's methodology is otherwise identical to that of Ball and Mankiw as described above and, as such, suffers the same faults. In particular, the assumption of dynamic homogeneity means that although the trend extracted from the time series $U + \Delta p / \hat{\delta}$ is *labelled* a NAIRU, no statistical evidence is provided to support this interpretation.

Unfortunately, the problem identified above with Ball and Mankiw (2002) and Hsing (2009) is far from untypical in a contemporary NAIRU estimation literature that seems to be more and more concerned with statistical filtering techniques and less and less concerned with the basic but important function of hypothesis testing. This point is made clear by the much larger literature that uses multivariate statistical filters to measure the value of the NAIRU, the most popular of which is the Kalman filter. Unlike

[5] It might be argued at this point that the commonplace finding that inflation has a unit root justifies the imposition of dynamic homogeneity in the empirical NAIRU literature. There are, however, two problems with this argument. First, it is not clear that inflation does, in fact, have a unit root (Culver and Papell, 1997; Basher and Westerlund, 2007; Narayan and Narayan, 2010). Second, even if it does, the finding that inflation has a unit root reveals only a specific statistical property of time-series inflation data – namely, that it is not mean-reverting over long intervals of time. But this may be true for any number of reasons. In and of itself, it does not provide a statistical test of the various behavioural hypotheses nested in the claim that there exists a unique, supply-determined NAIRU. This is effectively demonstrated in section 4 below where it is shown that even with dynamic homogeneity, the NAIRUH may be false because of hysteresis effects.

univariate filters which (as noted above) can, in principle, be applied directly to unemployment time series, the use of a multivariate filter requires the prior specification of a statistical model that stipulates how the unobserved trend that is of interest interacts with other time series. Kalman filter measurements of the NAIRU are usually based on a variant of equation [1], which can be written as:

$$p = \beta p^e + \sum_{i=1}^{n} \gamma_i p_{-i} - \delta(U - U^*) + \eta \qquad [1b]$$

where U^* denotes the unobserved trend rate of unemployment. The latter is typically regarded as time-varying and modelled as a random walk of the form:

$$U^* = U^*_{-1} + \nu \qquad [5]$$

where ν is a random error term. By combining [1b] and [5] and subjecting the resulting reduced form to a maximum likelihood estimation procedure, it is possible to simultaneously estimate both the unobserved (time-varying) trend rate of unemployment, U^*, and all of the other parameters of equation [1b]. U^* is then interpreted as the time-varying NAIRU.

Estimates of the time-varying NAIRU derived in this fashion can be considered superior to those based on univariate filters because they use more information – specifically, the co-movements of the unemployment rate with the other variables in equation [1b]. But the Kalman filter is a recursive process, which places certain demands on the estimation procedure described above. For example, the initial value of the time varying NAIRU must be imposed from without. The initial value of the trend rate of unemployment derived, using a univariate filter, from unemployment data is commonly used for this purpose. The main problem, however, is exactly the same as that identified with the approach taken by Ball and Mankiw discussed earlier: dynamic homogeneity, as

described in equation [3], must be *imposed* upon equation [1b] from the outset in order to make sense of the interpretation of U^* as a time-varying NAIRU. In fact, the statistical superiority of Kalman-filter-based estimates of the time-varying NAIRU stems from precisely the fact that the procedure, by construction, produces an estimate of the trend rate of unemployment U^* that is the best possible fit with the accelerationist hypothesis which (assuming dynamic homogeneity, $n = 1$, $p^e = p_{-1}$, and $\eta = 0$) re-emerges from [1b] in the form:

$$\Delta p = -\delta(U - U^*)$$

But all this is presupposed from the outset. Absent the *a priori* imposition of dynamic homogeneity, and using the usual equilibrium conditions $p = p^e = p_{-i} = p^*$ (for all $i = 1, \ldots, n$) and $\eta = 0$, we will obtain from [1b] the long run Phillips curve:

$$p^* = \frac{\alpha - \delta(U - U^*)}{1 - \left(\beta + \sum_{i=1}^{n} \gamma_i\right)} \qquad [2a]$$

