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ARTICLES

The Natural Rate of Interest: Selected Conceptual Differences among Wicksell, Mises, and Woodford and Implications for Estimation and Monetary Policy

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Recent estimates of the natural rate of interest (NRI) suggest a decline over the last three to four decades. However, the real return on productive capital remained relatively stable despite this decline, and the assumed link between real interest rates and saving-investment determinants may well be unstable. This article focuses on Knut Wicksell's "cumulative process" and his rejection of the claim by Ludwig von Mises that the NRI and financial market interest rates may be interdependent. The article agrees with arguments that Michael Woodford's reformulation of Wicksell's NRI is incompatible with Wicksell's views, suggesting that the position advanced by Mises, as well as his theory of the business cycle, can help to overcome the shortcomings of current estimates of the NRI. This conclusion is supported by estimates using a time-varying parameter dynamic factor model during the period 1980–2020, when the link between interest rates and saving-investment determinants seemed stable. Impulse response functions show that monetary policy may have had a persistent downward influence on real interest rates, increasing the gap between interest rates and the real return on productive capital. Evidence supports several features of Mises's theory of the business cycle. It follows that researchers estimating the NRI should be aware that Wicksell's thinking on the concept evolved and that they could benefit from attention to Mises's theory of the business cycle. The possible interaction between monetary policy and the financial sector can produce path dependence that needs to be taken into consideration when estimating the NRI.

1. Background and Motivation

The natural rate of interest (NRI), represented by r^*, is a ubiquitous latent variable in economics and finance. The concept of the NRI is attributed to Knut Wicksell (1936), who, concerned with the causes of changes in the

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value of money, first developed it in his 1898 book *Geldzins und Güterpreise* (*Interest and Prices*). Following disagreement with several scholars—in particular David Davidson (1909) and Ludwig von Mises—Wicksell (1934, 1935) modified the NRI concept to some extent in his two-volume *Föreläsningar i nationalekonomi* (*Lectures on Political Economy*), originally published in 1901 and 1906.[1] Mises's ideas on the concept of interest and more broadly on the macroeconomic dynamics of money and credit are in his 1912 *Theorie des Geldes und der Umlaufsmittel* (*The Theory of Money and Credit*) (Mises 1981) and his 1940 *Nationalökonomie: Theorie des Handelns und Wirtschaftens*, which he expanded into his 1949 *Human Action: A Treatise on Economics* (Mises 1998). The NRI was also at the center of significant discussions on the nature of the business cycle by Swedish economists Erik Lindahl (1939, 1958) and Gunnar Myrdal (1939) and regarding the value of money by Don Patinkin (1965). The NRI concept recently experienced a revival when, building on the real business cycle literature started by Finn Kydland and Edward Prescott (1982), it was integrated into modern macroeconomic theory by Michael Woodford (2003) in his book *Interest and Prices: Foundations of a Theory of Monetary Policy*.

Empirical estimates of the NRI abound. Recent estimates display a declining path over the last three to four decades. However, some stylized features of the data pose a challenge to available NRI estimates. First, despite this decline, the real return on productive capital remained relatively stable, and second, the assumed link between real interest rates and saving-investment determinants may well be unstable. This article aims to shed light on the possible causes of these two challenges to estimates of the NRI. While it agrees with scholars who argue that Woodford's reformulation of Wicksell's NRI is incompatible with Wicksell's views, this study goes further and argues that, in contrast to Wicksell's views, both Mises's view of the interdependence between the financial market interest rate and the NRI and his business cycle theory can help in understanding the challenges faced by estimates of the NRI. The estimation of a time-varying parameter factor-augmented vector autoregressive (FAVAR) model over the 1980–2020 sample period, when the link between interest rates and saving-investment determinants seems stable, suggests that US monetary policy may have had a persistent downward influence on real interest rates, increasing its gap with the real return on productive capital. The estimates also provide evidence supporting some key features of Mises's business cycle theory.

The declining trend in the NRI, sometimes even including negative values, appears when researchers use models of closed and open economies, either semistructural or dynamic stochastic general equilibrium (DSGE) models. Figure 1, taken from Brand, Bielecki, and Penalver (2018, 25), summarizes a

1 Dempsey (1943) contains a detailed discussion of the relation between Wicksell and Mises.

set of estimates from a wide variety of semistructural models of the NRI for the euro area and the US from 1999 to 2018.[2] These are the semistructural approaches of Holston, Laubach, and Williams (2017), Hlédik and Vlček (2018), Krustev (2018); and Brand and Mazelis (2019); the macrofinance model by Ajevskis (2018); the panel error-correction model by Fiorentini et al. (2018); and the rolling Bayesian vector autoregression (BVAR) by Jarocinski (2017).[3] Estimates for the euro area and the US show a decline which accelerated after the 2007–8 global financial crisis (GFC). Most estimates show a negative NRI since then.

Figure 2 displays euro area and US estimates using DSGE models from the same study. These models follow Woodford's (2003) definition of the NRI as the real interest rate that would prevail in a counterfactual economy characterized by flexible prices and wages in the absence of shocks to markups on goods and labor markets. The models are by Haavio, Juillard, and Matheron (2017) and Neri and Gerali (2019), who follow the approach of Smets and Wouters (2007) and add financial frictions. Estimates again display a declining NRI but are more volatile and contain more frequent periods of a negative NRI than several semistructural models.

Both DSGE models identify a "risk premium shock" as the main driver of the fall in the NRI. Presumably, this shock modified households' effective discount rate for one-period risk-free bonds and, according to Fisher (2015), can be interpreted as a shock to demand for safe and liquid assets. In Neri and Gerali (2019), the decline in the NRI is also attributed to a shock to the marginal efficiency of investment, capturing (*unidentified*) disturbances in financial intermediation. Other explanations for the decline in the NRI vary across studies. These include lower trend growth (e.g., Garnier and Wilhelmsen 2005); demographic factors, such as population aging and life expectancy (e.g., Carvalho, Ferrero, and Nechio 2016); rapid, unanticipated globalization and its depressing effects on markups (e.g., Natal and Stoffels 2007); and financial conditions (e.g., credit-supply and funding conditions), notably after the GFC (e.g., Borio 2014).

It is widely acknowledged that empirical estimates of the NRI are model dependent, and model estimates display high statistical uncertainty. These features naturally translate into uncertainty in the assessment of monetary conditions and are obvious in the estimates from the state-of-the-art modeling and technical capabilities displayed in figures 1 and 2.[4]

