Received: 21 July 2021 | Revised: 13 April 2022 | Accepted: 25 April 2022

DOI: 10.1111/meca.12398

METROECONOMICA INTERNATIONAL REVIEW OF ECONOMICS

WILEY

ORIGINAL ARTICLE

Monetary policy, rational confidence, and Neo-Fisherian depressions

Lucio Gobbi[1] | **Ronny Mazzocchi**[2] | **Roberto Tamborini**[1]

[1]Department of Economics and Management, University of Trento, Trento, Italy

[2]European Parliament, Brussels, Belgium

Correspondence
Roberto Tamborini, Department of Economics and Management, University of Trento, Via Inama 5, Trento 38100, Italy.
Email: roberto.tamborini@unitn.it

Funding information
Universita degli Studi di Trento
Open Access Funding provided by Universita degli Studi di Trento within the CRUI-CARE Agreement.

Abstract

Why do economies fall into depression equilibria with output and inflation below target? What is the appropriate monetary policy? We examine the so-called "Neo-Fisherian" claim that, at the zero lower bound of the policy interest rate, and the economy in a depression equilibrium, in order to restore the desired inflation rate the policy rate should be *raised* consistently with the Fisher equation. To this end, we study a New Keynesian economy where we introduce a process of expectations formation, less explored in the relevant literature, such that agents, facing multiple equilibria, seek to figure out their subjective probabilistic beliefs about the future long-run equilibrium of the economy ("normality", with inflation and output reverting to target, or "depression", with inflation and output remaining below target), driven by the observed state of the economy. Therefore, key to the macroeconomic process is the dynamic interaction between the agents' state of confidence in the return to normality and monetary policy. Differently from comparable works, we find that the Neo-Fisherian claim is a theoretical possibility depending on the interplay of a set of parameters and very low levels of agents' confidence. Yet, on the basis of simulations of the model, we may say that this possibility is remote for most commonly

We wish to thank two anaonymous reviewers of the Journal for their helpful comments and indications. We remain fully responsible for this paper.

found empirical values of the relevant parameters. Moreover, the Neo-Fisherian policy-rate peg is not sustained by the expectations formation process.

KEYWORDS
formation of inflation expectations, monetary policy, neo-fisherian theory

JEL CLASSIFICATION
D84, E31, E52

1 | INTRODUCTION

In the decade between the 2008-09 Great Recession and the 2019 outbreak of the Covid-19 pandemic, central banks across the board of advanced countries have been struggling to drive downward trending inflation and economic activity back to their desired targets. With policy interest rates rapidly falling to the zero lower bound (ZLB) and persistent stagnation, previous confidence in the effectiveness of "conventional" monetary policy has been shaken (Bernanke, 2010; Draghi, 2016; Schnabel, 2020; Smets, 2021). Central banks have then experimented a variety of "unconventional" monetary policies.[1] While the jury on these policies is still out, it is unclear how far the post-pandemic rebound will go, whether the ensuing inflationary pressure will take hold, or whether the factors of "secular stagnation" will remain in place (Bonatti et al., 2020; Goodhart, 2020; Lane, 2020; Rogoff, 2021). Be that as it may, questions about the stabilisation capacity of conventional monetary policy in the face of depressions remain high in the research agenda.

In this perspective, it is worth considering a strand of literature, labelled "Neo-Fisherianism", which asserts that the economy may remain stuck at too a low inflation equilibrium precisely because nominal interest rates themselves are low (e.g. Cochrane, 2014, 2016a, 2016b; Williamson, 2017). The forward guidance that the policy rate will remain low for an extended period of time is self-defeating because it validates beliefs that low inflation in the current circumstances is inevitable.

According to the Neo-Fisherian (NF) view, which hinges on the so-called Fisher equation (Fisher, 1930), the only way to drive the economy to the targeted level of inflation is to peg the policy rate to its Fisherian equilibrium value, that is the equilibrium, or Wicksellian "natural", real interest rate augmented by the target inflation rate. That is to say, if $r*$ is the natural rate and $\pi*$ is the inflation target, then the equilibrium policy rate should be

$$i^* = r^* + \pi^*$$

In practice, in a depression with $\pi_t < \pi*$ and $i_t < i*$, the central bank should *raise* the policy rate in order to lift inflation from its undesirably low rate.[2]

[1] These mainly consist of direct injections of large and targeted amounts of liquidity ("quantitative easing"), enhanced by the commitment to keeping interest rates low for an extented period of time ("forward guidance") (see e.g. Borio & Disyatat, 2010; Kool & Thornton, 2015; Lane, 2020; Williams, 2011). To counteract the dreadful economic consequences of the Covid-19 pandemic, central banks have felt compelled to carry on these strategies on an even larger scale.

[2] For non-negative $i*$, this argument presumes that $r* \geq -\pi*$. While uncertainty around the level of the natural rate of interest is large − indeed an unobservable variable according to Wicksell − all attempts at estimation point to a significant fall worldwide (Del Negro et al., 2019; Holston et al., 2017; Laubach & Williams, 2003; Marx et al., 2021). As for the European Monetary Union (EMU), estimates indicate that the natural rate should now be between 0.5% and −2.0% (Ajevskis, 2018; Brand et al., 2018; Brand & Mazelis, 2019; Fiorentini et al., 2018; Garnier & Wihelmsen, 2005; Gerali & Neri, 2019).

In this paper we pursue a twofold aim. First, understanding how economies may fall into depression equilibria. Second, assessing whether the NF policy may be a feasible solution. We take stock of two criticisms of the NF view in the relevant literature.[3]

The first concerns the hypothesis that inflation expectations automatically adjust upwards to the new higher nominal interest rate in order to satisfy the Fisher equation. Cochrane (2016a, 2016b) bypasses Friedman's critique that a pure policy-rate peg would make inflation dynamics explosive (Friedman, 1968; McCallum, 1986) by picking the backward stable equilibrium whereby the initial state is consistent with the perfect foresight solution.[4] These results appear to hold also when the model is opened to possible frictions and modification, including the preference for money, backward-looking Phillips Curve and different Taylor-Rule specifications. Yet several economists contest the arbitrary assumption of backward stable equilibrium. Although the latter is among all potential equilibria, there is no convincing argument that only this equilibrium selection method should be used (Kortelainen, 2017; Spahn, 2018).

The second, and consequential, criticism concerns the problem of expectation formation (e.g. Evans & McGough, 2018a, 2018b; García-Schmidt & Woodford, 2019).[5] Predicting what may happen as a result of a particular policy regime requires two ingredients. First, the identification of the process that generates inflation in the economy, inclusive of the role of expectations. Second, how expectations are generated on the basis of agents' (possibly limited) understanding of the data generation process and their relevant available information. Typically, the expectation formation process interacts with (is itself part of) the macroeconomic process in a "self-referential" or "reflective" loop.[6] Both Evans and McGough (2018b), and García-Schmidt and Woodford (2019) study an economy of this kind and they deliver a negative verdict about the NF claim. A common element is that the abandonment of the policy-rate feedback rule for the new policy-rate peg impairs convergence and stability of the system.

Following this approach, in Section 2 we deploy a standard New Keynesian (NK) three-equation model, consisting of the output-gap equation (OG), the Phillips Curve (PC) and the Taylor Rule (TR). In Section 3 we introduce an endogenous process of formation of inflation expectations where agents are not engaged in making good forecasts of next time-lapse inflation, as in common NK models, but in figuring out their subjective probabilistic beliefs about the future long-run state of the economy (Gobbi et al., 2019).[7] One main rationale is that transitions from normal to depression regimes are *possible* but *very infrequent*, so that agents do not (and know they do not) possess sufficient statistical

[3] Empirical studies of the NF view offer little guidance. They mainly hinge on testing the hypothetical positive correlation between interest rates and inflation, with neutral or possibly positive effects on output (see e.g. Bias & Hall, 2021; Cochrane, 2017; Lukmanova & Rabitsch, 2018; Uribe, 2017, 2018). However, correlation is not causation; the inverse sense of causation of the Fisher equation is also possible, namely that higher inflation should be matched by a higher nominal interest rate, a basic notion in finance prompted by Fisher himself. Indeed, Crowder (2018) tested and found that inflation causes nominal interest rates in the long run, but not the other way around.

[4] Similar conclusion can also be found in Uribe (2017, 2018).

[5] These belong to the literature that introduces various forms of boundedly rational expectations. Farmer (1993, 2019), Evans and Honkapohja (2001), Kurz (2011) provide thorough explorations of the different approaches.

[6] There is by now a large production of models with endogenous expectation formation as means of equilibrium selection. Here we only refer to those which directly address the NF claims.

