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The Phillips multiplier

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Abstract

We propose a model-free approach for determining the inflation-unemployment trade-off faced by a central bank, i.e., the ability of a central bank to transform unemployment into inflation (and vice versa) via its interest rate policy. We introduce the Phillips multiplier as a statistic to non-parametrically characterize the trade-off and its dynamic nature. We compute the Phillips multiplier for the US, UK and Canada and document that the trade-off went from being very large in the pre-1990 sample period to being small (but significant) post-1990 with the onset of inflation targeting and the anchoring of inflation expectations.

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1 Introduction

When I say there is a trade-off between inflation and unemployment, I do not mean [that there is] a stable downward-sloping Phillips curve. [...] At its heart, the inflation-unemployment trade-off is [...] a claim that changes in policy push inflation and unemployment in opposite directions. Mankiw (2001)

The existence of an inflation-unemployment trade-off is at the core of monetary policy making, because central banks rely on this trade-off to "transform" unemployment into inflation (and vice-versa) through their interest rate policy. The ability of a central bank to control inflation thus depends on the magnitude of this trade-off, or more precisely on the central bank's marginal rate of transformation (MRT) between unemployment and inflation.

The inflation-unemployment trade-off faced by policy makers, i.e., the MRT, is traditionally inferred from a Phillips curve linking inflation to real activity or more generally from a multivariate structural model involving a Phillips curve.

Unfortunately, this model-based approach suffers from two empirical challenges:[1] (i) specification uncertainty, and (ii) endogeneity issues. First, there is uncertainty about the model's relevant set of explanatory variables and about the appropriate dynamic lag structure (e.g., Gordon (2011)). Second, endogeneity issues are pervasive. For the Phillips curve, confounding from supply shocks, unobserved inflation expectations and measurement error in the natural unemployment rate all lead to highly uncertain and potentially biased coefficient estimates (e.g., Mavroeidis et al. (2014)).

In this paper, we avoid these empirical issues by proposing a model-free characterization of the inflation-unemployment trade-off faced by policy makers. We introduce a statistic –*the Phillips multiplier*– which is defined as the expected cumulative change in inflation caused by a monetary shock that lowers expected unemployment by 1ppt. The Phillips multiplier directly captures the central bank's MRT across different horizons and we show that it can be

[1] By "model-based", we designate any approach that proceeds in two-steps, which consist in (i) specifying and estimating a Phillips curve as in the limited-information approach (e.g., Mavroeidis, Plagborg-Møller and Stock (2014)) or a full system of structural equations as in a VAR or DSGE model (full information approach, e.g., Schorfheide (2011)), and (ii) inferring the policy-relevant trade-off from the estimated coefficients.

estimated by a simple instrumental variable regression where we regress cumulative inflation on cumulative unemployment using monetary shocks as instruments.

Compared to earlier model-based characterizations of the central bank's inflation-unemployment trade-off, the Phillips multiplier offers a number of benefits. First, the Phillips multiplier is a non-parametric characterization of the MRT: it captures how policy-induced changes in unemployment affect inflation over different time scales, from short time scales (less than a year), to medium term time scales (biennial), to longer time scales. As such, the Phillips multiplier does not rely on any underlying model and is robust to model mis-specification. Second, thanks to the use of instruments, the Phillips multiplier avoids the identification issues that have plagued the Phillips curve literature; confounding factors and measurement error.

Equipped with our Phillips multiplier, we revisit important lessons from the Phillips curve literature in a *robust* and *identified* setting: (i) how large is the MRT? (ii) what are the dynamics of the MRT, i.e. how fast and for how long can the central bank affect inflation with a policy-induced change in unemployment? is the long-run MRT infinite, as implied by a vertical long-run Phillips curve? (iii) has the MRT changed over time? Is the MRT smaller in the more recent period, as suggested by the flattening of the Phillips curve (e.g., Ball and Mazumder (2011)), or is that flattening spurious and instead due to mis-specification, confounding from supply factors or to a mis-measured natural rate of unemployment? And if the MRT is indeed smaller, is it because of better anchored inflation expectations or because of a lower sensitivity of inflation to economic slack?

We compute the US Phillips multiplier using as external instruments the Romer and Romer (2004) narratively identified monetary policy changes as well as the high frequency identified monetary policy shocks pioneered by Kuttner (2001) and Gürkaynak, Sack and Swanson (2005). Both identification schemes have their own advantages: the Romer and Romer (2004) shocks cover a long sampling period (1969-2007), while the high frequency shocks only cover the recent 1990-2008 period but are arguably more convincing in terms of the exogeneity assumption.

The Phillips multiplier, and thus the MRT, has changed considerably between the pre- and the post-1990 periods. In the pre-1990 period, the Phillips multiplier strictly increases (in absolute value) with the horizon and diverges at longer horizons, pointing to an infinite MRT. This is due to the inertial nature of inflation during this period: inflation reacts with a one year lag to changes in unemployment, and the response of inflation is much more persistent than that of unemployment. As a result, the Fed's ability to steer inflation with policy-induced unemployment movements is large.[2]

In the post-1990 period the situation is very different. While the Phillips multiplier is still significantly different from zero in the medium run, it is much smaller and there is no indication of divergence in the long run. The implication is that the Fed's MRT is substantially smaller, or in other words, that the Fed's ability to steer inflation with policy-induced unemployment movements has declined considerably.

This change in the MRT in the post-1990 period could be due to the anchoring of inflation expectations or to a change in the sensitivity of inflation to economic slack (holding expectations constant). To separate these mechanisms, we show that the Phillips multiplier can be written as the ratio of two separate dynamic multipliers: (i) a multiplier capturing the MRT while holding inflation expectations constant, and (ii) a multiplier capturing the degree of anchoring of inflation expectations.

We find that the anchoring of inflation expectations is responsible for most (if not all) of the change in the MRT.[3] Inflation expectations went from completely unanchored to almost perfectly anchored. In the pre-1990 period, inflation expectations responded one-for-one with inflation following monetary shocks, and this "zero-anchoring" implies a large long-run MRT. Intuitively, any policy-induced transitory change in inflation feeds into inflation expectations, which then feeds into future inflation and so on, making the transitory change in inflation persistent or even permanent. In the post-1990 period however, inflation expec-

[2] In the language of the Phillips curve literature, our non-parametric result corresponds to a close to vertical long-run Phillips curve, i.e., the absence of any long-run trade-off between inflation and unemployment: The Fed can only lower unemployment at the cost of an ever increasing rate of inflation.

[3] In contrast, the sensitivity of inflation to economic slack holding expectations constant is relatively flat between the two sample periods (at least given estimation uncertainty).

tations respond little to policy-induced changes in inflation, and this implies a much lower MRT. Intuitively, with well-anchored inflation expectations, inflation movements have no second-round effects through inflation expectations, and the overall inflation response to a change in policy is smaller and less persistent.