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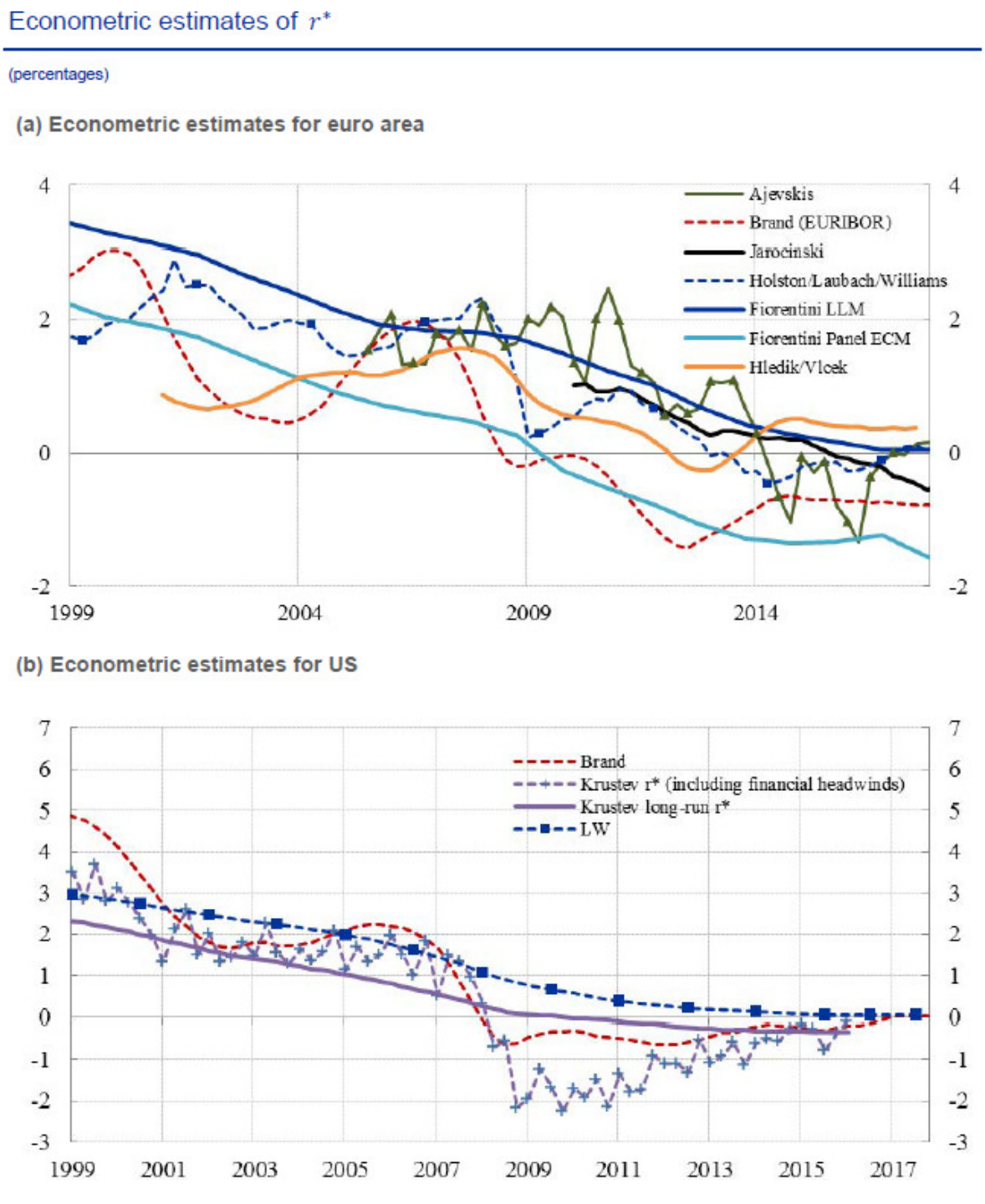
2 Because appendix B of Brand, Bielecki, and Penalver (2018) has an excellent description and comparison of the econometric approaches used in this article, and to conserve space, the models are not presented here.

3 More recent estimates for the US and the euro area in Guerrieri et al. (2023) confirm the downward trend in the NRI.

4 Interestingly, Wicksell (1936, 189) argued that ascertaining the natural rate would be impractical and unnecessary, which was also the opinion of early followers in the Austrian tradition as well as of critics of Wicksell's capital theory (e.g., Friedman 1964) on how to control the price level by way of the interest rate.

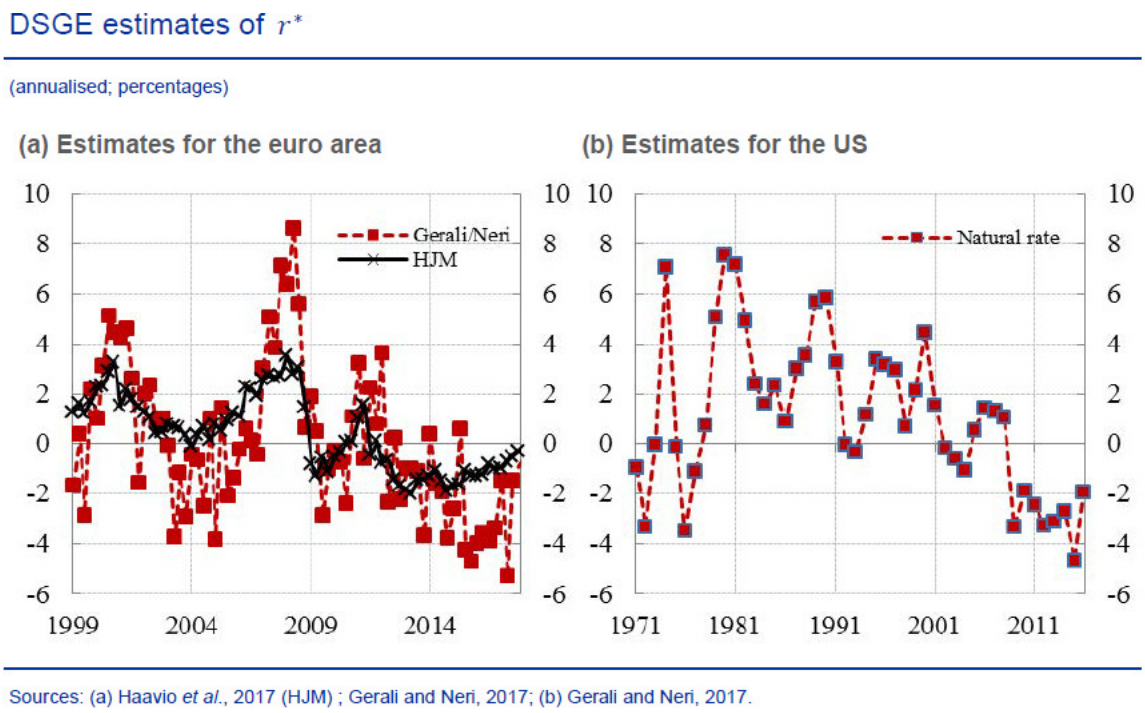
Figure 1. Estimates of the euro area and US NRI using semistructural models



Source: Brand, Bielecki, and Penalver (2018, 25).

Several stylized features pose a challenge for available NRI estimates. The following two are fundamental: (1) the difficulty of identifying "the" relevant real rate of interest and (2) the poor match between the time-series properties of the traditional determinants of real interest rates and savings and investment. The first challenge stems from the observation that, in contrast to

Figure 2. Estimates of the euro area and US NRI using DSGE models



Source: Brand, Bielecki, and Penalver (2018, 33).