[7] The importance of long-term, rather than short-term, expectations for the evolution of actual inflation is now recognised by central banks, and is witnessed by the collection of specific survey data (see e.g. Draghi, 2016). Rudd (2021) raises a number of criticisms against the neglect of the long-run expectations in standard macro-models.

evidence in order to compute robust "objective" estimates of the relevant events−a well-known argument put forward by Keynes (1937).[8]

As in Woodford (2003, ch. 2), the future long-run states of the economy are obtained by open-ended forward iteration of the Phillips Curve. Upon observing the state of the economy at each time t, agents elaborate a "regime-switch hypothesis", namely that, at each future date $t + n$, $n = 1, ...,$ the economy may remain in its "normal regime" with probability p_t, against the probability $1-p_t$ that it may switch to a "depression regime".[9] In the normal regime, agents view non-zero output/inflation gaps as transitory deviations from to the zero-gaps equilibrium. In the depression regime, gaps observed at any point in time will remain unfilled. In other words, p_t is a measure of agents' confidence in the central bank's ability to keep the economy in the normal regime, which we do not take for granted a priori.

For this purpose, in Section 4 we endogenise the evolution of the probability p_t by way of a "confidence function" (CF) of the form $p_t = \psi(z_t)$, where z_t is an index of the state of economy that includes realised output gaps. Rationality of the updating mechanism, in the sense of consistency with the data generation process, is warranted by some necessary properties of the CF that will be established, one of which is that the confidence in the normal regime falls more, the more the economy deviates from it.

The key results of the theoretical model are the following. First, depression equilibria may emerge, implying a permanent value of $p < 1$. Second, lower confidence in the normal regime acts as amplifier of output/inflation gaps making depression regimes more likely; hence regime switches may be induced by agents' beliefs instead of the other way round.[10] Third, depending on the value of p, we identify two types of depression states: NK ones, which could be cured it if were possible *to reduce* the policy rate further, and NF ones, such that *raising* the policy rate would be the right choice. These occur when p falls below a certain threshold level, that is, confidence in the normal regime is particularly low. In short, the occurrence of NF conditions is an empirical matter.

In Section 5 we identify the critical parameters that govern the above results, and by means of simulations we show that for values in line with their consensus range in the empirical literature, the conditions for the NF policy can be regarded as remote. Moreover, if the economy falls into a NF depression, pegging the policy rate to its Fisherian equilibrium value as a means to restore inflation on target is not supported by the expectations formation process. Further light is also shed on the conditions underpinning successful conventional policy, which result to be more stringent − depression states are more likely − than believed in earlier studies as shown by Chung et al. (2012).

[8] Chung et al. (2012) show that professional forecasters have underestimated the likelihood of the ZLB threat by "focusing too much on the Great Moderation experience and relying on structural models whose dynamics cannot generate sustained ZLB episodes" (p. 47). Our approach also avoids two controversial grounds. First, assumptions about agents' knowledge of the structure (estimation model) of the data generation process (which may quickly go out-of-date in the face of unusual events). Second, conjectures about how good agents are as econometricians of what econometric technique they prefer.

[9] Note that we assume regime switches as a subjective hypothesis of agents, whereas most of the literature consider exogenous, stochastic regime switches (relevant examples are Iiboshi, 2016; Arifovic et al., 2017; Aruoba et al., 2018; Nakata & Schmidt, 2019). Lansing (2019) presents a model with "endogenous switches"; yet, in the line of agents as econometric forecasters, the weight assigned to each regime is obtained by recursive optimisation of the forecast performance regarding output and inflation. None of these works, however, addresses the NF claims directly.

[10] Calibration with the US data of the model by Lansing (2019) shows the presence of the "self-referential effect" of the expectations formation process, a result that by itself jeopardizes the consistency of the hypothesis that agents as econometric forecasters can discover the "true" data generation processes.

Section 6 summarises and concludes pointing out that our findings leave open the question of how the economy can be rescued from a depression state when conventional monetary policy is stuck at the ZLB.

2 | THE STANDARD NEW KEYNESIAN MODEL, SHORT-RUN AND LONG-RUN EXPECTATIONS

We consider the standard NK framework for monetary policy (e.g. Galì, 2008). The model is linearized around a zero inflation steady-state. The two equations describing the economy are:

$$y_t = y^e{}_{t+1} - \alpha \left(i_t - \left(r_t{}^* + \pi^e{}_{t+1} \right) \right) + u_{yt} \quad (1)$$

$$\pi_t = \beta \pi^e{}_{t+1} + \kappa y_t + u_{\pi t} \quad (2)$$

Equation (1) is the output-gap equation (OG), derived from the household's Euler equation, where y_t is the logarithmic difference between current output and potential output, i_t is the nominal interest rate controlled by the central bank, r_t* is the "natural" (real) interest rate, that is, the interest rate corresponding to the general equilibrium of the economy at potential output. The term in parentheses can be read as the Fisherian "interest-rate gap", that is, the deviation of the policy rate from the natural rate and the expected inflation, with α measuring the (constant) elasticity of substitution of aggregate spending.

Equation (2) is the NK Phillips Curve (PC) and expresses current inflation π_t–the inflation gap for the central bank−as a function of the current output gap and expected inflation. The parameter $\beta < 1$ is the time discount factor, while $\kappa > 0$ is a parameter reflecting the degree of price flexibility in the goods market (κ increases with price flexibility).[11]

The superscript (^{e}) denotes a generic expectation of the variable, to be specified subsequently.

The economy may also be hit by different types of shocks. Most typical are output (u_{yt}) and inflation ($u_{\pi t}$) unanticipated shocks. Also r_t* may be the result of a constant r* and a shock u_{rt}.

The expectational variables appearing in the standard NK model can be dubbed "short-term expectations", that is, expectations of variables one period ahead. How can these be pinned down *rationally*? The key contribution of the NK theory of monetary policy is that, if the policy rate is driven by a feedback rule responding to observed (possibly foreseen) inflation gaps (and possibly controlling for output gaps), under suitable conditions the economy converges to a steady state with zero gaps. One such feedback rule is the standard Taylor Rule (TR) whereby the central bank adjusts the policy rate in a way consistent with inflation equalling its target and the Fisher Equation, while smoothing output gaps. With a zero inflation target, the TR equation that closes the model is as follows

$$i_t = r_t{}^* + \gamma_\pi \pi_\tau + \gamma_y y_\tau \qquad i_t \geq 0 \quad (3)$$

where $\gamma_\pi > 0$, $\gamma_y \geq 0$ are the policy parameters, and τ is a time index that can be determined according to various specifications, for example, "real time" $\tau = t$, forward looking $\tau = t + n$ ($n = 1, \ldots$), lagged

[11] In particular, $\kappa = (1-\phi)\,(1 - \phi\beta)\phi^{-1}$, where ϕ is the probability of prices being unchanged (the fraction of firms not changing their price) after a change in aggregate demand (Calvo, 1983). Clearly, $\phi = 1$, $\kappa = 0$, represent the Old Keynesian fixed-price economy where the Phillips Curve is horizontal, and the steady-state inflation is zero, whereas $\phi = 0$, $\kappa \to \infty$, represents the New Classical flex-price economy where the Phillips Curve is vertical, and the steady-state inflation is undetermined.

$\tau = t{-}n$ ($n = 1, \ldots$). A sufficient condition for convergence to the zero-gaps steady state $(\overline{\pi}, \overline{y}) = 0$ is $\gamma_\pi > 1$.[12] Consequently, the zero-gaps equilibrium is also the rational, "long-run" expectation of output and inflation. As long as short-run inflation expectations do not deviate systematically from their long-run benchmark, they are said to be "anchored" to the central bank's target.

Note, however, that agents holding the long-run expectation of the zero-gaps equilibrium *rationally*, *presume* that the central bank exerts stochastic control on the system, which in turn *presumes* the rational expectations hypothesis. In other words, the central bank succeeds in anchoring inflation expectations to its target if the agents expect it to succeed, and vice versa.

To break this circularity, let us take a step backward and address the following question concerning expectation formation: under what conditions do agents have reasons to believe in the central bank's ability to achieve the zero-gaps equilibrium (Evans & McGough, 2018b)? In the first place (Section 3), we shall introduce agents' state of confidence as an exogenous probabilistic belief and study the implications of less than full confidence. Then (Section 4), we shall rationalise agents' confidence by relating it to the observed state of the economy.

3 | AGENTS' CONFIDENCE, AND THE EXISTENCE OF NEO-FISHERIAN DEPRESSIONS

To begin with, let us inspect expectations formation more closely. According to the (substantive) rational expectations hypothesis, expectational variables coincide with the statistical expected value of their relevant generation process conditional upon available information as of time t – usually denoted by the operator $E_t(\bullet)$. In the case of inflation, this method consists of the forward iteration of the equation (2) of current inflation (Woodford, 2003, ch. 2; García-Schmidt & Woodford, 2019). Consequently, current inflation results to be determined as follows

$$\pi_t = \beta^N E_t \pi_{t+N} + \kappa \left(y_t + \sum_{n=1}^{N} \beta^n E_t y_{t+n} \right) \tag{4}$$

where N is the time horizon of forward iterations. Given $\beta < 1$, then, as $N \to \infty$, $\beta^N E_t \pi_{t+N} \to 0$; hence current inflation comes to depend on the current and the infinitely expected future path of output gaps. Consistently with the OG equation (1), the rational expectation of the future path of output gaps is in turn determined by the future path of the policy rate. As explained above, a feedback policy rule like the TR equation (3) ensures convergence to the zero-gaps equilibrium. Therefore, agents with well-anchored expectations, who firmly believe in the central bank's ability to keep the economy around its zero-gaps equilibrium up to random shocks, will project the series $E_t y_{t+n}$ consistently with the full model solution, that is, $E_t y_{t+n} = E_t \pi_{t+n} = 0$ for all n.