This is a conventional, negatively sloped Phillips curve, in which the permanent departure of the actual unemployment rate from its trend value will result only in permanently higher or lower steady state rate of inflation, rather than the ever-increasing (or decreasing) inflation that would result from the accelerationist Phillips curve associated with the existence of a NAIRU.[6] Once again, then, the process involves *assuming* rather than *testing for* dynamic homogeneity, and hence *assuming* rather than

[6] To put it differently, if unemployment is at its long run trend value at any point in time, then [2a] reduces to:

$$p^* = \frac{\alpha}{1 - \beta - \sum_{i=1}^{n} \gamma_i}$$

In other words, there is a *unique* steady state rate of inflation associated with $U = U^*$, rather than the continuum of steady state rates of inflation that we would expect if there existed a vertical Phillips curve passing through a NAIRU.

testing for the existence of a NAIRU: the time-varying trend rate of unemployment, U^*, extracted using the Kalman filter may be *labelled* a NAIRU, but there is no statistical evidence to suggest that this is consistent with the underlying data.[7]

Use of the Kalman filter under the assumption of dynamic homogeneity is rife in the contemporary literature that purports to measure the value of the NAIRU. Early examples of the method include Staiger, Stock and Watson (1997a) and Gordon (1997). The main concern of Staiger, Stock and Watson (1997a) is with imprecision in estimates of the NAIRU in the US, and the implications of this imprecision for monetary policy. The authors only ever discuss the Phillips curve relationship as being between unemployment on one hand and the *change* in the rate of inflation on the other – in other words, in terms of a relationship akin to equation [1a] above.[8] They do note that when lags of the change in inflation are included on the right-hand side of their estimating equation, "this is equivalent to specifying the Phillips relation in the levels of inflation and imposing the restriction that the sum of the coefficients on the lags add to one" (Staiger, Stock and Watson, 1997a, p.197). Other than this brief allusion to dynamic homogeneity, they offer no further discussion of the key implicit assumption that underlies their specification of the Phillips curve.[9]

[7] It is also possible to employ *both* univariate *and* multivariate filters as part of the same estimating procedure in order to measure the NAIRU, as, for example, in Staiger, Stock and Watson (2001) and Chouliarakis (2009). This process involves first applying a univariate filter to unemployment data, and then using the resulting univariate trend rate of unemployment in the multivariate model to which the Kalman filter is applied. According the Chouliarakis (2009, p. 486), the chief advantage of this approach stems from the fact that "a considerable part of the time variation in the natural rate is likely to be reflected in changes in the univariate unemployment trend" so that "the additional information contained in this trend can potentially contribute in delivering more precise estimates of the natural rate of unemployment." From the perspective developed in this paper, however, this approach suffers the same flaw that we have already identified with the independent use of either univariate or multivariate filters. As such, it is not considered further.

[8] See their initial specification of the Phillips curve in equation (1) on p.197.

[9] See also Staiger, Stock and Watson (1997b).

Gordon's (1997) estimates of the NAIRU for the US are based, in the first instance, on his "triangle" model of inflation, which specifies a Phillips curve similar to that found in equation [1] with $\beta = 0$ and with a variable capturing the effect of supply shocks on inflation added to the right-hand side.[10] He notes, with reference to this Phillips curve, the dynamic homogeneity necessary for the existence of a NAIRU, adding that "while the sum of the coefficients on lagged inflation is usually roughly equal to unity, that sum must be constrained to be *exactly* unity for a meaningful natural rate ... to be calculated" (p.15, emphasis in original). This constraint informs his subsequent use of estimating equations similar to those in [1b] and [5] to calculate the NAIRU, and there is no further discussion of the veracity of the assumption of dynamic homogeneity on which these calculations are based.