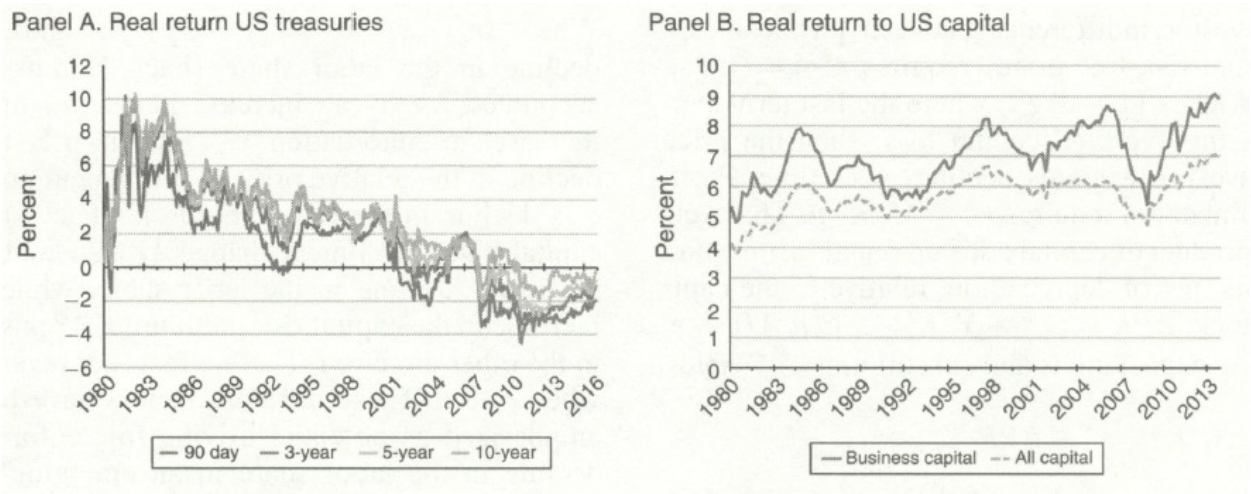
the estimated decline in the NRI, estimates of the return on physical capital have remained almost constant, indicating a persistent decoupling between financial markets' returns and the real economy. Figure 3, from Caballero, Farhi, and Gourinchas (2017)—a widely cited paper—shows the discrepancy between low real yields on US treasuries and the real return on physical capital. The authors use a simple growth and production model to reconcile these differences. They argue that rising markups and surging premia on "capital risk"—defined as the expected return on physical capital in excess of the risk-free rate—largely explain the discrepancy between the real yields on US treasuries and the real return on physical capital.[5]

The second challenge to available estimates of the NRI is illustrated by Borio, Disyatat, and Rungcharoenkitkul (2017), who use a sample of nineteen economies over a period going back to 1870 to show that real interest rates are not driven by variations in desired savings and investment, but rather by variations in real yields, which seemingly reflect differences in monetary policy regimes.[6] Controlling for the widely accepted determinants of desired savings and investment (e.g., demographics, potential growth, dependency ratio), they find only life expectancy to be statistically significant and only in the post-Volcker period. These findings (see also Borio, Disyatat,

5 Besides markups and capital risk premia, Caballero, Farhi, and Gourinchas (2017) also attribute some explanatory role to the decline in the labor share of income in the US since the 2000s.

6 See also Levrero (2021).

Figure 3. Real yields on US Treasury bills and return on physical capital



Source: Caballero, Farhi, and Gourinchas (2017, 615).

and Rungcharoenkitkul 2019 for an econometric analysis) challenge the theoretical foundations of most models used for the empirical estimation of the NRI. In fact, Brand, Bielecki, and Penalver (2018, 8) European Central Bank Occasional Paper "The Natural Rate of Interest: Estimates, Drivers, and Challenges to Monetary Policy" states: "This negative relationship between consumption and real interest rates underpins all models covered in this report."

One logical implication advanced by Borio, Disyatat, and Rungcharoenkitkul (2019) is that monetary policy may itself be a driver of the NRI. This possibility is of particular significance not just historically, but for current monetary theory and policy. A look at the data for the US returns on assets is appropriate. Data from Jordà, Schularick, and Taylor (2017); Chen et al. (2022); and Jordà et al. (2019) show that between 1980 and 2008 total returns on equity in the US were on average 1.7 percentage points higher than the return on US government bonds. As shown in table 1, this difference increased to over 9 percentage points in the post-GFC period (2009–20). This increase in the equity risk premium[7] broadly mimics the difference in total returns between risky assets and safe assets (i.e., a rise from 2.2 percent over 1980–2008 to 8.0 percent in the post-GFC period). The increase in equity returns mostly reflects an increase in capital gains, which more than offset the much smaller decline in dividend returns. The US stock market may have benefitted from the long period of accommodative monetary policy.[8] Returns on safe assets more than halved, with

7 Caballero, Farhi, and Gourinchas's (2017) "capital risk."

8 One mechanism by which this likely occurred is the risk-taking channel. See Silva, Kimura, and Sobreiro (2017) for a recent survey.

Table 1. Equity and bond returns, 1980–2020 (percent)

Equity		Government bonds	
1980–2008	2009–20	1980–2008	2009–20
Total return		Total return	
12.0	14.0	10.3	4.8
Dividend return		Bond rate	
3.0	2.2	7.4	2.4
Capital gain		Capital gain	
8.9	11.7	3.3	2.4

Sources: Jordà, Schularick, and Taylor (2017); Chen et al. (2022); Jordà et al. (2019); and author's calculations.
Note: The equity dividend yield declined to 2.0 percent in 2009–20 from 2.8 percent in 1980–2008.

unconventional monetary policy contributing to a decline in bond rates from 7.4 percent to only 2.4 percent. Average capital gains dropped from 3.3 percent to 2.4 percent.

The rest of this article is organized as follows. Section 2 first discusses three areas where the literature has argued that Woodford's interpretation of Wicksell may be inaccurate. These areas are the concept of the NRI, Wicksell's "cumulative process"—which could be referred to today as the dynamics of inflation—and money neutrality.[9] This third part of section 2 goes on to address the differences between Wicksell and Mises regarding the interdependence of the loan rate of interest and the NRI, and the corresponding relation between the money market and the real economy. These differences matter because they led Mises to study the issue of capital accumulation and develop his theory of the business cycle. Based on the discussion in section 2, section 3 computes the rate of return on capital for the US to offer an alternative to Caballero, Farhi, and Gourinchas's (2017) explanation of the gap between real yields on securities and the real return on physical capital. Section 4 provides an econometric analysis of the domestic and international effects of US monetary policy shocks, providing evidence that monetary policy may explain in part the gap between real yields on securities and the real return on physical capital. Section 5 provides concluding remarks and implications.

2. Wicksell, Mises, and Woodford—Selected Differences

Differences between Woodford and Wicksell have been discussed extensively in the literature (e.g., Amato 2005; Boianovsky 2006; Laidler 2006; Trautwein 2011; De Fiore and Tristani 2011). Differences between Wicksell and Mises have been addressed less frequently (e.g., Dempsey 1943; Del Vecchio 1917; Bellofiore 1998; Festré 2006). This section brings together these strands of literature to address three key areas relevant to the dominant

9 Only limited reference will be made here to the important discussion regarding Woodford's interpretation of Wicksell's pure credit economy and monetary policy rules. A good reference is Boianovsky and Trautwein (2006).

interpretation of the NRI and its empirical estimates: Wicksell's and Woodford's concepts of the NRI; (2) Wicksell's cumulative process and his disagreement with Mises on the interdependence between the financial market interest rate and the NRI; (3) long-run money neutrality in Wicksell's static analysis, Woodford's model, and Mises's business cycle.