However, thanks to Benhabib et al. (2001) (also Woodford, 2003), agents also know that they may face multiple equilibria, and in particular that if a negative shock large enough occurs and the policy rate hits the ZLB, the economy may be stuck in a "depression equilibrium" (or "liquidity trap") with negative output and inflation gaps.

Therefore, let us relax agents' *firm* belief in the long-run zero-gaps equilibrium and let it become a *probabilistic* one. They may consider a "regime-switch hypothesis", that is, that at each future date, $t+1, \ldots, t+n, \ldots$, the economy may remain in the "normal regime", with probability $p \in [0, 1]$, or it

[12] This is implied by the necessary and sufficient condition for the three-equation system OG-PC-TR to have two eigenvalues within the unit circle, namely $\kappa(\gamma_\pi - 1) + (1-\beta)\gamma_y > 0$ (Galì, 2008, p. 77 and ff.).

may switch to a "depression regime" with probability $(1-p)$. In the former case, net of i. i.d. random shocks, the expected value of gaps is zero as explained above.[13] In the latter, the observed gap at any time is expected to remain unfilled. For the time being, we consider p as an exogenous parameter measuring the state of confidence of agents in the normal regime in order to explore its implications.

According to the regime-switch hypothesis, the path of output gaps at each future date feeding into the iterated PC (4) is therefore the $(p; 1-p)$ mean value of the equilibrium gaps in the two regimes, that is,:

$$E_t y_{t+1} = (1-p) y_t, \ldots, E_t y_{t+n} = (1-p) E_t y_{t+n-1}, \ldots$$

Given this state of expectations, the PC becomes:

$$\pi_t = \beta^N \mathrm{E}_t \pi_{t+N} + \left(1 + \sum_{n=1}^{N} ((1-p)\beta)^n\right) \kappa y_t$$

Taking the limit for $N \to \infty$, we obtain

$$\pi_t = \omega \kappa y_t \tag{5}$$

where $\omega \equiv (1-(1-p)\beta)^{-1}$.

Since $\partial\omega/\partial p < 0$, the first noteworthy result is that the relationship between inflation and output gaps in the PC is *amplified* to the extent that p falls below 1. The reason is that if the economy falls into a negative output gap today, and agents assign non-zero probability to the hypothesis that so it will remain in the future, they will also lower their expected inflation, which amplifies the reduction of current inflation.

Like-wise, we should reformulate also the OG according to the regime switch hypothesis; that is to say, $\mathrm{E}_t y_{t+1} = (1-p) y_t$, and $\mathrm{E}_t \pi_{t+1} = \omega\kappa \mathrm{E}_t y_{t+1}$ (which is indeed the expected value of (5)). Substituting these values into (1) we obtain

$$y_t = \left(-\alpha \hat{i}_t + u_{yt}\right) \theta \tag{6}$$

where $\hat{i}_t \equiv i_t - r^*$, $\theta \equiv [1-(1-p)(1+\alpha\omega\kappa)]^{-1}$

Since also $\partial\theta/\partial p < 0$, the second result is that as p falls below 1 also output gaps are *amplified* for any interest-rate gap. The reason, again, is that the likelihood of switching to a depression regime lowers inflation expectations with the consequence that, given the policy rate, the market real interest rate is increased further, widening the gap. On the other hand, to the extent that the central bank is able to stimulate output by adjusting the policy rate, the gradient of recovery is also amplified. This is good news, since the instrument is more effective when it is most needed.

There is, however, a third result to be discussed, which leads to the NF view. It concerns the sign of the OG equation. Conventional monetary policy hinges on the negative relationship between the output/inflation gaps and the interest-rate gap: in order to rebalance a negative output/inflation gap, the prescription is a cut to the policy rate (i.e. create a negative interest-rate gap or reduce a positive one). Yet now this relationship also depends, not only on the magnitude, but also on the sign of θ. The conventional negative relationship holds if $\theta > 0$. It can be seen that this requires

[13] Note we are not saying that agents believe that in the normal regime the gaps are always nil, but that they believe the gaps are nil net of random schocks.

$\beta p^2 + (1 - \beta + \alpha\kappa)p - \alpha\kappa > 0$. This expression is equal to zero for two values of p: both are certainly real, and one is certainly negative. Yet one may be positive,[14] call it p^*. The expression of p^* is:

$$p^* = \left\{ [\beta^2 - 2(1 - \alpha\kappa)\beta + (1 + \alpha\kappa)^2]^{1/2} - (1 - \beta + \alpha\kappa) \right\} /2\beta \tag{7}$$

This implies that the conventional sign of the OG equation obtains only if $p > p^*$. As a consequence, if agents attach *particularly low confidence* ($p < p^*$) to the return to the normal regime, then the relationship among the interest-rate gap, output gap and inflation gap will be inverted. This may be called a "*NF depression*", that is, a state of particular depression such that in order to restore output and inflation it is necessary to *raise the policy rate*, or generate *a positive interest-rate gap*. A straightforward proof is provided by the limit case of confidence falling to zero. In fact, as $p \to 0$, the output and inflation gap relationships with the interest-rate gap become

$$y_t = \frac{1 - \beta}{\kappa} \hat{i}_t$$

$$\pi_t = \hat{i}_t$$

where the latter confirms the NF claim that a one-to-one relationship between inflation and nominal interest rate is established.[15] The intuition may be that a large (or total) loss of confidence in conventional monetary policy makes it actually countereffective, because, as argued by the NF authors, further commitment to low (or falling) policy rate validates the beliefs that the economy is in the depression state and low (or falling) inflation is inevitable. At that point, but only at that point, a belief reversal may come from a policy reversal. But, as we shall see subsequently, the restoration of the Fisherian equilibrium is far from being granted by the mechanical application of the Fisher equation.

Inspection of the determinants of p^* may provide further insights about the NF depressions. In particular, it is worth noting that p^* is increasing in κ, meaning that, *ceteris paribus*, NF depressions become more likely the more prices are flexible (see also the simulations in Section 5). In the limit case of full price flexibility, $\kappa \to \infty$, then $p^* \to 1$, that is, any small deviation from equilibrium would determine NF conditions confirming that these conditions only hold under frictionless general equilibrium hypotheses.[16]

4 | RATIONAL CONFIDENCE

So far we have treated the state of agents' confidence in the normal regime of the economy as an exogenous probabilistic belief, showing the consequences of states of less than full confidence. We now want agents' beliefs to be (procedurally) rational, that is, elaborated in accordance with the actual functioning of the economy and with a viable inference mechanism.

To this end, we time-index the probability p_t assigned to the economy being in the normal regime, and we posit that it is updated *vis-à-vis* a (set of) state variable(s) z_t available to agents in t, such that

[14] If $[\beta^2 - 2(1 - \alpha\kappa)\beta + (1 + \alpha\kappa)^2]^{1/2} + \beta - \alpha\kappa > 1$

[15] Yet, as soon as confidence is re-established, the economy switches back to the normal regime.

[16] High price flexibility is a condition for NF monetary policy also in the model by Garìn et al. (2018), and its countervailing role in interest-rate policy is an intuition that can be traced back to Wicksell himself (1898) (see Boianovsky & Trautwein, 2004; Leijonhufvud, 1981; Mazzocchi et al., 2014).

$z_t = 0$ when the economy is in the zero-gaps equilibrium, and $z_t \neq 0$ otherwise. The specification of z_t should reflect agents' understanding of the variables relevant to expectation formation. The natural candidate in our model is the output gap. A general format may be $z_t = \mu(y_t, y_{t-1}, \ldots)$.[17]

A consistent mapping ψ from z_t to p_t should display the following properties,

(i) $\psi(0) = 1$, (ii) $\psi_z < 0$, (iii) $\lim_{z_t \to \pm\infty} \psi = 0$

That is to say, confidence is maximal as long as the economy is at the zero-gaps equilibrium, it falls and tends to zero as the deviation (either positive or negative) from equilibrium grows larger. We may call this the "confidence function" (CF).