Since these early contributions, the use of multivariate filters to measure the NAIRU has proliferated – as has the accompanying preference for assuming, rather than meaningfully testing for, dynamic homogeneity. Batini and Greenslade (2006) use a Kalman filter to estimate the NAIRU in the UK. Dynamic homogeneity is assumed (p.32), with an appeal to Staiger, Stock and Watson (1997a). The authors do report (as part of a "sensitivity check") that, based on a log-likelihood test, "the hypothesis of dynamic homogeneity appeared to be consistent with the data" (pp.36-7). But this brief show of interest in testing for the existence of the NAIRU – while in and of itself quite laudable – is clearly secondary to the main purpose of the paper: providing measurements of the time-varying NAIRU derived from a statistical model that assumes dynamic homogeneity, in order to improve monetary policy interventions that are predicated on the existence of the NAIRU. For example, the authors make no effort to emphasize the

[10] See also Gordon (1998).

importance of testing for dynamic homogeneity (and hence seeking to verify whether or not a NAIRU actually exists) before undertaking procedures that purport to measure the value of the NAIRU.

Chouliarakis (2009), meanwhile, estimates the NAIRU in the UK using a variety of univariate and multivariate filters. When employing multivariate techniques, Chouliarakis reports that in his Phillips curve estimating equations, "the estimated sum of coefficients on lagged inflation, over the period under consideration, approaches unity" (p.487). He does not, however, clarify what "approaches unity" means, nor discuss by what (if any) statistical procedure he has reached this determination. Moreover, Chouliarakis immediately goes on to admit that "a meaningful calculation of the [NAIRU] requires that the sum should be ... exactly equal to unity". He then proceeds to impose, rather than statistically establish the validity of, this restriction, again by appealling to Staiger, Stock and Watson (1997a).

Table 1 provides a summary of recent contributions to the empirical NAIRU literature that employ univariate and/or multivariate filters to measure the NAIRU. It also records whether or not these contributions test for dynamic homogeneity. Overwhelmingly, they do not. This suggests that despite the seeming statistical sophistication that accompanies the use of univariate and/or multivariate filtering techniques, the basic problem with the second strand of the contemporary empirical NAIRU literature surveyed in this section is much the same as the problem with the first strand. To wit: a purported *value* of the NAIRU emerges from a process in which testing for the very *existence* of a NAIRU – a contested concept – is conspicuous by its absence.

[TABLE 1 HERE]

Of course, not all contributions to the contemporary empirical NAIRU literature rely on statistical filters to measure the NAIRU. Nevertheless, the same basic problem of measurement without testing arises even when filters are eschewed. For example, Cassino and Thornton (2002) adopt a structural approach to NAIRU estimation, based on Layard, Nickel and Jackman's (1991) wage-price equations amended to take account of short run dynamics arising from real and nominal rigidities. But their wage-price equations assume dynamic homogeneity so that in the long run (i.e., absent the influence of real or nominal rigidities) their estimating equation reduces to equation [2] above. Cassino and Thornton argue that the lack of robustness associated with the results they derive from their structural estimates of the NAIRU recommend greater use of non-structural approaches to NAIRU estimation (such as using the Kalman filter). But this misses the more profound point – that whatever the estimation technique used, the approach adopted involves measurement without testing.

4. Is the NAIRU hypothesis degenerative?

The essential problem with the literature reviewed in the previous section is that, literally interpreted, it does nothing more than extract a long run trend from a macroeconomic time series and then *designate* this trend as representing the NAIRU. This designation is either completely arbitrary (as in the case of the less sophisticated strand of the literature) or true by assumption (as in the case of the more sophisticated strand, that assumes rather than tests for dynamic homogeneity). But the *designation* of trend unemployment as a unique and stable supply-determined equilibrium rate of

unemployment consistent with stable inflation is nothing more than that – a designation. It provides no test through which the concept of the NAIRU could, in principle, be falsified. In short, modern methods of estimating the NAIRU elevate the NAIRUH beyond the status of a testable hypothesis to that of an article of faith. This "measurement without testing" does not constitute scientific progress.