2.1. The Concept of the NRI: What Are the Differences between Wicksell and Woodford?

2.1.1. Wicksell's concepts of the NRI

Wicksell used at least three somewhat different concepts of the NRI in his writings. While he criticized Eugen von Böhm-Bawerk's theory of capital, his widely referenced definition of the NRI in *Interest and Prices* clearly acknowledges the Austrian school's view that more roundabout methods of production imply a higher marginal productivity of capital. According to Wicksell (1936, 102), "There is a certain rate of interest on loans which is neutral in respect to commodity prices, and tends neither to raise nor to lower them. This is necessarily the same as the rate of interest which would be determined by supply and demand if no use were made of money and all lending were effected in the form of real capital goods. It comes to much the same thing to describe it as the current value of the natural rate of interest on capital." Therefore, the NRI is the rate of interest which would be determined by supply and demand if no use were made of money and all lending were effected in the form of real capital goods, or savings *in natura*. This definition of NRI equates the *monetary (or bank loan) rate determined by the financial sector* with the rate in the capital market at which the supply of and demand for *real capital goods* are in equilibrium.[10] Wicksell emphasizes in this definition the role of the NRI in equating savings and investment and bringing about macroeconomic price stability.

A second Wicksellian definition of the NRI is found in his *Lectures on Political Economy*, where he refers to the NRI as the "normal rate": "The rate of interest at which *the demand for loan capital and the supply of savings* exactly agree, and which more or less corresponds to the expected yield on the newly created capital, will then be the normal or natural real rate" (Wicksell 1935, 192–93). For Wicksell (1936, 226n), in an efficiently functioning banking system, savings always have a corresponding real equivalent which first takes the form of additions to the stock of raw materials and consumption goods, which later become what he calls "mobile" or "free" capital." This free and mobile capital is necessary as means for sustaining those who furnish the labor and land during the time required for the production of fixed real capital (i.e., the *waiting period*). Wicksell's second

10 Capital market refers to the part of a financial system concerned with raising capital by dealing in financial instruments such as shares and bonds.

concept of NRI puts the Austrian notion of the time structure of capital clearly at the center of his "pure credit" economy model of price level determination. Capital has not only a *value dimension* in monetary terms in each time period, but also a *time dimension* represented by the time that elapses between the application of labor and land and the emergence of the consumption goods that they are expected to generate. This concept of capital was later to become a key part of the Austrian tradition represented by Mises and Friedrich von Hayek, and it was also at the heart of the Cambridge capital controversy of the 1950s and 1960s.[11]

Wicksell's third definition of the NRI can be found in the exposition of his well-known cumulative process in chapter 9 of *Interest and Prices*, where he writes, "It has now to be supposed that, for some reason or other, a difference arises between the natural rate of interest and the contractual rate of interest. . . . Suppose that the natural rate is raised to i +1 per cent., while the banks maintain their customary rate of discount i. To whose advantage will this difference accrue? In the first place, of course, it accrues to the entrepreneurs" (Wicksell 1936, 141). According to this definition, *the NRI is largely equal to the real profit rate* (Festré 2006). For Wicksell, under perfect competition, equilibrium in both the real capital market and the loan market requires a new NRI that is common across different roundabout production processes.

Despite Wicksell's somewhat different definitions of the NRI, there is one common empirical feature, and the three definitions share three common conceptual features. From an empirical viewpoint, Wicksell never assumed that the NRI is directly observable, as it is a conceptual point of reference—an equilibrium—rather than a measurable parameter.[12] From a conceptual viewpoint, first, the NRI is always characterized by being consistent with equilibrium between savings *in natura* and investment. Second, this equilibrium is a long-run concept, and the NRI is itself subject to variations because of exogenous forces, such as technological shocks or changes in the labor force (Amato 2005). In contrast, the market rate of interest is a contractual rate. Third, the price level (or the inflation rate) is for Wicksell a measure of the investment-savings imbalance.[13]

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11 A fundamental and closely interrelated discussion in the Cambridge capital controversy regarded the circularity in capitalist income (total profit) defined as the rate of profit multiplied by the *amount of capital*, noting that the measurement of the *amount of capital* involves adding up heterogeneous capital goods. Interestingly from a historical viewpoint, Paul Samuelson (1966) rejected his former view that heterogeneous capital could be treated as a single capital good through a "surrogate production function." His acceptance of the criticism of the UK Cambridge view is unfortunately not well known. This matter need not be addressed here.

12 In modern parlance, for an inflation-targeting monetary policy regime, Wicksell's idea could be formalized with the following monetary rule: $i_t = i_{t-1} + \alpha(\pi_t - \pi^*)$, where i is the loan market rate of interest, π is inflation and π^* is the monetary authority's inflation objective. As long as π exceeds the monetary authority's inflation objective, the interest rate has to be raised. It has been shown that Wicksell's monetary rule is suboptimal relative to forward-looking Taylor rules because the latter accelerate the adjustment process following a shock. However, Taylor rules may introduce oscillations under certain conditions (Tamborini 2006; Tamborini, Mazzocchi, and Trautwein 2014). See Garrison (2006) for an Austrian critique of Taylor rules.

13 Wicksell, like Keynes later, was concerned with real disequilibrium as a result of saving-investment imbalances caused by "wrong" interest rates. In this sense, one could even argue that Woodford's framework is not truly Keynesian.

2.1.2. Woodford's Concept of the NRI

Woodford (2003, 248) defines the NRI "as the equilibrium real rate of return in the case of flexible prices." In chapter 5, he relates the NRI to the natural rate of output: "Indeed, the natural rate of interest is just the real rate of interest required to keep aggregate demand equal at all times to the natural rate of output" (Woodford 2003, 248). This NRI is therefore a real interest rate consistent with output at its potential level and with inflation at its target. For Woodford, the NRI is a function of the representative agent's discount rate and stochastic shocks when labor is the only factor of production. If capital is added to the production function, the NRI is a function also of the level of the capital stock (e.g., Gertler, Gilchrist, and Natalucci 2007). Further, in an open economy, the NRI depends on foreign output shocks as well (e.g., Galí and Monacelli 2008). What underlies all these models—henceforth "Woodford-style" models for simplicity—is the classical dichotomy by which the economy's real equilibrium can be determined independently of the nominal equilibrium. The NRI can be pinned down without reference to nominal variables, in particular without reference to a payment system that is essentially different from an accounting system of exchange—that is, a nonmonetary model.[14] This system of exchange is a *perfect* barter system (McCallum 2003).

Therefore, Woodford-style models exhibit the Hahn property, which "arises when in non-monetary models, accounting systems of exchange based on a Walrasian or Arrow-Debreu auction, have attached them some or all of the characteristics of money, credit and debt" (Rogers 2006, 295). Frank Hahn (1973) calls these types of models "inessential sequence economies" because while money can always be added to them, they imply a complete theoretical equivalence between monetary and nonmonetary equilibria. Barter is treated as if the double coincidence of wants, the dimensionality curse of millions of relative prices, and the settling of debt in complex modern economies have been somehow solved. As a result, when these models add money as a friction (as cash in advance or cash in arrears) that monetary policy will eliminate, it is logically unavoidable, albeit counterintuitive, that money is welfare-reducing because it imposes a constraint on the equilibrium solution generated by the Walrasian auction.