A suitable format is provided by logistic functions, which have wide applications in inference problems in order to transform observed variables into probabilistic assessments of the occurrence of an event.[18] We adopt the following specification, which has in fact the required properties[19]

$$p_t = \frac{4e^{-\eta z_t}}{(1 + e^{-\eta z_t})^2} \tag{8}$$

The choice of the parameter η and different specifications of z_t enable us to capture different scenarios regarding changes in agents' confidence in the normal regime *vis-à-vis* changes in the state of the economy, while keeping the model manageable. The parameter η regulates the gradient of the function, that is, the reactivity of p_t in response to any observed $z_t \neq 0$.[20] Figure 1 depicts the function for increasing values of η. Thus, high η may be appropriate when confidence is volatile possibly as a consequence of lack of reputation of the central bank, whereas high reputation of the central bank may be reflected in low η.

Since, as a consequence of the CF, inflation expectations deviate from the central bank's target, this mechanism rationalizes the notion of "deanchoring" of expectations in terms of excess sensitivity of *long-run* inflation expectations to *short-run* states of the economy (Bernanke, 2007; Buono & Formai, 2016; Fracasso & Probo, 2017; Gobbi et al., 2019; Gürkaynak et al., 2010). Analytically, key to the destiny of the economy is the interaction between the OG and the CF via TR. Let us assume the following sequence:

$$\text{time t: output/inflation gap} \rightarrow \begin{cases} \text{agents: revision of z} \rightarrow \text{ revision of } p \\ \text{central bank: revision of i} \end{cases} \rightarrow$$

$$\text{time t + 1: output/inflation gap} \rightarrow \ldots\ldots\ldots\ldots..$$

The complete model of the economy now consists of equations (3) (5) (6) (8). Substituting (5) into (3), we obtain the following system of policy control:

$$y_t = \left(-\alpha \hat{i}_{t-1} + u_{yt}\right) \theta_{t-1}$$

[17] This formulation, that we shall also employ in the simulation presented in Section 5, is empirically consistent with the now common assumption in macro-modelling that shocks follow auto-regressive processes.

[18] The most popular application to binary exclusive events as in our case is the so-called logit model, where z_t is a linear combination of observed variables.

[19] See Gobbi et al. (2019).

[20] It plays a role analogous to the gradient of recursive revisions of estimated parameters in learning models of the data generation process (Evans & Honkapohja, 2001; Evans & McGough, 2018b).

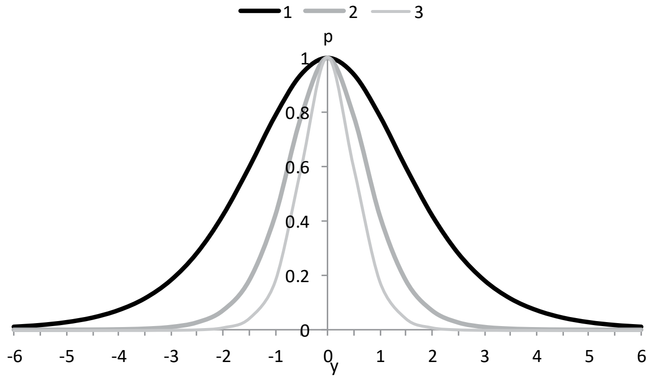

FIGURE 1 The confidence function with increasing values of η

$$\hat{i}_t = (\omega_t k \gamma_\pi + \gamma_y) y_t \tag{9}$$

$$p_t = \frac{4e^{-\eta z_t}}{(1 + e^{-\eta z_t})^2}$$

Four are the questions to be addressed. Does a steady-state exist with zero gaps and full confidence? Is it stable after a shock? Can the system settle down in a depression steady state (negative output/inflation gaps and less than full confidence)? Can the system fall into a NF depression?

The first question has a positive answer: ($\overline{y} = 0$, $\hat{i} = 0$, $\overline{p} = 1$) is always a solution to the system. As to stability, substitution of the TR and the CF into the OG yields a single nonlinear dynamic equation of y. The order of the equation depends on the specification of z_t. In the simplest case $z_t \equiv y_t$, the result is a first-order equation; hence stability requires that, in the neighbourhood of the zero-gaps steady state, $|\partial y_t / \partial y_{t-1}|_{y=0} < 1$. If z_t is also a function of lagged values of output gaps, it is not possible to give definite answers, and numerical simulations are necessary as will be seen in the next session.

As to the third question, a depression equilibrium is characterized by $\overline{y} < 0$, $i = 0$, and $\overline{p} < 1$. If such a state exists, it is a fixed point of the CF and the OG functions. Hence this state ensures self-consistency of beliefs: if agents observing $\overline{y}$ assign only probability $\overline{p}$ to the normal regime, then $\overline{y}$ is in fact the output gap at which the economy settles down. Confidence below unity (but above zero) means that agents have no further evidence in favour either of the return to the normal regime or of wider deviation from the current steady state. As previously seen in Section 3, depression equilibria may be NK, with conventional sign of the interest gap, if $\overline{p} > p^*$, or NF, with inverted sign, if $\overline{p} < p^*$.

We have established the existence of NF depressions as a theoretical possibility arising from the interplay among the factors that govern the dynamic behaviour of the economy: agents' time discount rate β, the expenditure elasticity to interest-rate gaps α, the degree of price flexibility κ, the output and inflation parameters γ_y and γ_π in the TR, and the CF driving agents' confidence in the normal regime *vis-à-vis* the state of the economy. Therefore, our conclusion is that the likelihood of NF depressions in reality is an empirical matter. What can we say in light of the existing consensus evidence on the relevant parameters?

5 | SIMULATIONS

In order to answer the above question we run empirical simulations of the system (9). Firstly, we chose the following set of baseline values of the parameters:

$\alpha = 0.3$, $r^* = 2\%$, $\beta = 0.98$, $\kappa = 0.3$, $\gamma_y = 0.5$, $\gamma_\pi = 1.5$, $\eta = 1$

References to the relevant empirical literature are provided in Appendix 1.

As to the specification of z_t, the current output gap may arguably be too raw information in an economy where output can actually fluctuate around the zero-gap equilibrium. The information our agents seek to extract is whether output is *trending away* from the zero-gaps equilibrium. Hence, a more suitable hypothesis is that they collect a longer series of output gaps and process them by means of some smoothing technique. We opted for a four-period moving average of output gaps $y_t, \ldots, y_{t-3}$. With virtual time set in quarters, this formulation, though simple, corresponds to quite common practice in detecting trends, and it smooths the impact of earlier observations after equilibrium. Starting from zero-gaps equilibrium, this working hypothesis adds some slack in the updating of confidence and avoids overreaction at the early stage of the process.

Secondly, the model economy can be hit by different types of shocks (see equations (1) and (2)). Here we present simulations only for i.i.d. output shocks u_y. This makes our exercise comparable to Evans and McGough (2018a), where agents are econometric forecasters. We envisaged a range of possible once-and-for-all output shocks hitting the system at time $t = 0$, up to $u_{y0} = -5\%$. In quarterly virtual time, the upper tail of this range includes large and extra-large shocks.

We present our results in two parts. The first one shows the simulations of the baseline system in the range of shocks in discrete unit steps. This will allow better understanding of the properties of the system. In the second part, the simulations map the long-run output-gap values in the joint space of the full range of shocks $u_{y0} \in [0, -5]$ and of four selected parameters: $\eta \in [0, 3]$, $\kappa \in [0, 1]$, $\gamma_\pi \in [0, 4]$, $r^* \in [2\%, -2\%]$ (for the selection of these intervals see Appendix 1). These simulations provide a view of the global properties of the system.

5.1 | The baseline system

The baseline system displays different long-run states depending on the magnitude of the shock. Recall that the system enters the NF depressions as $p_t < p^*$, which here has value 0.247, that is, a loss of about 75% of confidence – at first glance, quite a dramatic case. Figure 2 presents the simulation results as the phase diagram of the co-evolution of confidence p_t and the output gap y_t.

The path generated by the 1% shock is one of stability. The system converges (quickly) to the zero-gap equilibrium and $p = 1$, as expected under the guidance of conventional monetary policy. The initial shock to y triggers a small fall of p (0.94). As the policy rate is reduced y improves; the recovery of p lags behind owing to the agents' use of the moving average of y, but eventually the shock is fully absorbed and confidence is recovered. This example clarifies Woodford's notion that stability requires the policy rate to "fall faster" than inflation expectations (see Woodford, 2003, p. 126 on self-fulfilling inflations and deflations).

By contrast, the 2% shock exemplifies what may happen if the policy rate does not fall fast enough. The stimulus to y is not sufficient to restore p at a sufficient pace. The flat left tail of the diagram represents a NK depression. That is to say, a ZLB steady state characterized by $\left(\bar{y} = -1.7\%, \bar{\pi} = -1.0\%, \bar{i} = 0, \bar{p} = 0.592 > p^*\right)$. Conventional monetary policy is crippled, but the conventional sign of the OG still holds, so that raising the policy rate would be counterproductive.