One possible counter-argument to this claim is that the existence of the NAIRU is now so well established that it has become axiomatic – "promoted" to the "hard core" of macroeconomics research based on past empirical performance, and therefore no longer subject to the sort of scrutiny associated with hypothesis testing. But this argument is hard to sustain. Hence one of the notable features of Stanley's (2005) meta-analysis of the NAIRUH is the infrequency with which actually *testing* for the existence of the NAIRU has ever been a central feature of the empirical NAIRU literature. While it may well be the case that the NAIRU is now *de facto* part of the "hard core" of macroeconomics research, it has certainly not earned this status as a result of having been "tested to death". On the contrary, its elevation beyond the realm of testable hypotheses seems more in keeping with our earlier interpretation of its having become an article of faith.

Unfortunately, things get worse for the NAIRUH. At the same time that the NAIRU literature has retreated from testing, the usefulness of the (already weak) "dynamic homogeneity" test described earlier has been undermined by the idea of hysteresis in the NAIRU. To see this, note that on the basis of [4], we have $\delta U_n = \alpha$. Substituting into [1] and re-arranging, we arrive at:

$$p = \beta p^e + \sum_{i=1}^{n} \gamma_i p_{-i} - \delta(U - U_n) + \eta$$

or:

$$U - U_n = \Omega\left(\beta p^e + \sum_{i=1}^{n} \gamma_i p_{-i} - p\right) + \varepsilon \qquad [5]$$

where $\Omega = 1/\delta$ and $\varepsilon = \eta/\delta$. Equation [5] is essentially a Lucas supply function, which suggests that, given dynamic homogeneity as in [3], it is only possible for unemployment to vary from the NAIRU if $p \neq p^e \neq p_{-i}$ (for all $i = 1, \ldots, n$) or $\eta \neq 0$, events that are understood to represent transitory (disequilibrium) conditions. Hence in the long run, the actual rate of unemployment is anchored at the NAIRU regardless of the rate of inflation.

But notice that this last statement only implies that there is no trade-off between inflation and unemployment if we assume that:

$$\dot{U}_n = 0 \qquad [6]$$

Equation [6] can be considered the "missing equation" of NAIRU analysis (see Lavoie, 2006).[11] But suppose, in fact, that:

$$\dot{U}_n = f(U - U_n) \qquad [7]$$

where $f' > 0$. Equation [7] characterizes a NAIRU that is path dependent: its value changes if the actual rate of unemployment differs from the NAIRU at any point in time.[12] In the NAIRU literature, equation [7] is usually understood to connote the

[11] In the context of the model developed here, equation [6] should be interpreted only as implying that the value of the NAIRU is exogenous to the dynamics of unemployment and inflation adjustment: the appropriate contrast, as will become clear, is with equation [7], where the NAIRU is sensitive to the dynamics of unemployment adjustment. Hence equation [6] is not meant to imply that the value of the NAIRU is literally a constant. On the contrary, its value may well change over time, in response to variation in microeconomic factors affecting the willingness and ability of workers to find work that are independent of the macroeconomic events in [1]. Indeed, this is precisely the assumption on which the notion of the time-varying NAIRU, to which frequent reference has been made throughout this paper, is predicated.

[12] See, for example, Jenkinson (1987) for an early but useful survey of the channels through which the actual rate of unemployment can impact upon on the structure of the labour market and hence the long run equilibrium rate of unemployment.

existence of hysteresis in the NAIRU.[13] Notice that we are still referring to the existence of something called a NAIRU and (most importantly for our purposes) we are still assuming dynamic homogeneity. All we are proposing is that equation [6] (the missing equation of NAIRU analysis) be replaced with equation [7]. What are the consequences of this?