To provide additional evidence for these findings, we study the MRT for two other advanced economies for which external instruments are available: the UK and Canada. These two countries are of particular interest as both countries adopted (in respectively 1991 and 1992) an explicit inflation targeting mandate, which has been found to successfully anchor inflation expectations (e.g., Levin, Natalucci and Piger (2004) and Gürkaynak, Levin and Swanson (2010)). Thus, if the anchoring of inflation expectations leads to a large decline in the MRT, this decline should also be apparent with UK and Canadian data. Using the narratively identified monetary policy shocks from Cloyne and Hurtgen (2016) and Champagne and Sekkel (2017) we estimate the MRT using the Phillips multiplier, and we indeed find that the MRTs for the UK and Canada are considerably smaller (and no longer diverging) in the inflation targeting sample periods.

We see our model-free approach to characterize the MRT with the Phillips multiplier as paralleling the literature on the fiscal multiplier, see the review of Ramey (2016). The fiscal literature features two prominent ways to estimate the fiscal multiplier: (i) a model-based approach based on DSGE or VAR models (where the multiplier is indirectly inferred from the estimated parameters of the model) and (ii) a model-free approach where the multiplier can be obtained directly from an IV regression involving the cumulative sum of output and government spending, see Ramey and Zubairy (2018). While the Phillips curve literature has so far relied on (i) by taking as a starting point the existence of a well-specified Phillips curve relationship, our paper instead follows the non-parametric route pioneered by Ramey and Zubairy (2018) in the fiscal literature.

In the context of the vast Phillips curve literature, a few papers have tried to characterize the inflation-unemployment trade-off in an identified setting like us (King and Watson (1994), Cecchetti and Rich (2001) and Benati (2015)) but always in a model-based context, typically through structural VARs. Instead, the spirit of our approach is most closely related to Ball (1994)'s non-parametric estimate of the sacrifice ratio based on narratively-identified disinflationary episodes.

2 The MRT and the Phillips multiplier

In this section we introduce the Phillips multiplier as a statistic for characterizing the central bank's marginal rate of transformation (MRT) between unemployment and inflation: the ability of a central bank to use its instrument (the policy rate) to transform unemployment into inflation (or vice-versa).

In line with Mankiw (2001)'s definition of the inflation-unemployment trade-off, we define the central bank's average MRT between inflation and unemployment as the average change in inflation caused by a change in policy that lowers the unemployment rate by 1ppt over the next h periods:

$$MRT_h = \left.\frac{\partial \bar{\pi}_{t:t+h}}{\partial i_t}\right|_{\varepsilon_t^i=1} \Big/ \left.\frac{\partial \bar{u}_{t:t+h}}{\partial i_t}\right|_{\varepsilon_t^i=1}, \quad h \geqslant 0, \tag{1}$$

where $\bar{y}_{t:t+h} = \frac{1}{h}\sum_{j=0}^{h} y_{t+j}$ denotes the average value of some variable y over $[t, t+h]$ and $\left.\frac{\partial \bar{y}_{t:t+h}}{\partial i_t}\right|_{\varepsilon_t^i=1}$ denotes the marginal effect of an exogenous unit change ε_t^i in the central bank instrument i_t on some average variable $\bar{y}_{t:t+h}$.

Since the average responses of π and u are computed over increasingly larger windows $[t, t+h]$ as h increases, MRT_h captures the average marginal rate of transformation between inflation and unemployment at different levels of time aggregation: from short time scales (less than a year, $h < 4$ using quarterly data), to medium term time scales (biennial, $h = 8$), to longer time scales (e.g., $h = 20$). In this way, MRT_h characterizes the dynamic nature of the MRT faced by a central bank.

In this work we measure the average MRT directly using a statistic called the Phillips multiplier. We define the Phillips multiplier as

$$\mathcal{P}_h = \mathcal{R}_h^{\bar{\pi}}/\mathcal{R}_h^{\bar{u}}, \qquad h = 0, 1, 2, \ldots, \tag{2}$$

where $\mathcal{R}_j^{\bar{\pi}}$ and $\mathcal{R}_j^{\bar{u}}$ in (2) are the impulse responses of average inflation and unemployment to a one-unit policy shock ε_t^i. Specifically, $\mathcal{R}_h^{\bar{\pi}} = \frac{1}{h}\sum_{j=0}^{h} \mathcal{R}_j^{\pi}$ and $\mathcal{R}_h^{\bar{u}} = \frac{1}{h}\sum_{j=0}^{h} \mathcal{R}_j^{u}$, with $\mathcal{R}_j^{y}$ the causal impulse response at horizon j of a variable y to a one-unit shock ε_t^i:

$$\mathcal{R}_h^y = \mathrm{E}(y_{t+h}|\varepsilon_t^i = 1, w_t) - \mathrm{E}(y_{t+h}|\varepsilon_t^i = 0, w_t), \tag{3}$$

where w_t is a vector of control variable.[4]

The Phillips multiplier $\mathcal{P}_h$ is the natural statistical counterpart to our definition of the average MRT: it measures how the forecast for inflation changes when a change in policy lowers unemployment by 1ppt over the next h periods. The Phillips multiplier parallels the concept of the government spending multiplier in the fiscal literature, see Ramey and Zubairy (2018).[5]

A key advantage of the Phillips multiplier is that it can be estimated by an IV regression of cumulative inflation on cumulative unemployment using monetary policy shocks as instruments. Importantly, one does not need to compute the impulse responses of inflation and unemployment to a monetary shock.

Denote by ξ_t an instrumental variable for the policy shock ε_t^i. The following simple proposition summarizes the result.

Proposition 1. *The multiplier $\mathcal{P}_h$ can be estimated from the cumulative regression*

$$\sum_{j=0}^{h} \pi_{t+j} = \mathcal{P}_h \sum_{j=0}^{h} u_{t+j} + w_t'\gamma_h + e_{t+h} \tag{4}$$

[4]While the impulse response of the average value of a variable is little unusual in the macroeconomic literature, this is simply the cumulative impulse response of the variable discounted by the horizon.

[5]The government spending multiplier is often measured as the ratio of the cumulative impulse responses of output and government spending, Ramey and Zubairy (2018).

where $\sum_{j=0}^{h} u_{t+j}$ *is instrumented by* ξ_t *and where* w_t *is a vector of control variables.*

Proof. See appendix. □

The simple estimation strategy implied by (4) provides a number of advantages (see also Ramey and Zubairy (2018)). First, standard errors for the multiplier are readily available. Since the error terms e_{t+h} is likely to be serially correlated, we will adopt heteroskedasticity and serial correlation robust standard errors. Second, instrument relevance can be easily assessed, and we will report the heteroskedasticity and serial correlation robust F-statistic of Olea and Pflueger (2013) to assess the strength of the first-stage.

3 Comparison with a model-based approach

In this section we compare our model-free characterization of the inflation-unemployment trade-off with the traditional model-based approach. The latter consists of first estimating a Phillips curve which may or may not be embedded in a larger structural model, and then using the estimated coefficients to back out the policy-relevant trade-off. When compared to this model-based approach, the Phillips multiplier offers a number of benefits.