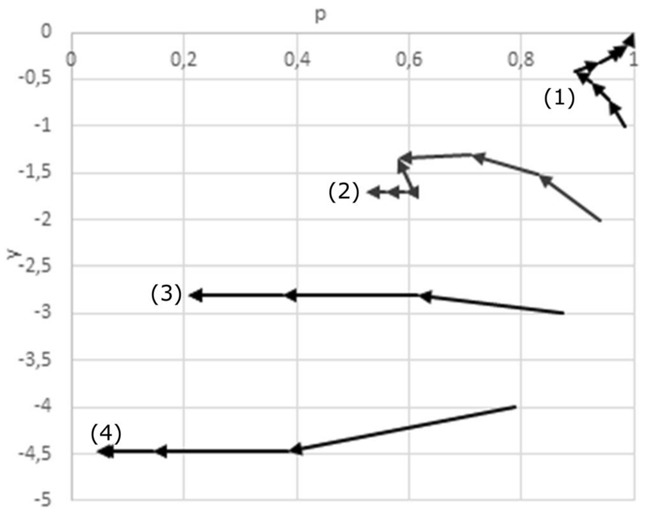

FIGURE 2 Phase diagram of confidence in the normal regime (p) and output gap (y) for increasing output shocks ($p^* = 0.247$). (1) Stability, (2) New Keynesian depression, (3) and (4) Neo-Fisherian depressions

The 3% and 4% shocks generate cases of NF depressions, that is steady states where $\left(\overline{y} < 0, \overline{\pi} < 0, \overline{i} = 0, \overline{p} < p^*\right)$. Apart from the larger losses of output, the key difference with respect to the NK depressions is that the fall of confidence is such that raising the policy rate would now have a positive effect on output.

Finally, larger shocks (not reported in the Figure) generate global instability, that is, the output gap tends to deviate further away from the initial shock.

To the extent that our baseline system replicates an economy with not too large volatility of confidence, we may say that the occurrence of NF depressions appear rather unlikely, that is for quite large shocks to output and dramatic fall in agents' confidence in the return to the normal regime. Even when NF conditions occur, though, our model does not support the prescription that the central bank should simply peg the policy rate to its Fisherian equilibrium value. The reason is similar to the one put forward by Evans and McGough (2018b, sec. 3), that is the extent to which expectations are adjusted upon the implementation of the Fisherian interest-rate peg. Inflation expectations do recover and so does the output gap, but this remains a once-and-for-all effect which may or may not set the economy back to the zero-gaps equilibrium (or it may even overshoot).

Consider the case of 3% shock in Figure 1, ending in a NF depression where $\overline{y} = -2.8\%, \overline{\pi} = -3.8\%, \overline{i} = 0, \overline{p} = 0.217 < p^*$. Now let the central bank announce that the policy rate is pegged to its Fisherian equilibrium value of 2%, with an increase of 0.50% on a quarterly basis. *Under the given depressed conditions*, the output and inflation gaps improve to −1.3% and −1.7%, respectively. Confidence also improves up to $p = 0.30$. Yet the economy remains far from full recovery. As a condition for convergence, a feedback rule of the policy rate is still needed, for example, a Taylor Rule with inverted signs, with, however, the unpleasant caveat that as soon as p returns above p^*, the rule should be switched back to the conventional signs. Overall, this promises to be a challenging exercise of stop-and-go policy engineering.

5.2 | Sensitivity to parameters

In order to check for the sensitivity of the baseline results to different values of shocks and parameters, we present simulations where the system's long-run states are mapped in the space of the full range of shocks $u_{y0} \in [0, -5]$ *vis-à-vis* each of the four parameters $\eta \in [0, 3]$, $\kappa \in [0, 1]$, $\gamma_\pi \in [0, 4]$, $r^* \in [2\%, -2\%]$, while keeping the other three unchanged at their baseline values. The maps, reproduced in Figure 3–6, are organized as follows. The long-run state of the system is gauged by the ratio of residual output gap to the initial shock after 30 iterations according to the following scale[21]:

- residual output gap <10% of shock: *stability* (light blue)
- residual output gap >10% of shock, $p > p^*$: *New-Keynesian depression* (green)
- residual output gap >10% of shock, $p < p^*$: NF depression (yellow)
- residual output gap >100% of shock: divergence (blue)[22]

Note that the distinction between NK and NF depressions is only based on whether the policy rate retains its conventional effect or it is reversed. This criterion does not necessarily imply that the former depressions are less severe than the latter, though we may say that is the most common case. As a matter of fact, most frequently *both* types of depressions are severe in that the residual output gap is more than 50% of the initial shock.

5.3 | Output shocks and the confidence function

The analytical model suggests that larger shocks and/or higher sensitivity of the CF may reduce the stabilization capacity of conventional monetary policy and increase the likelihood of NK or eventually NF depressions. This property is confirmed by our simulations as reported in Figure 3.

The Figure displays a sharp inverse stability frontier between output shocks and η. Conventional monetary policy grants stability up to shocks of about 2% provided that η does not exceed 1. Historical experience and empirics (see Appendix 1) suggest that this is in fact the region where advanced economies are most likely to be found. Conventional monetary policy fails for either larger shocks or higher values of η, or both. The former tend to push the economy into the region of NK depressions. Confirming the results of the baseline system, the region of NF depressions is relatively limited as it requires combinations of large shocks with high η. Moving further north-east in the map, the Figure shows a large region of divergence warning about the existence of unchartered waters where the system may go out of control.

5.4 | Output shocks and the Phillips Curve

Recall that, from equation (7), for $\beta \in [0, 1]$ p^* is increasing in κ, the price flexibility parameter (in the Calvo sense). Higher p^* means that the economy falls into NF depressions for smaller losses of agents' confidence, or that conventional monetary policy faces a narrower corridor of stability. The slope κ of

[21] To control for casual convergence/divergence of the very last observations, the classification is based on the output-gap values after the 25th observation.

[22] In this area there may be present steady states with output gap larger than the initial shock and truly dynamic instability, that we have not distinguished for simplicity.

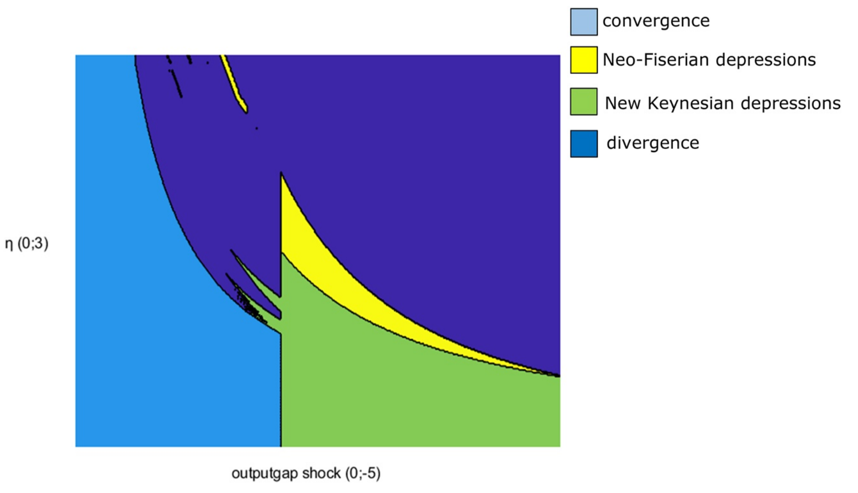

FIGURE 3 Map of long-run states for increasing values of output shocks and sensitivity of the confidence function (η) [Colour figure can be viewed at wileyonlinelibrary.com]

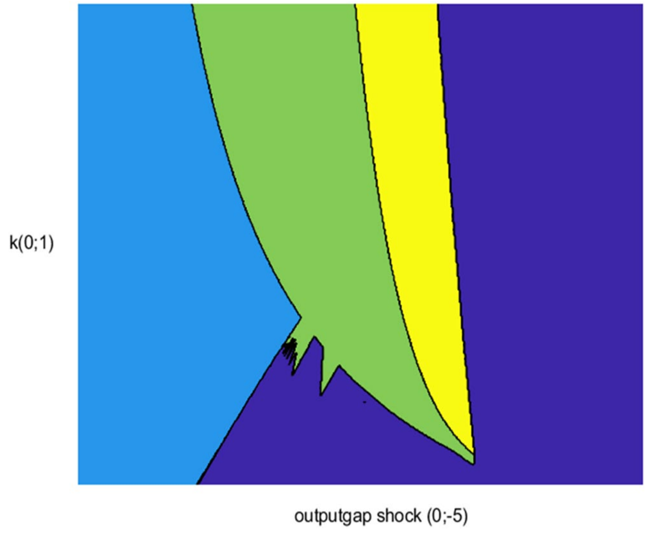

FIGURE 4 Map of long-run states for increasing values of output shocks and slope of the Phillips Curve (κ) [Colour figure can be viewed at wileyonlinelibrary.com]

the PC, plays a twofold role. On the one hand, increasing κ enhances the reactivity of inflation gaps and reinforces conventional monetary policy; on the other, p^* is raised enlarging the occurrence of NF depressions. This double-edge effect clearly emerges in the simulation reproduced in Figure 4.