In contrast, in Wicksell's pure credit economy the money supply is made up of current account balances. Money is endogenous, and the classical dichotomy between money and goods markets does not hold. In the loan market, firms borrow funds to invest, and households lend their savings in a

14 For a detailed analysis of such systems, see Ljungqvist and Sargent (2018, chap. 8).

process intermediated by banks.[15] Money demand equals bank deposits and is determined by firms' demand for loans to finance investment. It is demand for money to spend, not to hold.[16]

When Woodford (2003, chap. 5) assumes flexible prices in a closed economy with a production function that also includes capital, it is unclear whether the definition of the NRI should assume that price flexibility is a condition of past, present, and future states of the economy, or only of current and future states. There is no agreement in the profession on this matter (Amato 2005). However, the level of the capital stock differs in the two cases. When price flexibility is only a condition of current and future states of the economy, the NRI will not be independent of past nominal rigidities or of the history of monetary policy. As a result, the classical dichotomy assumed in most Woodford-style models will not strictly hold. Recently, Borio, Disyatat, and Rungcharoenkitkul (2019) argued that the interaction between monetary policy and the financial cycle generates path dependence. As a result, past monetary policy may have changed the level of the capital stock adjustment as well as the path of the NRI. To break the classical dichotomy in this type of economy, one must add a financial sector with frictions (both on the borrowing and the lending sides of agents' balance sheets).[17] Woodford (2003, 373) briefly discusses this point when he introduces endogenous capital stock variations in the model and seems to allow for the predetermined capital stock to be potentially affected by past policy choices. However, Woodford's model assumes complete markets, and, as is well known, this assumption cancels history dependence with respect to idiosyncratic shocks.[18]

In contrast, Wicksell's discussion of the NRI and price stability is framed within his pure credit economy, which is not frictionless. Banks intermediate between savers and borrowers or investors, and banks exist because of frictions relative to the Arrow-Debreu benchmark. Because the time-varying NRI is unobservable for commercial banks, the central bank, and economic agents, in Wicksell's framework all economic agents are prone to misperception, which engenders possible deviations of the loan market interest rate from the NRI (Trautwein 1997). As a result, the additional means of payment that are created (when the loan market rate is below the

15 Explicitly accounting for the financial system not only changes theoretical model outcomes, but there is also evidence that it matters empirically. For example, Igan et al. (2017) use sectoral balance sheet variables to study the transmission of monetary policy shocks in the US economy. They find that the balance sheets of various economic agents function as important links in the monetary policy transmission mechanism and materially affect the impulse response functions of inflation, output, and unemployment. DSGE models, notably those developed after the GFC, incorporate frictions to address these issues, as discussed below in this subsection.

16 Woodford's "cashless economy" is intended to mimic one of the extreme cases Wicksell discussed (i.e., his pure credit economy, although Wicksell's pure credit economy is not a cashless economy) (Laidler 2006). Woodford's payment system is informal credit that must be settled by the end of the period. However, without cash, final settlement cannot be achieved.

17 De Fiore and Tristani (2011) show that the classical dichotomy breaks down when certain types of credit frictions are introduced.

18 See, e.g., Ljungqvist and Sargent's (2018, chap. 17) discussion of precautionary savings and Bewley models.

NRI) set into motion Wicksell's cumulative process of income and price changes (discussed in section 3). While markets are not complete in Wicksell's pure credit economy, they are complete in Woodford-style models.[19]

The discussion so far has not done justice to a crucial aspect of Wicksell's notion of the NRI. Wicksell's second definition of the NRI puts the capital stock at the center of his pure credit economy—not just the level of the capital stock, but also its time structure. When banks (or a central bank with imperfect information) set the market rate of interest below the NRI, there is excess borrowing and investment by firms.[20] In contrast to Woodford's version of Wicksell, the divergence in Wicksell's concept between the market interest rate and the NRI generates a saving-investment imbalance at time *t* leading to a sequence of future output and inflation gaps. *Even in an economy with flexible prices as assumed by Wicksell*, fluctuations around the NRI produce nominal as well as real effects. These effects are driven by the limited information available to capital market participants. This constitutes a major difference from Woodford's model or most DSGE models that include financial frictions, an infinite horizon for the intertemporal optimization by the representative household, rational expectations, and a transversality condition that rules out rational bubbles, excess specific capital, and unpaid debt (Trautwein 2020). In these models, a gap between the real market interest rate and the NRI is associated with a *contemporaneous* output gap. Future output gaps depend only on future interest-rate gaps. Woodford-style models and DSGE models display a period-by-period equilibrium.[21]

A few recent studies do encapsulate some Wicksellian features in an otherwise New Keynesian framework (see appendix 1 for a short presentation of the core of the New Keynesian framework). For example, Mazzocchi (2013) has a DSGE model in which price level changes are *disequilibrium* phenomena consistent with excess investment or savings at the "wrong" market real interest rate (i.e., different from the NRI).[22] Closer to Wicksell's concept of disequilibrium, Rungcharoenkitkul and Winkler (2021) extend a New Keynesian model by introducing incomplete information. The monetary authority and private agents must learn about the NRI and infer each other's information from observed macroeconomic developments. As in Wicksell (and Mises), an informational feedback loop emerges when each agent

19 This fundamental difference makes Woodford-style models inappropriate for dealing with many important current issues, such as the likely effects of monetary policy on risk-taking behavior, the analysis of financial cycles driven by "excessive" leverage, and the coordination of monetary and macroprudential policies.

20 Dissatisfaction with workhorse models after the GFC prompted the introduction of real-financial linkages to address these issues. Unsurprisingly, "excessive maturity transformation" has been at the center of academic and policy discussions since then (e.g., Farhi and Tirole 2012; FSB 2021; Rungcharoenkitkul, Borio, and Disyatat 2021).

21 In these models, the economy is never in disequilibrium in the Wicksellian sense. Faced, say, with excess capital, economic agents would consume it in the form of dissaving or leisure. However, there are some exceptions in the literature, such as Brunnermeier, Eisenbach, and Sannikov (2013) and models with overlapping generations often used in the older New Keynesian literature (e.g., by B. Bernanke and Gertler (1989) which have asset price bubbles without transversality conditions.

22 This is not a disequilibrium in the usual sense of deviation from the steady state.

underestimates the effect of the inferences others make from his own action. This mechanism may lead to large and persistent changes in the perceived NRI that are disconnected from fundamentals.

In summary, differences between Woodford-style models and Wicksell relate to the speed of markets' adjustment to equilibrium and to how complete agents' information matrix is. Woodford-style models are based on intertemporal optimization in an economy with labor (and homogeneous capital), imperfect competition, and price stickiness. While financial frictions due to asymmetric information could be added, these do not interfere with the *continuous intertemporal general equilibrium*. They only amplify fluctuations following shocks.[23] Instead, Wicksell's pure credit economy is characterized by an intertemporal coordination failure between savers and investors in the Austrian school tradition (e.g., Hayek 1935), by imperfect capital markets due to incomplete information, and by trading at "wrong" interest rates (Laidler 2011). In Wicksell's economy, the main concern is with real disequilibrium business cycles triggered by "wrong" interest rates and driven by saving-investment imbalances.[24] For Wicksell—as well as Keynes—price and wage flexibility would not per se eliminate the effects of "wrong" market interest rates nor induce their correction.

Appendix 2 contains a summary of the NRI in Wicksell, main differences from Mises, and the NRI in Woodford and Woodford-style models.