To answer this question, suppose that for the sake of simplicity we linearize equation [7], writing:[14]

$$\dot{U}_n = \theta(U - U_n) \qquad [7a]$$

Substituting [5] into [7a], we arrive at:

$$\dot{U}_n = \theta\Omega\left(\beta p^e + \sum_{i=1}^{n}\gamma_i p_{-i} - p\right) + \nu \qquad [8]$$

where $\nu = \theta\varepsilon$. What equation [8] tells us is that any increase in p above its current equilibrium value will reduce the value of NAIRU.[15] Since the NAIRU is the long run equilibrium rate of unemployment, and since $U = U_n$ is consistent with stable inflation,[16] we are back to the sort of long-run tradeoff between unemployment and inflation

[13] Strictly speaking this is something of an abuse of terminology, since hysteresis is a specific form of path dependency (rather than a synonym for path dependency), "true" hysteresis involving (among other things) discontinuities, which would imply that the function f (.) in [7] is non-linear. See, for example, Lang (2009), Lang and De Peretti (2009) and Cross (2014) for recent discussions of proper and improper uses of the term hysteresis in macroeconomics.

[14] In light of what was said in the previous footnote, note that, in so doing, we cannot claim to be modelling "true" hysteresis here. Instead, the term "hysteresis" must be interpreted as a euphemism for path dependency in what follows – thus replicating a common (but unfortunate) trait of the NAIRU literature.

[15] Notice that *any* increase in the current rate of inflation will suffice to produce this result. Even if the increase is inflation is anticipated, inertia in the inflation process will ensure that $\dot{U}_n \neq 0$ in [8]. Of course, in the absence of inertia (i.e., if $\gamma_i = 0$ for all i), and assuming that we continue to observe dynamic homogeneity (which would now imply that $\beta = 1$), only an unanticipated increase in the rate of inflation would suffice to change the value of the NAIRU. The frequency with which unanticipated inflations occur depends, in part, on the process by which decision makers form expectations. Note, however, that absent perfect foresight, the capacity for expectational error is always present, and so, by extension, is the capacity for "hysteretic" changes in the value of the NAIRU as described in equation [8].

[16] Recall the first of the equilibrium conditions that was used to derive the result in [4] above.

originally described in [2]. But this time, we are using the concept of a NAIRU and are assuming dynamic homogeneity in the inflation process. In other words, the hysteresis hypothesis is consistent with dynamic homogeneity in the inflation process, but yields a predicted long run relationship between inflation and unemployment that is completely at variance with that of the NAIRUH. Clearly, then, dynamic homogeneity – even if the empirical NAIRU literature were still eager to test for rather than simply assume its existence – is not enough to establish the existence of a unique NAIRU that is invariant with respect to the rate of inflation.

The potential empirical importance of these observations is demonstrated by Logeay and Tober (2006), who first estimate the value of the NAIRU for the Euro Area using a Kalman filter. In this respect, there is little that distinguishes their approach from the literature that was criticized in the previous section for ignoring the potential non-existence of the NAIRU. However, Logeay and Tober then perform a further operation, which involves examining the sensitivity of their estimated NAIRU to variations in actual and long run unemployment. Their results are in keeping with the hysteresis hypothesis (the NAIRU is shown to be functionally dependent on realized unemployment outcomes), which results in their rejecting the long run policy-neutrality postulates associated with NAIRU analysis. Put differently, what Logeay and Tober (2006) show is that time variation in the value of the NAIRU is better explained by variation in the actual rate of unemployment and accompanying hysteresis effects than by autonomous variation in the "structural" determinants of the NAIRU (as, for example, in Nickell et al, 2005). This finding is in keeping with other empirical research on unemployment which shows that variation in the structural determinants of the NAIRU provides little explanation of

observed changes in the actual rate of unemployment in the long run (Baker et al, 2005). But as noted above, while perfectly consistent with dynamic homogeneity, the alternative (hysteresis-based) explanation of time variation in the NAIRU does not uphold the long-run policy neutrality postulates associated with the NAIRUH.