The stability frontier drawn by κ *vis-à-vis* shocks initially widens and then shrinks. It is worth noting that the former effect, which makes the system more resilient to shocks under conventional policy, operates up to values of κ around 0.4 found by the econometric estimates of "steeper" PC (see Appendix 1). For higher κ, its unfavourable effect prevails, so that shocks beyond 1% tend to impair conventional policy. Yet, NF depressions seem to emerge in a relatively smaller and more remote set of very large shocks and high values of κ.

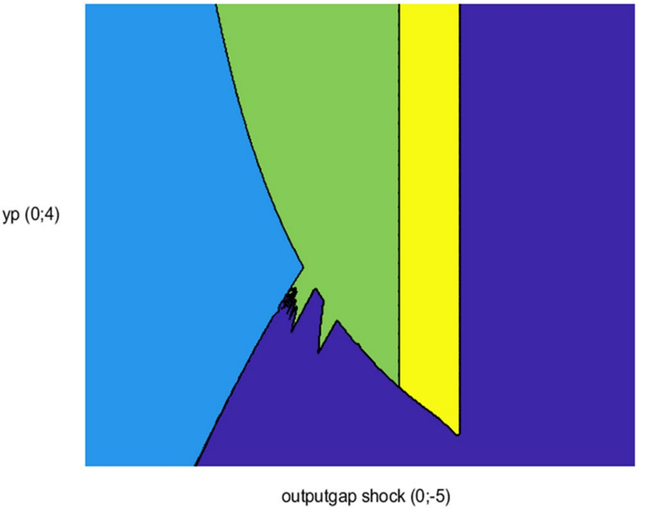

FIGURE 5 Map of long-run states for increasing values of output shocks and inflation parameter in the Taylor Rule (γ_π) [Colour figure can be viewed at wileyonlinelibrary.com]

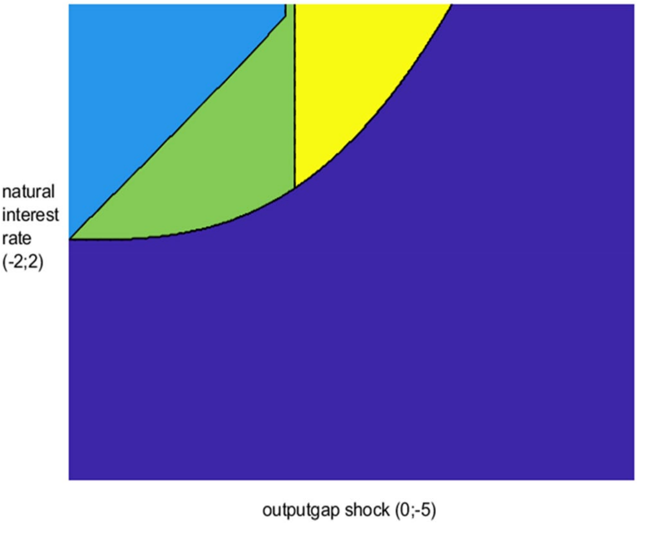

FIGURE 6 Map of long-run states for increasing values of output shocks and decreasing values of the natural interest rate (r^*) [Colour figure can be viewed at wileyonlinelibrary.com]

5.5 | Output shocks and the Taylor Rule

We have seen that one of the key factors of stability is that the policy rate “falls faster” than inflation expectations, that is, confidence in the normal regime. Therefore, it seems reasonable to recommend a reactive inflation parameter γ_π in the TR, also in consideration of the fact that the PC may actually be rather flat. On the other hand, we have also shown that, when confidence is endogenous, the impact of changes in the policy rate on output gaps is amplified. Thus, working in tandem with κ, γ_π displays in Figure 5 the same double-edge effect.

Our simulations seem to lend support to the NK consensus that recommends setting γ_π in the range 1.5-2, where in fact the stability region is maximal, allowing conventional policy to accommodate shocks in the order of 2%. Larger shocks up to 3% shift the system in NK depressions, but it takes extra-large shocks to obtain NF depressions.

5.6 | Output shocks and the natural interest rate

The tendency of the natural interest rate r^* to fall detected by several researchers (see fn. 2), plays a central role also in the theoretical models of depression considered so far. In several studies, the fall of the natural rate appears as the single shock leading to the depression state. Here we show how different levels of r^* interact with different output shocks.

It is worth recalling that in the standard NK framework the main reason why the fall of r^* is conducive to depression is that it impairs the ability of conventional monetary policy to stimulate the economy by lowering the policy rate. In terms of our system (9), if $r^* + \pi^* < 0$, the policy rate is stuck at the ZLB, the interest-rate gap is $\hat{i} < 0$, and the economy operates under a constant negative demand gap. Since we have assumed $\pi^* = 0$, this threshold is reached as $r^* < 0$. The map provided by Figure 6 is fully consistent with this scenario.

The map can be split into two halves according to whether r^* is positive (upper half) or negative (lower half). The area of stability in the upper-left corner shows that conventional monetary policy remains effective even for r^* falling down to zero, provided that output shocks are not too large. Note, however, that absorbable shocks shrink as r^* falls. Next, for excessive output shocks relative to the level of r^*, the economy falls in NK depressions, then in NF depressions and eventually in the area of divergence. As r^* becomes negative, conventional monetary policy becomes totally ineffective, and the economy is bound to divergence for whatever shock, that is, it ends up with output gaps larger than the initial shock. It is also to be stressed that when the economy lies in this area, the NF prescription to raise the policy rate to its Fisherian equilibrium level $r^* + \pi^*$ is meaningless for the basic reason that such a level remains negative.[23]

6 | CONCLUSIONS

In this paper we have sought to address two questions. Why do economies fall into depression equilibria? Is the NF reversal of conventional low (or zero) interest-rate policy a solution?

The common element bridging the two questions is how agents form their expectations about the future evolution of output and inflation. We have deployed a model economy where agents' expectations are based on their correct understanding of the data generation process, and on their confidence in the central bank's ability to keep inflation on target in the long run (the normal regime of the economy). Agents' confidence is not taken for granted once and for all, but is expressed as probabilistic beliefs about the economy being in the normal versus a depression regime revised according to the observed state of the economy.

Our main conclusions are that, first, endogenous confidence in the normal regime interacts with the dynamics of output and inflation in such a way that lower confidence amplifies negative inflation and output gaps making ZLB depressions more likely. Second, conditions for the success of

[23] We owe this point to an anonymous referee of the journal. We do not consider here the opposite policy advice to raise the inflation target (see e.g. Garìn et al., 2018 for this kind of exercise).

conventional monetary policy require combinations of shocks, reactivity of the agents' beliefs and price flexibility that are not too large. These conditions are more easily flouted than predicted by the standard models. Third, there exist sets of conditions whereby the NF policy becomes feasible; namely, when the economy settles down in a particularly deep ZLB depression and confidence in the normal regime falls below a certain threshold level. Yet, in light of most common empirical values of the relevant factors, and for economies with a history of stability and central bank's credibility, we may say that the latter event is quite unlikely. Finally, we share with other studies the point that the expectations formation process does not support the policy prescription of pegging the policy rate at its Fisherian equilibrium level as a means to reset inflation on target.

Our findings leave it open to further investigation the question of how the economy can be rescued from a depression when conventional monetary policy is stuck at the ZLB. In case of NK depressions, the mix of unconventional monetary policies *cum* fiscal stimuli that we have observed over the last decade seems consistent with the necessity to spur economic activity, and restore confidence (raise p) at the ZLB of the policy rate. In the (unlikely) case of NF depression, our model points to the same solution, unless the central bank wishes to engage in the hazardous experiment of increasing the policy rate. If the former solution works, then we will observe the *inverted NF correlation* with the policy rate rising in tandem with inflation (see fn. 3).

In any case, an important point, which often seems disregarded, is that the right policy action depends on the state of agents' confidence. For this is part of the structure of the economy, and it would be a mistake to assume that in a depression agents would react to a policy action as if they had full confidence in the central bank's ability to steer the economy back on track. Deeds not words drive agents' confidence.

ACKNOWLEDGMENTS

Open Access Funding provided by Universita degli Studi di Trento within the CRUI-CARE Agreement.

REFERENCES

Ajevskis, V. (2018). *The natural rate of interest: Information derived from a shadow rate model* (Latvijas Banka Working Paper, n. 2018).

Arifovic, J., Schmitt-Grohé, S., & Uribe, M. (2017). *Learning to live in a liquidity trap* (NBER Working Paper Series, n. 23725).

Aruoba, S. B., Cuba-Borda, P., & Schorfheide, F. (2018). Macroeconomic dynamics near the ZLB: A tale of two countries. *The Review of Economic Studies*, *85*, 87–118.