First, by being defined directly from the impulse response functions of inflation and unemployment to a monetary shock, the Phillips multiplier avoids the endogeneity issues that have plagued the estimation of the Phillips curve, see Mavroeidis et al. (2014). In particular, since monetary shocks are orthogonal to supply shocks and to the natural unemployment rate u_t^*,[6] the Phillips multiplier will allow us to estimate the MRT (i) without bias from confounding supply shocks and (ii) without any need for a measure of the natural unemployment rate (because $\mathcal{R}_h^{u-u^*} = \mathcal{R}_h^u$). Note that these confounding factors have led to large estimation uncertainty in the Phillips curve literature, see Mavroeidis et al. (2014).

Second, unlike the Phillips curve, the Phillips multiplier characterizes the MRT in a *non-parametric* fashion. This provides robustness to mis-specification, which is particularly attractive given the large uncertainty regarding the set of relevant explanatory variables to

[6] Under the common assumption that monetary policy is neutral under flexible prices (e.g., Galí (2015)).

include in the Phillips curve as well as the appropriate dynamic lag specification. See Gordon (2011), King and Watson (1994) and the discussion in the appendix.

More generally, the coefficients of the Phillips curve alone may not be enough the characterize the inflation-unemployment trade-off faced by the central bank. Indeed, since the central bank influences real activity through its interest rate policy, the specification of the (IS) curve may also matter. In fact while the MRT reduces the slope of the Phillips curve in the basic New-Keynesian model (Galí (2015)), this is not a general result, and the MRT typically depends on both the Phillips *and* the (IS) curve coefficients.[7] We provide such an example in the appendix. Since the (IS) curve suffers from similar specification and endogeneity issues as the Phillips curve (Fuhrer and Rudebusch (2004)), the estimation issues get compounded. The non-parametric and identified nature of the Phillips multiplier, a statistic specifically designed to characterize the MRT, allow us to side-step these issues.

4 Empirical estimates of the US Phillips multiplier

In this section we compute the Phillips multiplier for the US. Since our direct estimation of the MRT relies on the existence of external instruments for exogenous changes in policy, the sample period we consider is dictated by the availability of relevant instruments.

Our baseline estimates for the US are based on the Romer and Romer (2004) narrative measure of exogenous monetary policy changes, which has the advantage of covering the longest sample period (1969-2007). As an alternative, we will also rely on the recent high-frequency identification (HFI) approach pioneered by Kuttner (2001) and use surprises in fed funds futures prices around FOMC announcement as instruments for monetary shocks.[8]

For all specifications throughout this paper, we use quarterly data and include four lags of inflation and unemployment as control variables w_t in regression (4). Finally, as implied

[7]Intuitively, the central bank's trade-off between inflation and unemployment depends on the relative speed with which monetary policy affects unemployment versus inflation, and this relative speed depends on the dynamic specifications of *both* the Phillips curve *and* the (IS) curve.

[8]See Gertler and Karadi (2015), Miranda-Agrippino (2016), Nakamura and Steinsson (2018) for more recent examples of the use of HFI instruments to identify the effects of monetary policy.

by equation (3) we conduct all our analyses under a stationarity assumption.[9]

4.1 Full sample estimates

For our baseline estimate based on the Romer and Romer narrative shocks, the sample covers 1969-2007 thanks to Tenreyro and Thwaites (2016)'s extension of the Romer and Romer series. Inflation is measured as the (annualized) quarter-to-quarter change in the PCE price level.

Figure 1 shows our baseline estimate for the Phillips multiplier for horizon $h = 0$ until $h = 20$ and also reports the Olea and Pflueger (2013) F-stats from the first stage of the instrumental variable regression (4).[10] The F-statistics document to what extent the monetary policy shocks are correlated with cumulative unemployment at horizon h. The F-stats statistics are reasonable (around 10) for h between 8 and 14 quarters. After this period, the F-statistics start to drop and the confidence bounds for the multiplier increase markedly.

The Phillips multiplier is initially indeterminate, but as time goes by $\mathcal{P}_h$ becomes negative, reaches about -2ppt after $h = 12$ quarters and diverges thereafter. Note that a large (or infinite) long-run MRT implies that a transitory policy-induced change in unemployment has a very persistent (or permanent) effect on inflation. With a large MRT, the Fed's ability to steer inflation with policy-induced unemployment movements is large. Equivalently, a large MRT implies that the Fed could lower unemployment permanently only at the cost of ever increasing inflation.[11]

To better understand the dynamic of the multiplier, we can separately study its individual components, namely the impulse responses of average inflation and unemployment. Indeed, the numerator $\mathcal{R}_h^{\bar{u}}$ and denominator $\mathcal{R}_h^{\bar{\pi}}$ of $\mathcal{P}_h$ are the impulse responses of the average levels of inflation and unemployment over the next h period following a monetary policy shock. Using local projections with instrumental variables (see Jordà (2005), Stock and

[9] We note that the main ideas of our methodology can be applied when a unit root is present.

[10] As instruments, we use the three monthly Romer-Romer shocks in each quarter.

[11] An infinite long-run MRT is reminiscent of the accelerationist Phillips curve of the 1970s where unemployment was related to *changes* in inflation. We will come back to this point in the next section, where we study the multiplier over different sample periods.

Watson (2018)), we can estimate the impulse responses of average inflation and average unemployment from

$$\begin{aligned} \bar{\pi}_{t:t+h} &= x_t \beta_h^{\pi} + w_t' \gamma_h^{\pi} + e_{h,t+h}^{\pi} \\ \bar{u}_{t:t+h} &= x_t \beta_h^{u} + w_t' \gamma_h^{u} + e_{h,t+h}^{u} \end{aligned} \quad (5)$$

where x_t is the fed funds rate instrumented with the Romer and Romer monetary shocks, and the parameters β_h^{π} and β_h^{u} capture the effect of a one unit change in the policy rate on average inflation and unemployment.

As shown in the right-column of Figure 1, the multiplier is initially indeterminate because both unemployment and inflation respond with a lag to monetary policy, the well known transmission lags of monetary policy (e.g., Svensson (1997)). Then, the multiplier builds up (in absolute value) over time, because the response of inflation is delayed relative to that of unemployment and because the response of inflation is more persistent than that of unemployment: as average unemployment starts to mean-revert to its unconditional mean at $h \simeq 10$ (which ceteris paribus increases $\mathcal{P}_h = \mathcal{R}_h^{\bar{\pi}} / \mathcal{R}_h^{\bar{u}}$ in absolute value), inflation remains elevated and shows no sign of mean reversion. As a result, the multiplier keeps increasing and diverges. The central bank can trigger a persistent (possibly permanent) change in inflation at a finite unemployment cost, i.e., the MRT is large.

4.2 The US Phillips multiplier over time

Our results based on the full 1969-2007 sample mix very different policy regimes that blur the interpretability of our results. In fact, a number of Phillips curve-based studies have suggested substantial changes in the persistence of inflation as well as in the magnitude of the inflation-unemployment trade-off; from the close to unit-root behavior of inflation in the 1970s (e.g., King and Watson (1994)) to the flattening of the Phillips curve in the post-1990 period (e.g., Ball and Mazumder (2011) and Blanchard (2016)).