2.2. Wicksell's Cumulative Process, Disagreement with Mises, and Differences with Woodford's Economic Dynamics

In chapter 9 of *Interest and Prices*, Wicksell (1936) methodically describes his cumulative process. If for some reason the market rate of interest fixed by the banks is lower than the NRI, this will start Wicksell's cumulative process of inflation, characterized by the economy adjusting to an excess of investment over savings. Wicksell's disequilibrium is the result of a failure of the coordination mechanism in the capital market, not in the goods or labor market. If banks (or the central bank) set the market rate of interest below the NRI, demand and supply excesses in the capital market will be cleared by open market operations. Therefore, households and firms will condition their optimal plans for saving and investment on the observed market real rate of interest, although these plans will not be mutually consistent, since the real value of households' savings will not be matched by the value of the capital stock value chosen by firms. This implies an intertemporal disequilibrium because there is no counterpart excess demand or supply in the goods market. In Wicksell's pure credit economy, the connection between money creation

23 For a critical survey of DSGE models with financial frictions from a Wicksell-Keynes perspective, see, e.g., Trautwein (2020).

24 Saving-investment imbalances belong to the Austrian and Keynesian traditions, which came before the New Keynesian DSGE framework with an RBC core with period-by-period stock equilibrium and a Phillips curve.

and nominal income is examined in its out-of-equilibrium dynamics from one level of money and nominal income to another level of money and income.

In contrast to what may be suggested by Woodford-style models, Wicksell did not rely exclusively on static expectations to analyze the cumulative process. Strictly speaking, he used static expectations only in presenting the stationary state of his model.[25] Wicksell was well aware that the system's stationary state should display a constant price level, so for him the challenge was the evolution of inflation expectations over the disequilibrium cumulative process (e.g., Leijonhufvud 1981; Boianovsky and Trautwein 2004). First, Wicksell assumed that economic agents believe in a "normal" inflation rate to which the economy would tend. However, he later discussed alterations to his cumulative process in which expectations are assumed to be adaptive[26] or even explosive.[27] Wicksell (1936, 148) did allow nonstationary price expectations: his cumulative process can become exponential if the elasticity of price expectations is greater than unity, even if there is no divergence between the market rate of interest and the NRI. Therefore, Wicksell considered learning in his cumulative process by shifting expectations from static to adaptive and forward looking.

In addition, Wicksell's systematic presentation of his cumulative process involves no increase in capital goods following a positive productivity shock. If real wages increase, the rise in productivity should lead to a rise in real capital, but in a 1909 essay Wicksell (1999, 2, 42) assumes that "real capital and real wages do *not* undergo any change." Under these circumstances, even if prices fall, money wages must also fall, and therefore the entrepreneur will have the same return as if prices had remained constant. Essentially, Wicksell

25 "In a completely undisturbed and stationary state, we have seen that the entrepreneur meets with neither a profit nor a loss; he merely obtains the same return for the trouble of conducting his business as he would have obtained for conducting a similar business on behalf of others, for instance of a company" (Wicksell 1936, 138–41).

26 "When prices have been rising steadily for some time, entrepreneurs will begin to reckon on the basis not merely of the prices already attained, but of a further rise in prices" (Wicksell 1936, 96).

27 "Through its influence on supply and demand, an *expectation* of a rise in prices in the future is by its very nature capable in itself of bringing about only a somewhat *smaller* rise than is actually expected" (Wicksell 1936, 97). "It is possible in this way to picture a steady, and more or less uniform, rise in all wages, rents, and prices (as expressed in money). But once the entrepreneurs begin to rely upon this process continuing—as soon, that is to say, as they start reckoning on a future rise in prices—the actual rise will become more and more rapid. . . . In the extreme case in which the expected rise in prices is each time *fully* discounted, the annual rise in prices will be indefinitely great" (148).

discards the possibility of capital accumulation through *forced saving*.[28] This was Wicksell's view prior to his debate with Davidson[29] and his criticism of Mises on forced saving.[30]

However, in a crucial concession to Mises, Wicksell admitted later that the market rate of interest and the NRI are *interdependent*. Wicksell then stated that forced saving could induce the real rate of interest to decrease, prolonging the upward movement of prices. He introduced the possibility of capital accumulation in part 3 of volume 1 of *Lectures on Political Economy* (Wicksell 1934).[31] But he did not deal with the maladjustments that the cumulative process can generate in the capital structure or the impact such maladjustments may have on employment and income.[32] While Wicksell originally disagreed with Davidson and Mises that the increase in productivity will result in a rise in wages and should immediately lead to an increase in real capital, it becomes clear that the sufficient condition for the cumulative process to occur is that the ex ante NRI should be capable of varying independently of the loan rate of interest (Myrdal 1939, 54ff.). The necessary condition for this to happen is the existence of some lag in the convergence of the two rates.

By building on such adjustment lag and focusing on relative price movements, Mises extended Wicksell's cumulative process and developed his own theory of the business cycle. The fundamental differences between Wicksell and Mises are that for the latter the NRI and the market rate of interest are interdependent and a credit expansion can result in forced saving with a corresponding decline in the NRI. While the market rate of interest and the NRI could diverge due to productivity shocks à la Wicksell or due to an initial credit expansion à la Mises, the business cycle will last as long as is necessary for the two rates to converge in a new equilibrium. For Mises, banks cannot keep the loan rate of interest below the NRI for long. Attempts will result in either the NRI declining to the loan rate as real capital formation results from "real savings" or nonbank creditors raising loan rates to compensate for rising prices. If banks resist by maintaining the

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28 The term "forced saving" is perhaps unfortunate and has created confusion within the Austrian school tradition and between the Austrian school and Keynesians (e.g., Garrison 2004). The term is kept here because it was used by Wicksell and Mises. "Forced saving" refers to the possibility suggested by Mises, and admitted by Wicksell in his later writings, that additional capital is produced as a result of the credit expansion that drives down the market rate of interest without the required ex-ante *saving in natura* having been realized. In other words, the producers react as if the additional investment funds had been made available by voluntary saving in the widely accepted sense of saving as an abstention from consumption. See Mises's (1998, 545–83) *Human Action* for the author's detailed discussion of the subject.

29 See Thomas (1935) for a discussion of Davidson's monetary theory and his criticism of Wicksell as well as for a reference to Mises's discussion of forced saving and his disagreement with Wicksell on this matter.

30 As reported by Ohlin in the introduction to the second English edition of *Interest and Prices* (Wicksell 1936), Wicksell amended the second Swedish edition of his *Lectures* (1915) following Davidson's criticism and Mises's publications (Festré 2006). Besides Dempsey's (1943) discussion of the relation between Wicksell and Mises, see also Uhr (1960). Del Vecchio (1917) contains a clear discussion of the differences between them.