What all this means is that even as economists have retreated from directly testing for dynamic homogeneity and hence the existence of a NAIRU, the usefulness of this traditional test has been undermined. A competing (hysteresis) hypothesis has emerged that is fully compatible with the dynamic homogeneity condition specified in the null hypothesis of the traditional test for the existence of a NAIRU, but yields completely different implications for the long-run relationship between unemployment and inflation. Lakatos (1970, p.182) claims that "for the sophisticated falsificationist a theory is 'acceptable' or 'scientific' only if it has corroborated excess empirical content over its predecessor (or rival)". With respect to the matter of dynamic homogeneity, this claim cannot be made of the NRH, but *can* be made of its predecessor (the negatively-sloped Phillips curve) which, by virtue of the hysteresis hypothesis, can absorb the observation of dynamic homogeneity. Since the NRH cannot absorb the observation of no dynamic homogeneity (on which basis the negatively-sloped Phillips curve is traditionally founded),[17] it is the negatively-sloped Phillips curve that corroborates excess empirical content relative to its rival (the NRH), making it the 'acceptable' theory by Lakatos's criterion.

Given the absorption of the observation of dynamic homogeneity by a competing hypothesis, the question at this remove is not just *whether* but *how* to test for the

[17] Note that such observation does occur in the empirical NAIRU literature, either directly (as in Setterfield et al, 1992) or indirectly, through the observation of large Type II errors associated with empirical tests for dynamic homogeneity (as in Setterfield and LeBlond, 2003).

existence of a NAIRU.[18] And in a discipline that values generating testable hypotheses as a hallmark of scientific progress, the question that then arises is: what is the scientific status of such a concept?

For economists such as Blaug (1994), who self-identify with the Popperian and Lakatosian projects in the methodology of science, generating new testable hypotheses that are exposed to the potential for falsification is an essential feature of any scientific research program that is "progressive" rather than "degenerative". This methodological position is, of course, contestable. For instance, a number of the contributions to Backhouse (1994) recommend that economists adopt views of their discipline and/or its object of analysis – and corresponding methodological strictures – that depart radically

[18] Note that calculating the trend rate of unemployment and then insisting that this must be a NAIRU because inflation increases/decreases when unemployment is below/above the trend value does not suffice to solve this problem, for the simple reason that we would get much the same result from a standard (negatively sloped) Phillips curve. Hence note from [1] and [2] that:

$$\frac{dp}{dU} = -\delta$$

whereas:

$$\frac{dp^*}{dU} = \frac{-\delta}{1-\left(\beta + \sum_{i=1}^{n} \gamma_i\right)}$$

Assuming that $\beta + \sum_{i=1}^{n} \gamma_i < 1$ consistent with a traditional, negatively sloped Phillips curve, we can see that the increase in long run inflation resulting from a decrease in unemployment is some multiple of the increase in short run inflation. In other words, starting from an initial point on the long run Phillips curve in [2] (consistent with constant inflation), any decrease in unemployment below its current value will see inflation rise initially and then *keep rising over time*. So simply noting that inflation rises/falls as unemployment falls/rises does not establish the existence of a unique rate of unemployment consistent with table inflation: there will always be a *succession* of increases (decreases) in inflation following a reduction (increase) in unemployment, even if we do *not* observe dynamic homogeneity. As such, the observation of successive increases/decreases in inflation following a change in unemployment does not, in and of itself, establish that the Phillips curve is vertical at the original rate of unemployment. What *really* distinguishes the NAIRUH from the standard Phillips curve is that, according to the NAIRUH, starting from a position consistent with constant inflation, any permanent decrease in unemployment will cause inflation to keep rising *indefinitely* (the accelerationist hypothesis), whereas according to the standard Phillips curve, the increase in inflation will be finite (inflation will eventually reach a new steady state value, consistent with [2]). And according to Fair (1999, 2000), evidence supports the idea that following a reduction in unemployment, the observed increase in inflation is strictly finite. At the end of the day, then, rather than rescuing the NAIRUH, we arrive via this line of reasoning at a result that delivers yet another blow to the hypothesis.