In this section, we parallel the Phillips curve literature and study the evolution of the Phillips multiplier over time, using our non-parametric and identified approach to re-assess the evolution of the MRT over time. Importantly, unlike earlier Phillips-curve based studies, our approach will allow us to discard confounding effects that could give the illusion of a change in the MRT, notably a change in the variance contribution of supply shocks (which varies the magnitude of the endogeneity bias), or mis-measured changes in the natural rate of unemployment.[12]

To investigate a possible change in the Phillips multiplier since 1990, we draw on HFI monetary surprises.[13] Specifically, we follow Gertler and Karadi (2015) and consider changes in Federal Funds futures rates (FF) around FOMC announcement dates as external instruments.[14] This measure is plausibly uncorrelated with other shocks because they are changes across a short announcement window. To estimate the Phillips multiplier using HFI instruments, we proceed as with the Romer-Romer shocks except that we add as control variables the Greenbook forecasts for inflation and unemployment. This is to capture any changes in the Federal Funds futures rates driven by the part of information set of the Fed that differs from that of the market.

Since HFI monetary surprises are only available in the more recent period (1990-2008),[15] we will report two sets of results to assess the evolution of the Phillips multiplier over time: first, the Phillips multiplier estimated using the Romer-Romer narrative shocks over 1969-1989, and second the Phillips multiplier estimated using the HFI monetary surprises over 1990-2008.

The results are shown in Figure 2. While the estimated multipliers are similarly indeterminate at short horizons, their behaviors differ markedly at longer horizons. The pre-1990

[12]For instance, if the natural rate of unemployment was over-estimated during the late 1990s, the unemployment gap would have been under-estimated (not small enough), leading to a downward-biased estimate of the slope of the Phillips curve.

[13]Unfortunately, the Romer and Romer narrative instruments cannot be used to study the MRT in the more recent period (such as post-1990), because they have very low relevance (low first-stage F-stats) and thus cannot be used to estimate the Phillips multiplier. See Ramey (2016) for a forceful account of the difficulty of using the Romer-Romer shocks to learn about the effects of monetary policy in the post-1990 period.

[14]Similar, as Gertler and Karadi (2015), we found that "FF4", the three month ahead monthly Fed Funds futures, provided the best first-stage, and we will present results based on these instruments.

[15]We intentionally exclude the post-2008 period (the zero lower-bound period) during which forward guidance played a more prominent role and the Fed started employing unconventional monetary tools that could have different effects than conventional monetary tools, see Swanson (2017).

multiplier clearly diverges with the horizon, while the post-1990 multiplier is roughly stable at some small (but non-zero) long-run value. In other words, in the pre-1990 period, the MRT is large: monetary policy can have a very persistent, perhaps permanent, effect on inflation at a finite unemployment cost. In contrast, in the post-1990 period the MRT is small (but significant) and does not diverge. Consequently, the multiplier is substantially smaller in the post-1990 period with a multiplier at about -0.15 after 3-4 years, an order of magnitude smaller than in the pre-1990 period.

To help understand this flattening of the multiplier, Figure 3 plots the impulse responses of average inflation and unemployment in the two sample periods; pre-1990 and post-1990. The reasons for the change in the multiplier are twofolds: for a given change in unemployment, the response of inflation (i) is a lot more muted (one order of magnitude smaller) in the more recent period, and (ii) no longer displays inertia relative to unemployment and in fact appears to mirror the impulse response of unemployment. In the next section, we will explore to what extent the anchoring of inflation expectations can be behind this change in the behavior of inflation and the MRT.

5 MRT and anchoring of inflation expectations

One hypothesis for the large change in the value of the MRT is a change in the anchoring of inflation expectations. As noted by the Phillips curve literature, the anchoring of inflation expectations could lead to inflation displaying less inertia and turning from an I(1) to an I(0) process (e.g., Levin et al. (2004)),[16] and thereby the re-emergence of a long-run inflation-unemployment trade-off, i.e., to a non-vertical long-run Phillips curve (Akerlof, Dickens and Perry (2000), Svensson (2015)).

[16]For instance, drifting (i.e., unanchored) inflation expectations can lead to a high share of wage indexation to past inflation, which will raise inflation persistence. In contrast, with anchored inflation-expectations, there should not be any wage indexation to past inflation, and inflation will display less inertia.

5.1 Decomposing the Phillips multiplier

We explore the change in the MRT by decomposing the Phillips multiplier into the ratio of two separate dynamic multipliers: (i) a multiplier capturing the MRT holding inflation expectations constant, and (ii) a multiplier capturing the degree of anchoring of inflation expectations. We have

$$\mathcal{P}_h = \frac{\mathcal{K}_h}{1-\mathcal{A}_h}, \qquad h = 0, 1, 2, \ldots \tag{6}$$

where $\mathcal{K}_h$ is the "expectation-augmented Phillips multiplier" and $\mathcal{A}_h$ is the "anchoring multiplier" which are defined as follows

$$\begin{aligned} \mathcal{K}_h &= \mathcal{R}_h^{\bar{\pi}-\bar{\pi}^e}/\mathcal{R}_h^{\bar{u}} \\ & \qquad\qquad\qquad h = 0, 1, 2, \ldots, \\ \mathcal{A}_h &= \mathcal{R}_h^{\pi^e}/\mathcal{R}_h^{\pi} \end{aligned} \tag{7}$$

The multiplier $\mathcal{K}_h$ is the dynamic non-parametric analog of κ, the slope of an expectation-augmented Phillips curve (e.g., Coibion and Gorodnichenko (2015)), while $\mathcal{A}_h$ captures how policy-induced inflation movements pass through to inflation expectations, and can be interpreted as a dynamic measure of the degree of anchoring of inflation.[17] Full anchoring of inflation expectations corresponds to $\mathcal{A}_h = 0$, while full pass-through of inflation to inflation expectations implies $\mathcal{A}_h = 1$. As we will see, the $\mathcal{A}_h$ parameter share close similarities with the "α" parameter in the Phillips curve literature and Solow-Tobin tests of the natural rate hypothesis, e.g., Gordon, Solow, Perry and Gordon (1970).[18]

Expression (6) makes clear that two factors can lead to a decline in the Phillips multiplier: (i) a decline in the sensitivity of inflation to economic slack holding inflation expectations constant (a decrease in $\mathcal{K}_h$), and (ii) an increase in the anchoring of inflation expectations

[17] By focusing on the elasticity of inflation expectations to a shock, this measure is similar in spirit to other measures found in the literature, see e.g., Gürkaynak et al. (2010).

[18] In earlier Phillips curve regressions, α was traditionally the loading on past inflation meant to proxy for expected inflation. In that context, a value of α close to one implies the existence of a (close to) unit-root in inflation and no long-run trade-off between inflation and unemployment. In addition to being non-parametric and properly identified with monetary shocks, our approach also differs from that literature, because we use a survey-based measure of inflation expectations and do not model inflation expectations with past inflation (and thereby avoid the Sargent (1971) critique of Solow-Tobin-type tests.).

(an increase in $\mathcal{A}_h$).