Bank of Ireland. (2014). *Examining the sensitivity of inflation to the output gap*. Quarterly Bullettin, April.

Benhabib, J., Schmitt-Grohe, S., & Uribe, M. (2001). Monetary policy and multiple equilibria. *The American Economic Review*, *91*(1), 167–186.

Bernanke, B. (2007). *Inflation Expectations and Inflation Forecasting*. Speech at the monetary economics workshop of the National Bureau of Economic Research Summer Institute. https://www.federalreserve.gov/newsevents/speech/bernanke20070710a.htm

Bernanke, B. (2010). *On the implications of the financial crisis for economic Policy. Bendheim center for finance and center for economic policy studies*. Princeton University.

Bias, P., & Hall, J. D. (2021). A test of neo-fisherism: 1964-2019. *The B.E. Journal of Macroeconomics*, *21*(1), 221–251.

Blanchard, O. J., Cerutti, E., & Summers, L. (2015). *Inflation and activity. Two explorations and their monetary policy implications*. (IMF Working Paper, n. 15/230).

Boianovsky, M., & Trautwein, M. (2004, June). *Wicksell after Woodford* [Paper presentation]. The History of Economics Society meeting, Toronto.

Bonatti, L., Fracasso, A., & Tamborini, R. (2020, September). *Covid-19 and the future of quantitative easing in the euro area: Three scenarios with a trilemma*. Publication for the committee on Economic and Monetary

Affairs. Monetary Dialogue Papers, European Parliament, Luxembourg. https://www.europarl.europa.eu/cmsdata/211393/2_Tamborini%20final.pdf
Borio, C., & Disyatat, P. (2010). *Unconventional monetary policies: An appraisal*. The Manchester School, *78*, 53–89.
Brand, C., Bielecki, M., & Penalver, A. (2018). *The natural rate of interest: Estimates, drivers and challenges to monetary policy* (ECB Occasional Paper, n. 217).
Brand, C., & Mazelis, F. (2019). *Taylor-rule consistent estimates of the natural rate of interest*. (ECB Working Paper Series, n. 2257).
Buono, I., & Formai, S. (2016). *The evolution of the anchoring of inflation expectations* (Occasional Papers, n. 321). Bank of Italy.
Calvo, G. A. (1983). Staggered prices in a utility-maximizing framework. *Journal of Monetary Economics*, *12*(3), 383–398.
Chung, H., Laforte, J. P., Reifschneider, D., & Williams, J. C. (2012). Have we underestimated the likelihood and severity of zero lower bound events? *Journal of Monet, Credit and Banking*, *44*, 47–82.
Cochrane, J. H. (2014). The neo-fisherian question. *The grumpy economist blog*. *6*. https://johnhcochrane.blogspot.com/2014/11/the-neo-fisherian-question.html
Cochrane, J. H. (2016a). *Do higher interest rates raise or lower inflation?* Stanford University (Working paper).
Cochrane, J. H. (2016b). "A very simple neo-fisherian model", *The grumpy economist blog*. https://johnhcochrane.blogspot.com/2016/03/a-very-simple-neo-fisherian-model.html
Cochrane, J. H. (2017). Michelson-Morley, Fisher, and Occam: The radical implications of stable quiet ination at the zero bound. *NBER Macroeconomics Annual*, *32*, 1661–1707.
Corsello, F., Neri, S., & Tagliabracci, A. (2019). *Anchored or de-anchored? That is the question* (Occasional Papers, 516). Bank of Italy.
Del Negro, M., Giannone, D., Giannoni, M., & Tambalotti, A. (2019). Global trends in interest rates. *Journal of International Economics*, *118*(C), 248–262.
Draghi, M. (2016). How central banks meet the challenge of low inflation. In *Marjolin lecture, SUERF conference*. Deutsche Bundesbank, Frankfurt, February 4. http://www.ecb.europa.eu/press/key/date/2016/html/sp160204.en.html
Evans, G. W., & Honkapohja, S. (2001). *Learning and expectations in macroeconomics*. Princeton: Princeton University Press.
Evans, G. W., & McGough, B. (2018a). Equilibrium selection, observability, and backward-stable solutions. *Journal of Monetary Economics*, *98*, 1–10.
Evans, G. W., & McGough, B. (2018b). Interest rate pegs in new keynesian models. *Journal of Money, Credit, and Banking*, *50*, 939–965.
Farmer, R. A. E. (1993). *The macroeconomics of self-fulfilling prophecies*. Cambridge (Mass.): MIT Press.
Farmer, R. A. E. (2019). *The indeterminacy agenda in macroeconomics*. CEPR Discussion Paper Series, n. 13745.
Fiorentini, G., Galesi, A., Pérez-Quirós, G., & Sentana, E. (2018). *The rise and fall of the natural interest rate*. Banco de Espanã, Documentos de Trabajo, n. 1822.
Fisher, I. (1930). *The theory of interest*. New York: MacMillan.
Fracasso, A., & Probo, R. (2017). When did inflation expectations in the euro area de-anchor? *Applied Economics Letters*, *24*, 1481–1485.
Friedman, M. (1968). The role of monetary policy. *The American Economic Review*, *58*(1), 1–17.
Galì, J. (2008). *Monetary policy, inflation, and the business cycle: An introduction to the new keynesian framework*. Princeton: Princeton University Press.
García-Schmidt, M., & Woodford, M. (2019). Are low interest rates deflationary? A paradox of perfect-foresight analysis. *The American Economic Review*, *109*(1), 86–120.
Garìn, J., Lester, R., & Sims, E. (2018). Raise rates to raise inflation? Neo-fisherianism in the new keynesian model. *Journal of Money, Credit, and Banking*, *50*(1), 243–259.
Garnier, J., & Wihelmsen, B. (2005). *The natural real interest and the output gap in the euro area. A joint estimation* (Working Paper Series, no. 546). European Central Bank.
Gerali, A., & Neri, S. (2019). Natural rates across the atlantic. *Journal of Macroeconomics*, *62*(C), 1–14.
Gobbi, L., Mazzocchi, R., & Tamborini, R. (2019). Monetary policy, de-anchoring of inflation expectations, and the new normal. *Journal of Macroeconomics*, *61*, 1–15. Special Issue "Macroeconomics, Rationality and Institutions. https://doi.org/10.1016/j.jmacro.2018.10.006

Goodhart, C. A. E. (2020). *After coronavirus: Deflation or inflation?* (SUERF Policy Brief, n. 25).
Gürkaynak, R. S., Swanson, E., & Levin, A. (2010). Does inflation targeting anchor long-run inflation expectations? Evidence from the U.S., UK, and Sweden. *Journal of the European Economic Association*, *8*, 1208–1242.
Holston, K., Laubach, T., & Williams, J. C. (2017). Measuring the natural rate of interest: International trends and determinants. *Journal of International Economics*, *108*(Supplement 1), S59–S75.
Iiboshi, H. (2016). Monetary policy regime shifts under the zero lower bound: An application of a stochastic rational expectations equilibrium to a markov switching DSGE model. *Economic Modelling*, *52*, 186–205.
Keynes, J. M. (1937). General theory of employment. *Quarterly Journal of Economics*, *53*, 109–123.
Kool, C. J. M., & Thornton, D. L. (2015). How effective is central bank forward guidance? *Federal Reserve Bank of St. Louis Review*, *97*, 303–322.
Kortelainen, M. (2017). *Neo-fisherian monetary policy* (Bank of Finland Economics Review, n. 2).
Kurz, M. (2011). Symposium: On the role of market beliefs in economic dynamics, an introduction. *Economic Theory*, *47*, 189–204.
Lane, P. R. (2020). *The monetary policy toolbox: Evidence from the euro area*. Keynote speech at the 2020 US monetary policy forum, New York, 21 February.
Lansing, K. (2019). Endogenous forecast switching near the zero lower bound. *Journal of Monetary Economics*, in press.
Laubach, T., & Williams, J. C. (2003). Measuring the natural rate of interest. *The Review of Economics and Statistics*, *85*, 1063–1070.
Leijonhufvud, A. (1981). *Information and coordination: Essays in macroeconomic theory*. Oxford: Oxford University Press.
Luk, P., & Vines, D. (2015). *Optimal monetary and fiscal policy in an economy with endogenous public debt* (CEPR, Discussion Paper Series, n. 10580).
Lukmanova, E., & Rabitsch, K. (2018). *New VAR evidence on monetary transmission channels: Temporary interest rate versus inflation target shocks* (Department of Economics Working Paper Series, n. 6681). WU Vienna University of Economics and Business.
Marx, M., Mojon, B., & Velde, F. R. (2021). Why have interest rates fallen far below the return on capital? *Journal of Monetary Economics*, *124*(S), 57–76.
Mazzocchi, R., Tamborini, R., & Trautwein, H. M. (2014). Wicksell, Keynes, and the New Neoclassical Synthesis: What can we learn for monetary policy? *Economic Notes*, *43*, 79–114.
McCallum, B. T. (1986). Some issues concerning interest rate pegging, price level indeterminacy, and the real bills doctrine. *Journal of Monetary Economics*, *17*, 135–160.
Nakata, T., & Schmidt, S. (2019). *Expectations-driven liquidity traps: Implications for monetary and fiscal policy* (ECB Working Paper Series, n. 2304).
Oinonen, S., & Paloviita, M. (2014). *Updating the Euro area Phillips Curve: The slope has increased*. Discussion Papers, Bank of Finland Research, n. 31.
Riggi, M., & Venditti, F. (2014). *Surprise! Euro area inflation has fallen,Occasional Papers*. Bank of Italy, n. 237.
Rogoff, K. (2021). *Are inflation fears justified?* Project Syndicate.
Rudd, J. B. (2021). “Why do we think that inflation expectations matter for inflation? (And should we?)”, *Finance and Economics Discussion Series*. Federal Reserve Board, n. 2021/62.
Schnabel. (2020). *COVID-19 and monetary policy: Reinforcing prevailing challenges, Speech at the Bank of Finland monetary policy webinar*, 24 November.
Smets, F. (2021). Comment expliquer la faiblesse durable des taux directeurs dans la Zone Euro? *Revue d'Economie Financiere*, *144*, 47–60.
Smets, F., & Wouters, R. (2003). An estimated dynamic stochastic general equilibrium model of the euro area. *Journal of the European Economic Association*, *5*, 1123–1175.
Spahn, P. (2018). *Unconventional view on inflation control: Forward guidance, the neo-fisherian approach, and the fiscal theory of price level*, (n. 02/2). Hohenheim Discussion Papers In Business, Economics And Social Sciences.
Taylor, J. B. (1993). Discretion versus policy rules in practice. *Carnegie-Rochester Conference Series On Public Policy*, *39*, 195–214.
Uribe, M. (2017). *The Neo-Fisher effect in the United States and Japan* (NBER Working Papers, n. 23977).
Uribe, M. (2018). *The Neo-Fisher effect: Econometric evidence from empirical and optimizing models* (NBER Working Papers, n. 25089).

