ECONOMICS DISCUSSION PAPER 20.06 ISSN

The Riddle of the Natural Rate of Interest*

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April 2020

Abstract

We provide a general equilibrium model with optimizing agents to compute the natural rate of interest for the G7 countries over the period 2000 to 2017. The model is solved for the equilibrium natural rate of interest, which is determined by a parsimonious equation that is easily computed from raw *observable* data. The model predicts that the natural rate depends

1. INTRODUCTION

Many central banks seem to base monetary policy decisions regarding the short-term nominal interest rate on Wicksell (1898). The decision for setting the short-term nominal interest rate to achieve an inflation target depends on a variable called the Natural rate of interest. Wicksell (1898) laid out the theory of the natural rate of interest, where he essentially was concerned with explaining why prices rise or fall – i.e., inflation, which he regarded as the main problem of monetary theory. Bertil Ohlin, who wrote the introduction to Wicksell's book "Interest and Prices," explains the crux of Wicksell's idea:

> "…Must not the "natural" rate of interest, governed by the marginal productivity of capital, i.e., of the roundabout methods of production which would exist if money were not used, have some connections with the rate of interest as it actually appears on the capital market? There was only one possible answer. But what was this connection? ***These two rates of interest, the natural rate and the money rate, which is quoted on the market, tend of course, to coincide. If the former differs from the latter, money can no longer be said to be "neutral," and monetary consequences in the shape of change in prices are bound to ensue. If the money rate were kept below the natural rate prices would rise, if above they would fall.*** " [Boldface and italics is our emphasis].

The prediction of the Wicksellian theory is(from the of 2., in.3(fls)4.8(tionccu)5.6(4(s1e01

Making monetary policy is daunting for a number of reasons. Monetary policy is a response to shocks whose nature and permanency are hard to determine ex-ante and to identify econometrically ex-post. Random shocks nudge the macroeconomic variables away from their equilibrium levels. The equilibrium variables are unobservable, whether the natural rate of unemployment or the non-accelerating inflation rate of unemployment (NAIRU); the real interest rate, and potential output, are unobservable. The natural real interest rate is also unobservable.

Policymakers must come up with an estimate, or a guess, of the “natural” real interest rate that they think is consistent with the level of real output that is equal to potential output, and to the inflation rate that is equal to expected inflation. Both potential output and expected inflation are unobservable.

Estimation of the unobservable natural rate requires a macroeconomic model(s). Macroeconomic models are subject to specification errors because the econometrician does not know the true *data generating process*. In addition, there are estimation errors.

Moreover, the effect of monetary policy on the economy takes time; the *lags are long and variable* (Friedman, 1961). Thus, monetary policy has to be forward-looking; forecasting and projecting macroeconomic variables is an essential job for central banks. Forecasting using econometric models is associated with forecast errors that could be large and variable. These errors increase around the economy’s turning points and could seep into policy decisions. They are usually persistent and undoing them is costly. Macroeconomists know that the making of monetary policy is associated with significant uncertainties. Unlike risk, there is no insurance against uncertainty. Random variables have natural levels of variations that we cannot reduce.[2]

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[2] A random variable ض has an observed mean square around its mean,

There are a few important contributions to the estimation of the natural rate of interest. See, for example, Orphanides and Williams (2002) and Laubach and Williams (2003). The determinant of the natural real rate of interest in Laubach and Williams (2002) is the growth rate of potential output; they use data for real GDP, core inflation, oil prices, import prices, the federal funds rate, and an estimate of an output gap, and use the Kalman filter to estimate the unobservable neutral rate of interest.

Hamilton *et al.* (2015) argue that the data do not lend support to such determinants. They use long-term annual data and model the real rate as non-stationary. Then, they compute the steady state as an explicit time series forecast. Their evidence points to a significant uncertainty about the steady state real interest rate.

Beyer and Weiland (2019) emphasize the uncertainty around such estimates and the problems *stagnation* argument that monetary policy is ineffective at or near the Zero Lower Bound (i.e., the interest rate is close to zero) and, therefore, fiscal stimulus for the U.S. and Germany over the period after the Great Recession (2009-2017), we found

2. THE MODEL

We follow standard theory used in quantitative studies of business cycle. See Cooley (1995) and Cole and Ohanian (1999). In the depression literature, see, Kehoe and Prescott (2002); in public finance literature, see, Christaino and Eichenbaum (1992) and Baxter and King (1993); in the stock market literature see, McGrattan and Prescott (2003), and Boldrin, Christian and Fisher (2001).

Our model is a structural micro-foundation, whereby the household maximizes a discounted log-linear and time – separable utility function in order to make decisions about consumption-savings and consumption-leisure choice.[3]

The household holds bonds and stocks, owns the capital stock, and rents it to the firm. The firm combines capital and labor to produce real output using a constant return to scale Cobb-Douglas production function. The household also pays taxes on the consumption good, on investments, on labor income, and on capital income. All tax revenues, except those used to finance the pure consumption good are given back to households in the form of transfers. The transfers are lump sum (independent of household income). Public expenditures are generally substitutes for private consumption in the G7

income tax rate; is the rental price of capital, and is transfers. Tax revenues, except those used to finance pure public good consumption, are returned to households as lump-sum transfer payments – i.e., independent of the household's income.[5]

Taxes could affect the prices of consumption and investment goods (e.g., investment tax credit).[6] The household owns bonds and stocks , where their prices are and respectively (the superscript denote bonds, and stocks).

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2.2 The Firm

We assume a firm producing output, , using capital and labor in a Cobb-Douglas production function that exhibits a constant return to scale with the shares of capital and labor, and (1-) respectively. The variable is labor-augmenting technical progress, which we assume to be exogenous for simplicity.

$$, \tag{4}$$

[5] The majority of public expenditures in G7 (i.e., education, health etc.) are perfect substitutes for private consumption, except for military spending. This is especially true for the U.S., Christaino and Eichenbaum

Solving from the time-sequential Lagrange multiplier problems, and focusing on the variables, consumption-leisure ratio