As $h \to \infty$, $\mathcal{K}_\infty$ can be seen as capturing the cumulative direct effect of economic slack on inflation, while $\mathcal{A}_\infty$ captures the cumulative second-round effects arising from the adjustment of inflation expectations to inflation movements that then feed into inflation and in turn affect inflation expectations further, etc... Given our interest in the decline in the long-run value of the Fed's MRT, we will let $h \to \infty$ to discuss two polar cases:

(i) With no anchoring of inflation expectations ($\mathcal{A}_\infty = 1$), the MRT diverges as $\mathcal{P}_\infty \underset{\mathcal{A}_\infty \to 1}{\longrightarrow} \infty$. Intuitively, any policy-induced transitory change in inflation will feed into inflation expectations, which will then feed into future inflation; making the transitory change in inflation permanent (in the limit where $\mathcal{A}_\infty \to 1$).[19] The central bank is able to engineer large movements in inflation with small transitory movements in unemployment.

(ii) With some anchoring of inflation expectations, there is incomplete pass-through between inflation and inflation expectations, i.e., $\mathcal{A}_\infty < 1$.[20] This implies $0 < \mathcal{P}_\infty < \infty$, provided that $\mathcal{K}_\infty$ is non-zero and finite. Intuitively, if after a policy change, inflation expectations do not fully adjust to the overall change in inflation (incomplete pass-through), movements in inflation have limited second-round effects and the cumulative change in inflation is smaller. As a result, policy-induced unemployment movements will generate smaller and only transitory inflation movements. More generally, the stronger the anchoring of inflation expectations (the smaller $\mathcal{A}_\infty$), the smaller (in absolute vaule) the long-run Phillips multiplier, i.e., the smaller the long-run MRT.

[19] In the language of the Phillips curve, the slope of the Phillips curve depends on inflation expectations, so that while the Phillips curve may be downward slopping in the short-run because current inflation deviate from inflation expectations, in the long-run, the slope of the Phillips curve tends to infinity if inflation expectations full adjust to movements in inflation.

[20] An imperfect pass-through is clearly at odds with the full-information rational expectation. See Coibion, Gorodnichenko and Kamdar (2017) for consistent supporting evidence of departures from full-information rational expectations, and Akerlof et al. (2000) for some implications of near-rational expectations on the long-run slope of the Phillips curve.

5.2 Anchoring versus Flattening

To measure inflation expectations, we rely on the inflation forecasts of households from the University of Michigan Survey of Consumers, and we use households' forecast of price changes over the next 12 months, consistent with Coibion and Gorodnichenko (2015)'s finding that household forecasts appear to be a more relevant measure of inflation forecasts for the Phillips curve than professional forecasts.[21]

Figure 4 plots the multipliers $\mathcal{K}_h$ and $\mathcal{A}_h$, estimated for the pre-1990 and post-1990 samples using the Romer-Romer and HFI identification strategies. We can see that the pre- and the post-1990 periods correspond precisely to cases (i) and (ii) discussed in the above section, and the main reason for the change in the value of the MRT at medium to long horizons is a drastic change in the anchoring of inflation expectations. The MRT holding inflation expectations constant is relatively flat ($\mathcal{K}_h^{pre-90} \simeq \mathcal{K}_h^{post-90}$) between the two sample periods (at least given estimation uncertainty), but the anchoring multiplier differs markedly in the two periods. There is full pass-through of inflation to inflation expectations ($\mathcal{A}_h \simeq 1$, $h > 10$) in the pre-1990 period, and the Phillips multiplier $\mathcal{P}_h = \frac{\mathcal{K}_h}{1-\mathcal{A}_h}$ is large and diverging.[22]. In contrast, for the post-1990 period, there is close to perfect anchoring ($\mathcal{A}_h \simeq 0$, $h > 10$), and we find $\mathcal{P}_{20} \simeq \mathcal{K}_{20} \simeq -.15$.

6 The Phillips multiplier across countries

In this final section, we estimate the Phillips multiplier for two other advanced economies for which external instruments are available: the UK and Canada. These two countries are of particular interest as an external validity test for our previous results. Indeed, both countries adopted (in respectively 1991 and 1992) an explicit inflation targeting mandate, which has been found to successfully anchor inflation expectations (e.g., Levin et al. (2004)

[21] We obtain similar results with median one-year ahead forecasts from the Survey of Professional Forecasters or with longer-term 10-year ahead inflation expectations as estimated by the Board of Governors.

[22] In the language of the Phillips curve, the long-run slope of the Phillips curve is vertical and there is no long-run trade-off between inflation and unemployment

and Gürkaynak et al. (2010)). Thus, if the anchoring of inflation expectations leads to a large decline in the MRT, this decline should also be apparent with UK and Canadian data.

As measures of exogenous monetary policy changes, we rely on the narrative instruments constructed by Cloyne and Hurtgen (2016) for the UK and by Champagne and Sekkel (2017) for Canada. For the UK, inflation is measured as the (annualized) quarter-to-quarter change in the retail prices index (excluding mortgage interest payments) following Cloyne and Hurtgen (2016). The sample period covers 1975-2007. For Canada, inflation is measured as the (annualized) quarter-to-quarter change in the PCE price level and the sample period covers 1974-2014.

The left column of Figure 5 shows the estimated Phillips multiplier for the UK over two sample periods, the pre-inflation targeting period (1975-1990, plain red line) and the inflation targeting period (1991-2007, plain blue line) along with their 95 percent confidence bands. Similarly, the right column shows the Phillips multiplier for Canada estimated over the pre-inflation targeting 1975-1990 period (plain red line) and the inflation targeting 1992-2014 period (plain blue line).

The results are similar for the UK and Canada, and overall very similar to the US estimates. Consistent with the anchoring of inflation expectations leading to a large drop in the MRT, the UK and Canada multipliers are considerably smaller (although still significantly different from zero) and no longer diverging in the inflation targeting sample period. In terms of magnitude, the long-run MRT appears largest in the UK, followed by Canada and then the US. An interesting avenue for future research is to explore the significance and possible reasons for this result, for instance whether it indicates a stronger anchoring of inflation expectations in the US, or instead a lower $\mathcal{K}_h$, i.e., a lower overall sensitivity of inflation to economic slack (holding inflation expectations constant).

7 Conclusion

The inflation-unemployment trade-off faced by policy makers is traditionally inferred from the coefficients of an estimated Phillips curve. However, such model-based approach is fraught with specification and endogeneity issues. In this paper we propose a model-free approach to directly characterize the central bank's MRT with the *Phillips multiplier*; the cumulative change in inflation caused by a policy shock that raises unemployment by one percentage point.

Using instruments for the US, UK and Canada, we revisit the main lessons of the Phillips curve literature in a robust and identified setting. We find that (i) over short time scales (less than a year) the MRT is indeterminate because of transmission lags in policy, (ii) over medium time scales (biennial) the MRT is significantly negative, and (iii) the MRT went from being very large in the pre-1990 sample period to being small (but still significant) in the post-1990 period, i.e., during the onset of inflation targeting. Using inflation expectation data for the US, we find that most of the change in the US MRT owes to the anchoring of inflation expectations. In contrast, the overall sensitivity of inflation to economic slack (holding inflation expectations constant) is not markedly lower between the two periods.