from those associated with the Popper—Lakatos brand of positivism. But there is evidence to suggest that falsificationism is (at least implicitly) widely viewed as a methodological benchmark in economics. First, the number of contributions to Backhouse (1994) to which the Popper-Lakatos tradition is central is testimony to the tradition's lasting effect on the practice of economics (see Setterfield, 1999). Second, critical essays on empirical practice are frequently wont to call attention to the importance of hypothesis testing. For example, in their assessment of empirical methods in real business cycle theory, Gregory and Smith (1995) argue that:

> From the econometricians perspective, one of the most perplexing aspects of many calibration exercises is the absence of formal statistical testing. Usually, researchers present a table of simulated moments beside a table of historical moments, and then comment on which disparities are large and which are not, without supplying any metric by which closeness can be judged.
>
> (Gregory and Smith, 1995, p.1601)

Summers (1991, p.129), meanwhile, identifies the belief that "the best empirical work in macroeconomics formally tests substantive hypotheses rigorously derived from economic theory" as one of three core beliefs that "many macroeconomists and most econometricians believe and teach their students". In his subsequent assessment of macroeconometrics designed to identify "deep parameters" in the New Classical tradition, he laments that:

> Without ... some metric for evaluating the extent to which the data are inconsistent with a maintained hypothesis formal statistical tests are uninformative.
>
> Science proceeds by falsifying theories and constructing new ones.
>
> (Summers, 1991, p.135)

Farmer's (2013) empirical assessment of New Keynesian dynamic stochastic general equilibrium (DSGE) models is still more explicit in its appeal to the Popper-Lakatos tradition. Having shown that his own model better explains US data than the New

Keynesian model, he describes New Keynesianism as a degenerative research programme on the basis of its need to continually modify subsidiary hypotheses in order to provide an adequate account of new data.

Finally, even economists who eschew formal methodological enquiry altogether may be said to tacitly identify (or be allied) with the Popper—Lakatos tradition. It is instructive to note in this regard Blaug's (1994, p.131) approving remarks about the work of Mayer (1993).

As long as the economics profession (or large tracts of it) continues to at least tacitly identify with the Popper—Lakatos tradition – and the evidence presented above suggests it does – then it is reasonable to use the standards of this tradition as a yardstick by which to judge the practices of economists, including those of NAIRU proponents. Hence the essential claim of this paper is that recent developments in the empirical NAIRU literature fall short of the standards of a progressive research programme. As previously argued, new testable hypotheses that seek to establish the existence of a NAIRU are sorely needed if the original concept of the NAIRU (that of a unique supply-determined equilibrium rate of unemployment consistent with stable inflation) and the associated NAIRU hypothesis (that there is no long run tradeoff between unemployment and inflation) are to be upheld in the face of a competitor hypothesis (based on the concept of hysteresis). But rather than developing new testable hypotheses, the modern empirical NAIRU literature has largely retreated from testing altogether. Not even the null hypothesis of dynamic homogeneity is regularly tested:[19] instead, even in the more sophisticated strand of the contemporary empirical NAIRU literature, it is typically *assumed* to be a property of the object of analysis. This faith in the NAIRU hypothesis is

[19] As noted earlier, it is questionable to what extent it ever *was*. See Stanley (2005, pp.617—18).

perhaps charming,[20] but it is difficult to reconcile with the pursuit of science as envisaged by the Popper—Lakatos tradition. Instead, the characteristics of the contemporary empirical NAIRU literature highlighted above mark the latter out – despite its seeming statistical sophistication – as a degenerative rather than progressive research programme.