31 This was not possible in his systematic exposition of the cumulative process where he assumed only one good.

32 Hicks (1967, 66) noted that in Wicksell's broader analysis of the cumulative process, the existence of a disequilibrium stage involving different movements of capital goods prices and consumer goods prices is undeniable.

low loan rate, the economy will follow a disorderly unraveling toward a crisis. Wicksell's cumulative process could end in hyperinflation or deflation, but he did not discuss the attendant disorders in production, the capital structure, employment, and the income distribution. Wicksell was clearly aware of the opposition between static and dynamic analysis in economics[33] and explicitly admitted that he could not contribute to the latter.[34]

2.3. Money Neutrality in the Long Run?

In his pure credit economy, Wicksell rejects the assumption of a constant velocity of money, which was instead consistent with his "pure cash" economy. In his pure credit economy, lending and borrowing occur in a competitive banking sector, and the classical dichotomy disappears: "Money is continually becoming more fluid, and the supply of money is more and more inclined to accommodate itself to the level of demand" (Wicksell 1936, 110). This is also the case in modern inflation targeting frameworks. As in Wicksell, in Woodford-style models—and in the current consensus in the profession—money is not neutral in the short run, which allows monetary policy to regulate the price level (or inflation) by controlling interest rates.[35]

As mentioned above, Wicksell came to accept Mises's argument that the loan rate of interest and the NRI were interdependent, but he did not consider himself capable of elaborating a theory of the business cycle. This was undertaken first by Mises and then in 1931 by Hayek (1935). Mises's business cycle theory evolved from his *Theory of Money and Credit* (1934) to reach its final stage in *Human Action: A Treatise on Economics* (1949). It is useful to discuss the key differences between business cycle dynamics according to Mises and according to Wicksell's cumulative process. While Mises agrees with Wicksell that the NRI is time varying, for him the NRI cannot be a barter rate and is not unique.

2.3.1. Wicksell's barter NRI and Mises's monetary "originary interest"

In *Human Action*, Mises developed the concept of "originary interest," which is best understood by referring first to *The Theory of Money and Credit*, where Mises integrated monetary analysis within the Austrian theory of marginal value with the stated objective of explaining money's purchasing

33 Wicksell always kept his discussion of the cumulative process separate from his discussion of the nature and causes of business cycles (e.g., Boianovsky 1995; Boianovsky and Trautwein 2001).

34 Wicksell (1934, 218) wrote in his *Lectures*: At the close of a boom, paper credit often seems to make up, in part (though actually it does not), for the shortage of real capital—and still more in a period of depression when investment in fixed capital hardly pays, but savings continue, though perhaps at a slower pace. The process of capital accumulation is here not a little enigmatic. It *must* continue in some real form, since there is no other; but in what? Further investigation of this question is highly desirable and would probably throw much light on a field which is still the darkest in the whole province of economics, namely the theory of the trade cycle (and of *crises*). But we cannot consider that subject here since we have, throughout, restricted our observations to the economic phenomena of equilibrium in the ordinary sense—to static analysis as distinct from dynamic.

35 For Wicksell, the real balance effect was clearly insufficient to control the price level.

power. For Mises, explaining the determination of the loan market interest rate is not formally different from explaining the determination of the ratio between money and other economic goods. In his framework, the interest on loans or the monetary rate of interest is indeed identical to the interest on capital.[36] Changes in the exchange ratio between "present goods" (i.e., goods immediately available for consumption) and goods of "higher orders" (i.e., goods not yet ready for consumption) "are not different phenomena from the variations in the objective exchange value of money" (Mises 1981, 388). Practically, this means that an increase in the money supply, ceteris paribus, brings about excess cash balances, which implies market pressure toward raising goods prices. But Mises stresses that money does not flow into the economy uniformly and instantaneously. It first flows toward intermediate goods because of credit expansion, so that production goods prices rise more than consumption goods prices. This is tantamount to a fall in the rate of interest (Mises 1981, 388).

Similarly, the fall in the purchasing power of money mirrors the rise in the price of production goods *relative* to that of consumption goods. For Mises, only the existence of money makes it possible to analyze the difference in value between present and future goods. In contrast to Wicksell, Mises argues that in a barter economy the phenomenon of interest could never be isolated from the evaluation of future price movements of individual goods. Thus the NRI cannot be defined as the rate of interest that would prevail in a barter economy because such an economy would have no rate of interest. And even if there were such an NRI, it would still be irrelevant for the analysis of a monetary economy. The relevant benchmark is no longer the Wicksellian NRI that would exist in a barter economy, but rather the monetary interest rate that would exist in the absence of credit expansion (Mises 1998, 547–62).

Mises's concept of the rate of interest changed over time. In his last major work, *Human Action*, he presents the phenomenon of interest as the manifestation of *time preference*, no longer referring to Böhm-Bawerk's NRI. For Mises, the originary rate of interest is the discount of future goods against present goods, an expression of the category of time preference. It is the ratio of the value assigned to the satisfaction of wants in the immediate future to the value assigned to that same satisfaction in the distant future. He writes, "It is a ratio of commodity prices, not a price in itself" (Mises 1998, 523).

36 Specifically, Mises (1981, 399), following Böhm-Bawerk (1884, 1889), defines the NRI as "the level of productivity of that lengthening of the period of production which is just justifiable economically and of that additional lengthening of the period of production which is just not justifiable; for the interest on the unit of capital upon whose aid the lengthening depends must always amount to less than the marginal return of the justifiable lengthening."

While Wicksell's and Woodford's analysis of inflation is based almost entirely on changes in the general price level, Mises's analysis is based on variations of relative prices in the *time structure of capital goods*.[37]

The concept of originary interest can be related to Frank Ramsey's (1928) classical growth model. With population growth n and no uncertainty, r^* is the general equilibrium interest rate (NRI):

$$r^* = \frac{1}{\varphi}\dot{c} + n + \beta.$$

The NRI moves in tandem with households' discount rate β and the rate of population growth n, and it moves inversely to the intertemporal rate of substitution φ weighted by growth rate of per capita consumption $\dot{c}$. In chapter 19 of *Human Action*, Mises argues that Wicksell's NRI coincides with the rate of interest on loans *only* in the stationary state of Wicksell's pure credit economy. In such a case, he writes, "we may call this rate the neutral rate of interest" (Mises 1998, 535). Such a neutral rate of interest exists only in the stationary state where money is neutral and coincides with households' discount rate β (Tamborini, Mazzocchi, and Trautwein 2014).

In a growing economy, as in Woodford-style models and most DSGE models, the NRI will also be driven by other forces, notably shocks to preferences and technology. For Mises, in a growing economy the originary interest rate will additionally be driven by risk and uncertainty (e.g., credit risk, sovereign risk, geopolitical uncertainty) as well as by monetary policy. All these forces can bring lasting changes in the final originary interest rate. Therefore, in Mises's dynamic analysis there is no single originary interest rate; there is only a tendency toward the establishment of such common rate. According to this narrative, shocks such as technological or monetary policy shocks alter not a *state of equilibrium* but a *process which tends to equilibrium*. The reason credit expansion by banks can lead the loan market monetary rate to deviate temporarily from the tendency to long-run equilibrium is the nonneutrality of money in a growing economy.

2.3.2. Mises's Credit Cycle

For Mises, a credit expansion by banks induces the gross rate of interest on loans to decline and stimulates economic activity.[38] No broad price effect occurs until the additional supply of money has affected the prices of goods

37 The Cambridge capital controversy briefly referred to in section 2.1.1 is clearly an integral part of the discussion of macroeconomic dynamics ignored in contemporaneous analysis of the NRI.