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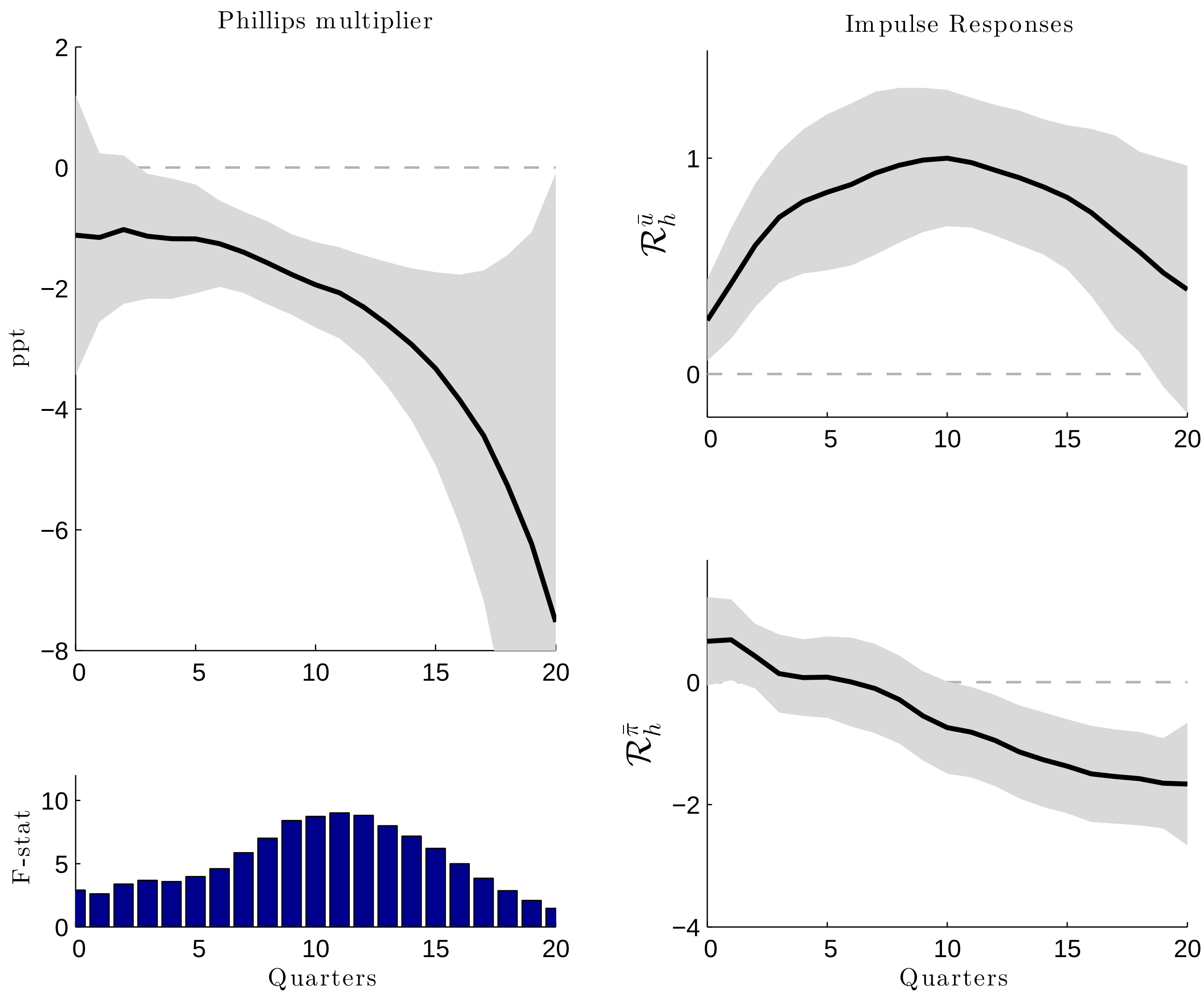
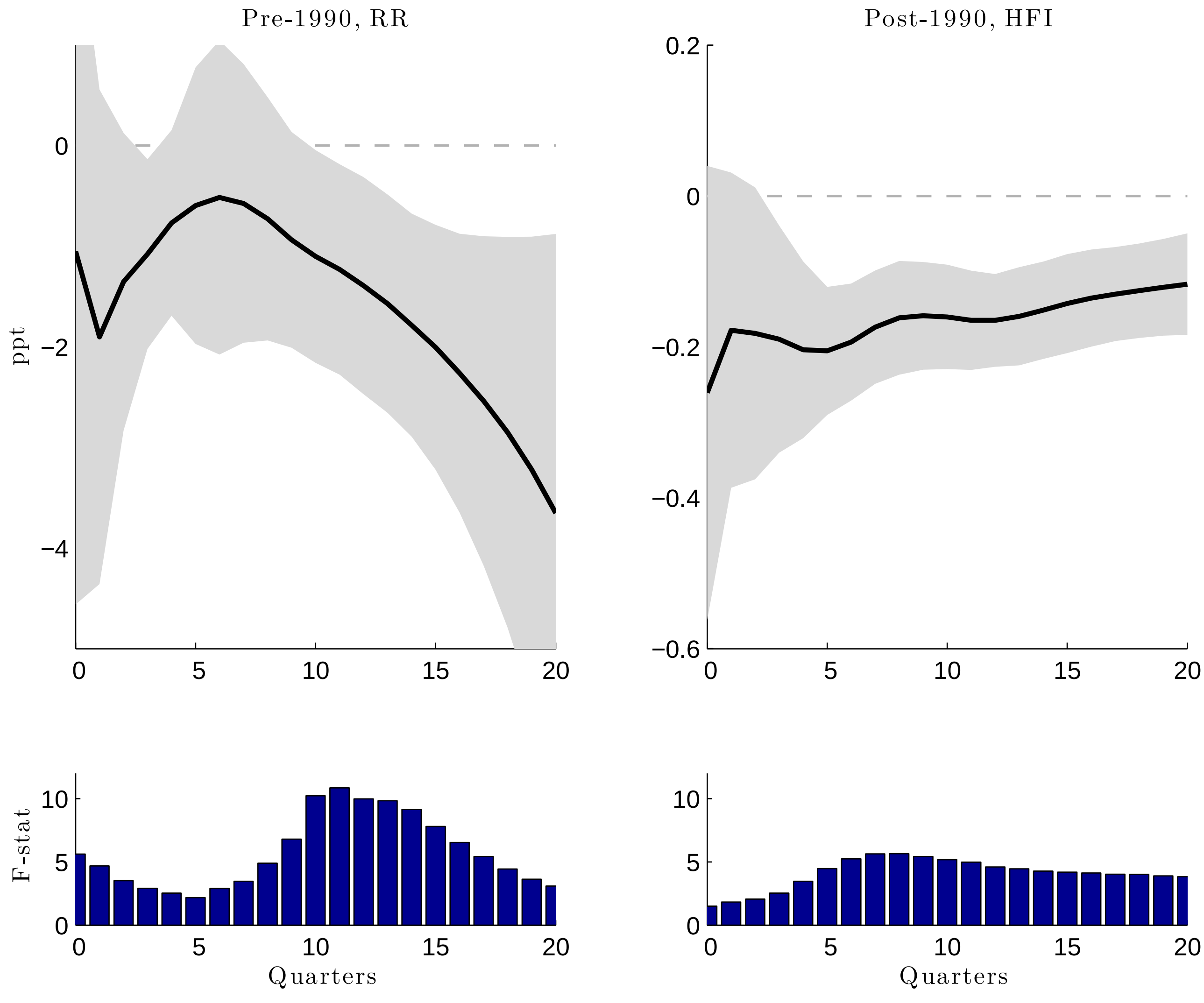
Figure 1: The Phillips multiplier $\mathcal{P}_h$ — 1969-2007, RR