5. Conclusion

This paper draws attention to some recent developments in the empirical NAIRU literature. Despite the seeming sophistication of much of this literature, it can ultimately be characterized as embracing "measurement without testing". More specifically, the contemporary empirical NAIRU literature is long on the use of statistical filters to derive trends from unemployment time series, but extremely short on hypothesis testing designed to establish – according to recognizable statistical criteria – whether or not the trends so-described constitute time-varying NAIRUs. Instead, the property of dynamic homogeneity – that could, in principle, be used to establish a testable hypothesis that would either verify or falsify the existence of a NAIRU – is simply *assumed* to hold, and is imposed upon the data in the course of what is then *assumed* to constitute a process of measuring the "NAIRU". The traditional test for the existence of a NAIRU, based on verifying dynamic homogeneity, is by no means powerful or conclusive. As discussed earlier, it is plagued by large Type II errors, whilst an alternative hypothesis to the NAIRUH (based on hysteresis) is also consistent with dynamic homogeneity, but yields a predicted long run relationship between unemployment and inflation that is totally at variance with that of the NAIRUH. These observations, however, should motivate a re-

[20] It might be considered more so were it not for the macroeconomic policy positions that NAIRU theory supports, which critics of the NAIRU identify as severely detrimental to the real economy.

doubling of efforts directed at testing – specifically, the development of new tests that are capable of both verifying the existence of a NAIRU *and* distinguishing the NAIRUH from competitor hypotheses. They do not justify abandoning testing and "elevating" the NAIRUH out of the realm of testable (or *tested*) hypotheses.

Unfortunately, this is exactly what has happened. From the Popper-Lakatos falsificationist perspective to which most economists (at least implicitly) subscribe, this is inconsistent with the behaviour of a progressive research programme. It is this observation that leads us to identify modern empirical NAIRU analysis as degenerative. The retreat from testing in the empirical NAIRU literature has coincided with theoretical developments that have resulted in the empirical observation (dynamic homogeneity) that was previously thought to corroborate the existence of a NAIRU being successfully absorbed by a competing hypothesis (the negatively-sloped Phillips curve) that can consequently claim to exhibit excess empirical content *vis a vis* the NRH. This raises questions about the scientific status of the NAIRU concept, and whether it is better interpreted as a matter of fact or an article of faith.

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Table 1: Measurement without testing in the contemporary empirical NAIRU literature

Study	Filter(s) used in NAIRU estimation	Imposition of dynamic homogeneity based on statistical test?
Apel and Jansson (1999)	Kalman filter	No
Ball and Mankiw (2002)	HP filter	No
Basistha and Startz (2008)	Kalman filter	No
Batini and Greenslade (2006)	Kalman filter	Yes: based on a log-likelihood test, "the hypothesis of dynamic homogeneity appeared to be consistent with the data" (pp.36-7)
Chouliarakis (2009)	HP filter Low-pass filter Kalman filter	No
De Loo (2000)	Kalman filter	No
Driver et al. (2006)	Kalman filter	Yes: "to explore the role of expectations further … we re-estimate both models without imposing the restriction that the sum of the coefficients on the inflation terms must equal unity … As the model with dynamic homogeneity imposed is much closer to the unrestricted model in the case with expectations ... imposing the constraint has very little impact on the log likelihood" (pp 57-58)
Fabiani and Mestre (2004)	HP filter Kalman filter	No
Gordon (1997)	Kalman filter	No
Hsing (2009)	HP filter	No
Salemi (1999)	Kalman filter	No
Srinivasan (2014)	Kalman filter	No
Staiger, Stock and Watson (1997a)	Kalman filter	No
Staiger, Stock and Watson (2001)	Kalman filter	No
Valadkhani (2013)	Kalman filter	No