Wicksell, K. (1898). Geldzins und Güterpreise. Eine Untersuchung über die den Tauschwert des Geldes bestimmenden Ursachen. Jena, Gustav Fischer; Eng. tr. In *Interest and prices. A study of the causes regulating the value of money*. Macmillan.

Williams, J. (2011). *Unconventional monetary policy: Lessons from the past three years. Federal Reserve Bank of San Francisco Economic Letter, n*. 31.

Williamson, S. D. (2017). Neo-fisherism: A radical idea, or the most obvious solution to the low- inflation problem? *The Regional Economist*, 5–9.

Woodford, M. (2003). *Interest and prices*. Princeton: Princeton University Press.

How to cite this article: Gobbi, L., Mazzocchi, R., & Tamborini, R. (2022). Monetary policy, rational confidence, and Neo-Fisherian depressions. *Metroeconomica*, *73*(4), 1179–1199. https://doi.org/10.1111/meca.12398

APPENDIX 1

- α. The elasticity of expenditure to the interest-rate gap α can be found in calibrations of consumers' intertemporal elasticity of substitution or in econometric estimates of the New Keynesian IS function. The former procedure is common in the Real-Business-Cycle literature, which typically converges on values between 0.5 and 1. Direct econometric estimates yield lower values between 0.2 and 0.3 (e.g. Garnier & Wihelmsen, 2005; Laubach & Williams, 2003; Smets & Wouters, 2003). Hence we set the baseline value at $\alpha = 0.3$.
- r^*, β. According to the New Keynesian standard model, the equilibrium value of the natural rate is $r^* = 1/\beta - 1$. The consensus value $r^* = 2\%$, dating to the original specification of the TR (Taylor, 1993), yields the commonly used value of $\beta = 0.98$. The range of values between 2% and −2% that we have used in the simulation corresponds to the most recent evidence mentioned in fn. 2.
- κ. Calibration of the slope of the PC κ in New Keynesian models yields very low values. For instance, a common order of magnitude of firms not adjusting prices in the face of shocks is around 75% (e.g. Smets & Wouters, 2003:; Luk & Vines, 2015); then, the Calvo equation with $\beta = 0.98$ yields $\kappa = 0.09$. Direct econometric estimates of the slope of the PC equation over the last decades typically provide higher values, in the range of 0.5. However, after Blanchard et al. (2015), various works have produced evidence of "flatter" PC, with κ falling between 0.2 and 0.3. More recent works, mostly based on European data, find a "steepening" of the PC in the aftermath of the Great Recession (e.g. Bank of Ireland, 2014; Oinonen & Paloviita, 2014; Riggi & Venditti, 2014), with the estimated slope around 0.4. Note that this finding is consistent with our hypothesis of lower confidence in the normal regime, according to which these estimates may actually be measuring $\omega\kappa$. For the baseline model we chose a mid value among these estimates, that is, $\kappa = 0.3$, whereas for simulations in Section 5.2 we set a range up to twice the largest available estimates, $\kappa \in [0, 1]$, in order to capture the effects of increasing price flexibility (according to the Calvo equation, $\kappa = 1$ results from about 60% of flexible prices).
- γ_y, γ_π We adopted the usual benchmark of Taylor's (1993) original empirical model, $\gamma_y = 0.5$, $\gamma_\pi = 1.5$, and we considered the range $\gamma_\pi \in [0, 4]$ for the simulations in Section 5.2.
- η. We do not have direct evidence for the reactivity η of the CF. As already said above, the suitable empirical counterpart of our model can be seen in works seeking to detect the "deanchoring" of inflation expectations from the central bank's target by gauging their correlation with changes in output. Among them, the closest to our model is Gürkaynak et al. (2010), who find significant reactivity of long-term inflation expectations to various macroeconomic news in US, UK and

Sweden. Following news about real GDP, the estimated reactivity varies between 0.3 in Sweden and 1.8 in the US. In our model, the corresponding relationship is $E_t\pi_{t+1} = \omega\kappa(1-p)y_t$. For one point of output gap, the range of values of η consistent with the above estimates is (approximately) between 1.8 and 3.4. As can be seen from Figure 1, such an order of magnitude can be regarded as quite reactive, possibly too reactive if the system initial state is in equilibrium (and the central bank enjoys a good reputation). Adopting a similar technique applied to the Euro Zone, Corsello et al. (2019) find a reactivity of 0.142 before 2013 increased to 0.256 afterwards; the implied values of η are, respectively, 1.29 and 1.66

Another indirect empirical insight into the dimension of η can be drawn from Chung et al. (2012), who show that a wide selection of major forecast models of the US economy largely underestimated the probability of the economy hitting the ZLB in the course of 2008-12. They also show that the probability can be increased substantially, together with the goodness of forecasts of the main variables, by including parameter and latentvariable uncertainty, and extending the sample up to 2010. After shocking the models at 2008:1, the highest probability they obtain for the ZLB lasting at least 1 quarter or 8 quarters is 29% and 6% respectively. But 6% is rather optimistic since the ZLB actually persisted for more than 8 quarters.

Figure A1 plots the path of p (the complement to Chun et al. estimated probability) generated by our CF updated on observing the four-quarter moving average of US output gaps around the major shock of the second half of 2008, that is, from 2007:1–2009:1. Three values of η are considered 0.7, 1, 1.5.

The highest probability estimated by Chung et al. is matched by the CF with $\eta = 0.7$ at the seventh quarter (2008:3), that is, p = 72.8%, with further deterioration to 41.6% in the eighth quarter at the climax of the slump. At the same time points, the CF with η = 1 yields p = 53.9% and 20.2% respectively, a better-fitting guess of the subsequent inability of the Federal Reserve to return to the normal regime quickly.

Overall, we chose $\eta = 1$ as baseline value of the CF, which seems to fit the phenomena discussed above reasonably well. For the simulations in Section 5.2 we chose a range up to the highest value compatible with the estimations by Gürkaynak et al. (2010), that is, $\eta \in [0, 3]$.

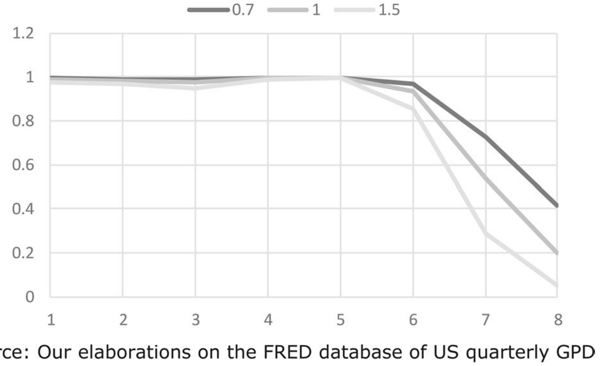

FIGURE A1 Probability of return to the normal regime updated with the moving average of US quarterly output gaps, 2007:1–2008:4