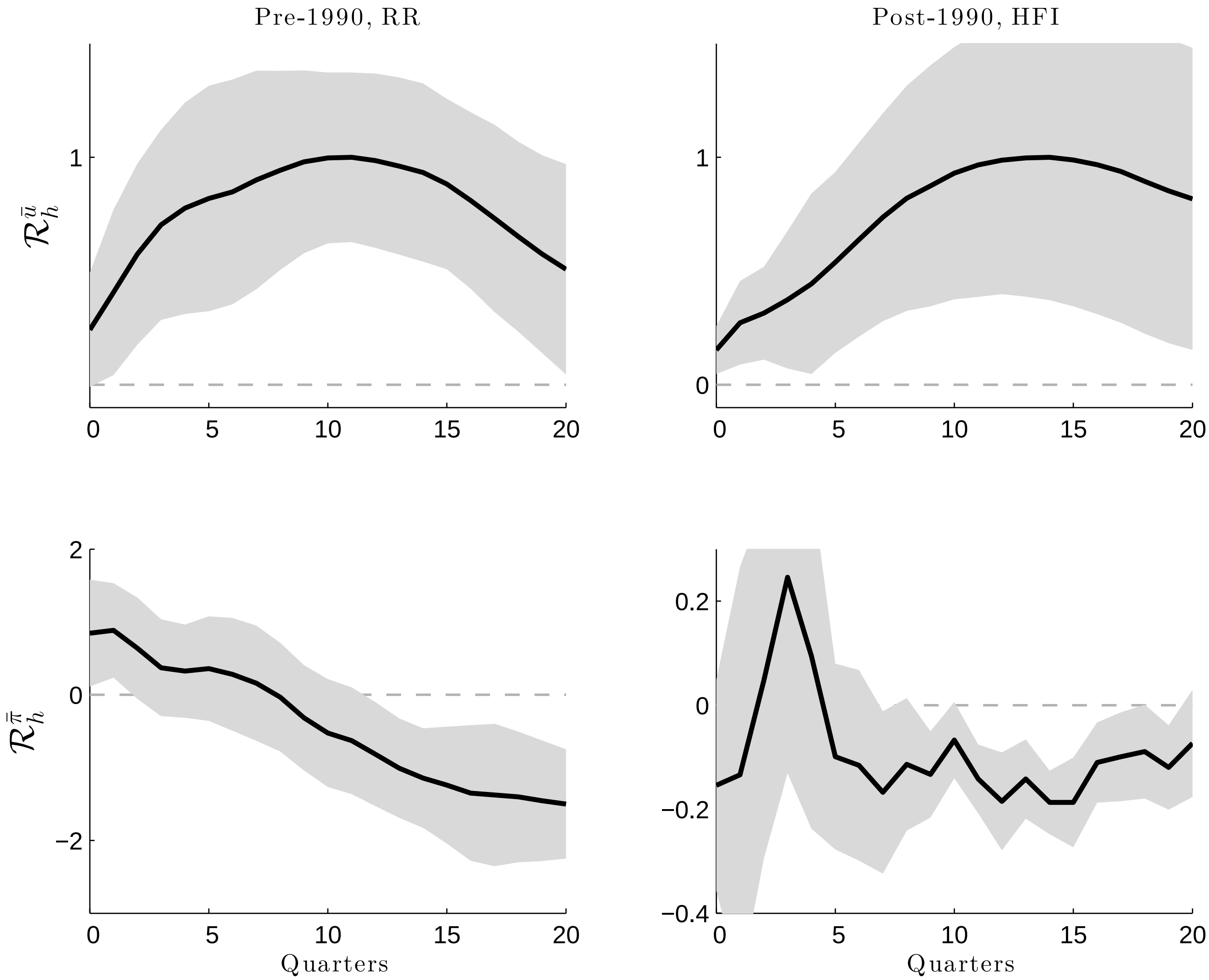
Notes: Phillips multiplier estimated using Romer and Romer (RR) narrative monetary shocks as instruments. The sample is 1969q1-2007q4. Newey–West 95% confidence intervals displayed.

Figure 2: The Phillips multiplier $\mathcal{P}_h$ over time — RR/HFI



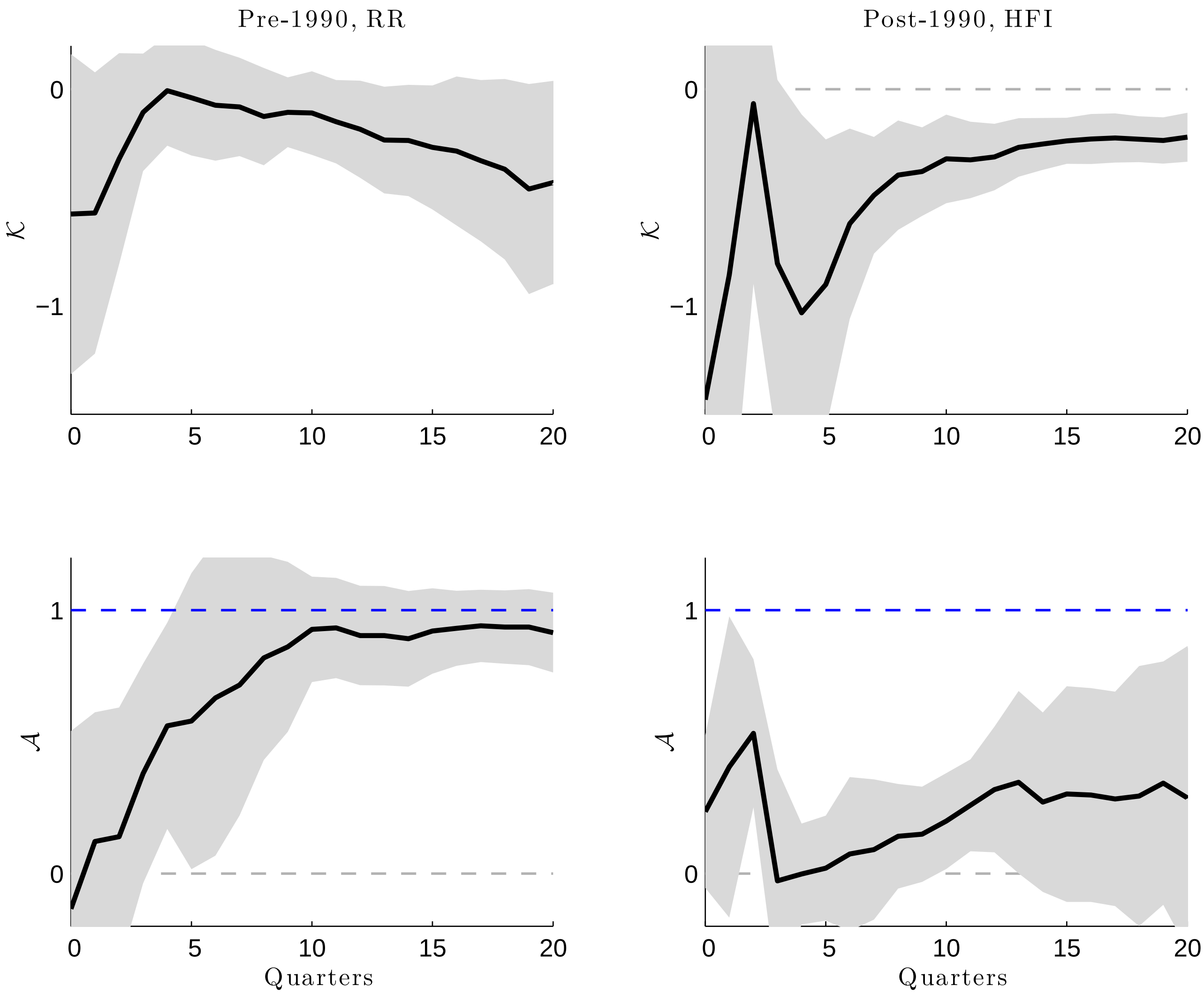
Notes: Left column: Phillips multiplier estimated using Romer-Romer (RR) monetary shocks over 1969q1–1989q4. Right column: Phillips multiplier estimated using High-Frequency Identified (HFI) monetary surprises ("FF4", the three month ahead monthly Fed Funds futures) over 1990q1-2008q4. Newey–West 95% confidence intervals displayed.

Figure 3: IRs of average inflation and unemployment — RR/HFI



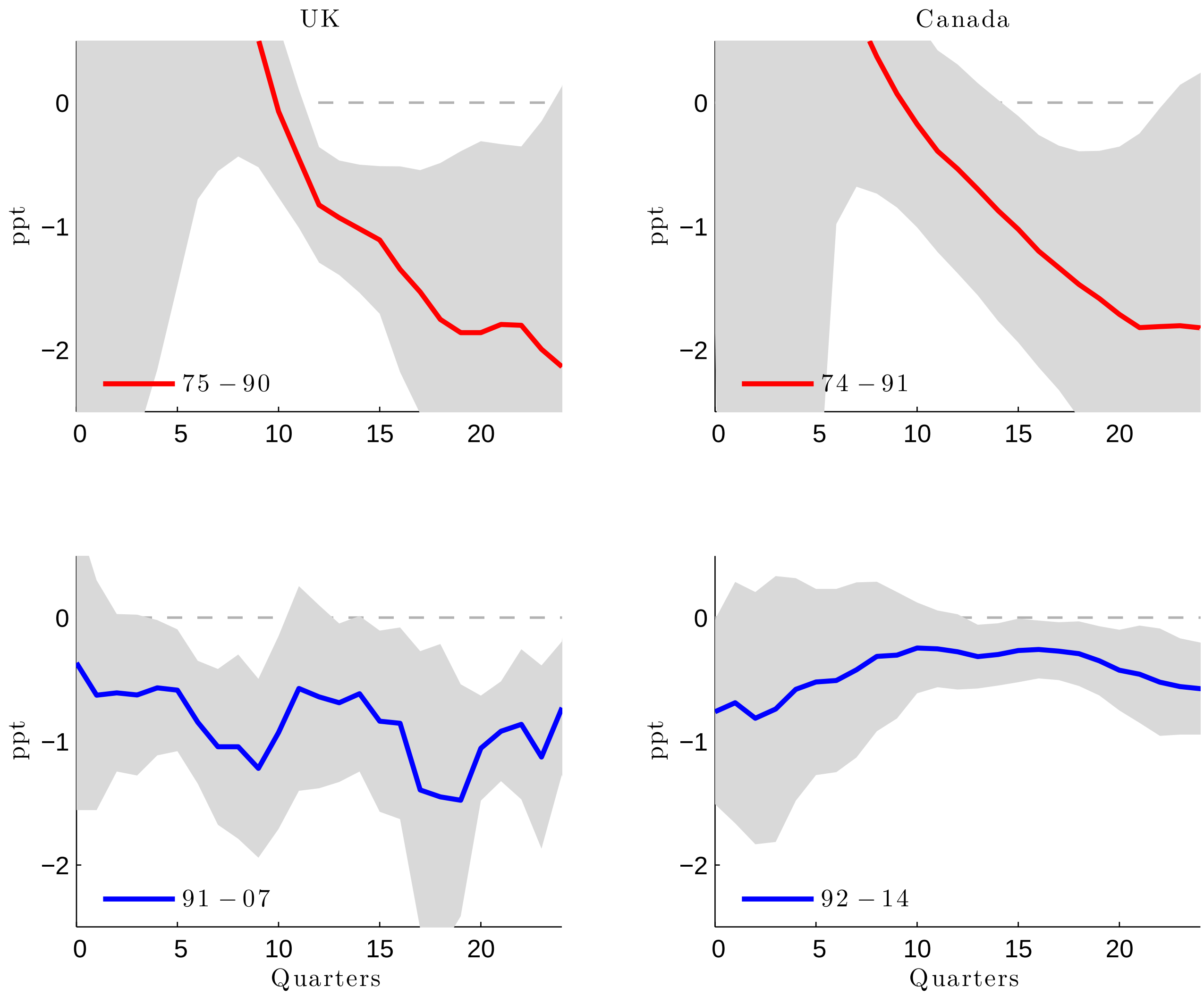
Notes: Left column: Impulse responses for $\bar{u}_{t:t+h}$ and $\bar{\pi}_{t:t+h}$ computed using the Romer and Romer narrative monetary shocks as instruments over 1969q1–1989q4. Right column: Impulse responses for $\bar{u}_{t:t+h}$ and $\bar{\pi}_{t:t+h}$ computed using High-Frequency Identified (HFI) monetary surprises ("FF4", the three month ahead monthly Fed Funds futures) over 1990q1–2008q4. 95% confidence intervals for the local projection estimates are displayed. For ease of comparison, the size of the monetary shock is set such that the impulse response of average unemployment peaks at 1ppt in both cases.

Figure 4: $\mathcal{K}_h$ and $\mathcal{A}_h$ over time



Notes: Left column: The "expectation-augmented Phillips multiplier" ($\mathcal{K}_h$) and the "anchoring multiplier" ($\mathcal{A}_h$), estimated using Romer-Romer (RR) monetary shocks over 1969q1–1989q4. Right column: the same multipliers estimated using High-Frequency Identified (HFI) monetary surprises ("FF4", the three month ahead monthly Fed Funds futures) over 1990q1–2008q4. Newey-West 95% confidence intervals displayed.

Figure 5: $\mathcal{P}_h$ across countries and over time — UK and Canada



Notes: Left column: Phillips multiplier for the United Kingdom estimated over 1975q1–2007q4 using Cloyne-Hurtgen monetary shocks. Right column: Phillips multiplier for Canada estimated over 1974q1–2015q3 using Champagne-Sekkel monetary shocks. Newey-West 95% confidence intervals displayed.