38 In chapter 20 of his *Human Action*, Mises (1998, 548) states: "For the sake of simplicity we assume that the whole additional amount of money and money-substitutes flows into the loan market and reaches the rest of the market only via the loans granted. This corresponds precisely to the conditions of an expansion of circulation credit." Mises also considers another channel by which the credit expansion affects the rate of interest. This influence is indirect and permanent because it works through the economy by affecting income and wealth

and services. However, the decline in the gross market rate of interest on loans affects firms' calculation about the probability of success of investment projects. The upswing starts, and provided that the credit expansion continues, the gross rate of interest on loans will tend to increase to accommodate a positive price premium. This process eventually makes it possible for the increasing market rate to catch up with the originary interest rate plus the positive price premium. For Mises, the credit cycle induces an expansion in the time dimension of the structure of production (capital) that initially puts upward pressure on intermediate and capital goods, contributing to a decline in the originary interest rate. The process continues until the fall in the originary interest rate is large enough to offset the gap (between the gross interest rate on loans and the originary interest rate) created at the start of the credit expansion. Alternatively, if banks continue the credit expansion, a hyperinflation process develops.[39]

The credit expansion will generate additional purchasing power that can enter the economic system in different ways, and Mises noted that some *relative prices* will be affected earlier than others. Agents and sectors whose purchasing power rises earlier than others may face lower relative prices for the goods and services they demand than agents and sectors who demand the same goods and services but whose purchasing power only increases later. Prices and wages are affected at different times and to different extents.[40] These relative prices changes will affect the structure of business, the size and composition of production in the various branches of industry, consumption, and wealth and income distributions.[41] In contrast to Wicksell's cumulative process, such changes can modify the originary interest rate and permanently alter the capital stock value and its time structure; Mises (1998, 539) writes, "In the changing economy, the rate of interest can never be neutral. In the changing economy, there is no uniform rate of originary interest; there only prevails a tendency toward the establishment of such uniformity." Money is not neutral even in the long run.

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distribution through changes in the exchange value of money. The impact on the loan interest rate is uncertain: the loan market interest rate may decrease or increase depending on whether the new income and wealth distribution induce more or less capital accumulation. Addressing this matter in detail would go beyond the objective of this research. See Mises (1998, 545–47).

39 The possibility of hyperinflation also appears when agents' price expectations are not based only on past inflation but also on the future state of the economy (Mises 1998, 545).

40 Criticism often made of this observation by Mises seems inconsistent with the widely held view that, e.g., to correct what is perceived as "disequilibrium" in residential real estate prices, prudential instruments such as limits on loan-to-value or debt-to-income ratios should be used to quench demand, which, ceteris paribus, will also reduce the relative price of housing. Disequilibria in relative prices due to "excessive" lending are abundant (e.g., Cerutti, Claessens, and Laeven 2017; Ampudia et al. 2021; ESRB 2022). In addition, among the several quantitative easing policies of the European Central Bank, in the Targeted Longer-Term Refinancing Operations II and III, the interest rate was linked to participating banks' lending. The more loans were issued to nonfinancial corporations and households (except loans for house purchases), the more attractive was the interest rate (see ESRB 2022). Clearly, ceteris paribus, the relative price of commercial property compared to that of residential property could be expected to rise following these policies.

41 Recently, models that include agents' heterogeneity—heterogeneous agent New Keynesian (HANK) models—are being developed following the seminal work of Kaplan, Moll, and Violante (2018). In these models, aggregate monetary policy shocks affect the return on capital and thus are not distributionally neutral. In addition, households with different levels of wealth and assets are affected differently (Trautwein 2020). Thus, HANK models are a step in the direction of recognizing the distributional effects of monetary policy discussed by Mises.

This analysis contrasts also with Woodford-style models and more broadly with the current consensus, which holds that central banks control the nominal interest rate and, given sticky prices, affect the real rate on interest but not the NRI.[42] According to this consensus, central banks control aggregate demand to preserve price stability, ensuing changes in investment do not affect savings, and changes in current output have no effect on potential output (Fontana 2007). The crucial assumptions of Woodford-style models and most DSGE models are that the level of savings, potential output, and NRI are independent of monetary policy; they are solely driven by technical progress, labor force growth, and the relative price of capital.[43]

Finally, the time horizon of the real effects of monetary policy is unclear in Woodford (2003). The introductory chapter of the book and the discussion of investment in the neo-Wicksellian model (361–72) suggest that money is nonneutral also in the long run, as pointed out by Boianovsky and Trautwein (2006). However, Woodford rarely discusses monetary policy nonneutrality. This may be because in his framework nonneutrality is defined as the discrepancy between the flexible-price benchmark of a natural rate of output and actual output under nominal rigidities, an admittedly minimalist concept of monetary policy nonneutrality. Clearly, monetary policy nonneutrality in the long run leaves numerous and fundamental questions unanswered, but discussing them is beyond the scope of this article.

3. Estimate of the US NRI Based on Wicksell and Mises

Following the theoretical discussion above, this section uses the US national income and product accounts to compute the NRI as suggested by the work of Wicksell and Mises. As proposed by Wicksell and further elaborated by Mises (1998, 487–514), capital formation is imputable (in the long run) to land, labor, *and time*. For these authors, capital (in contrast to capital goods) is not an independent factor of production that earns a net rent for its owner. Instead, capitalist-entrepreneurs are remunerated for the risk they take on in advancing liquidity to the other factors of production; this is the monetary expression of Wicksell's free and mobile capital, which is necessary as means for sustaining those who furnish the labor and land during the time required for the production of fixed real capital. Businesses' *real return on investment*[44] is calculated by summing the net operating surplus of nonfinancial corporations and deducting all advances to factor owners which

42 The long-run nonneutrality of money is a view also shared by authors not necessarily belonging to the Austrian tradition (see, e.g., Wray 1990 and Fontana and Realfonzo 2005).

43 As argued by Guiseppe Fontana (2007, 52), "In this regard, the main tenet of this alternative Wicksellian view of monetary policy is that despite all theoretical and empirical progress, the new consensus view endorses a modified version of the old neoclassical dichotomy between the monetary and real sectors."

44 This is the third definition of the NRI in Wicksell (as discussed in section 2.1.1), which is largely equal to the real profit rate. However, as argued in section 2.3.1, for Mises, Wicksell's NRI coincides with the rate of interest on loans *only* in the stationary state of Wicksell's pure credit economy, where money is neutral and coincides with households' discount rate β. In a growing economy, these NRI estimates need to include Mises's profit risk rate as well, approximated, as done in these sections' estimates, by the gap between risky and safe assets.

are not directly linked to interest on financial capital (such as "rental income" and "proprietors' income"), which include a significant wage component from sole proprietorships and partnerships, and the often unimportant "other transfer payments."[45] Wicksell's NRI, the businesses' *real rate of return on investment*, is therefore obtained by summing "corporate profits adjusted for inventory valuation and capital consumption of domestic companies" and "net interest paid on financial assets" (i.e., the numerator) and then dividing it by the net stock of produced assets (private and nonresidential) augmented by capitalists' expenditure on factor incomes, labor, and land (i.e., the denominator).

As shown in figure 4, the NRI of the US oscillated between about 5.8 percent and 7.8 percent from 1980 to 2020. The average was 6.8 percent over 1980 and 2020, declining slightly to 6.3 percent in the post-2008 period.[46] This decline, probably the outcome of accommodative monetary policies,[47] pales in comparison to the trend decline in the sample period 1999–2020 documented in, for example, Brand, Bielecki, and Penalver (2018) and Caballero, Farhi, and Gourinchas (2017). In figure 4, the NRI does not approach zero and remains well above the federal funds rate.

In the stationary state,[48] the Misesian originary interest rate would be consistent with a quarterly discount factor of 0.983 on average (i.e., an average NRI between 7.0 percent and 6.5 percent). These rates would also be consistent with Caballero, Farhi, and Gourinchas's (2017) estimates of the return on US physical capital. However, these NRI estimates do not properly distinguish the NRI from Mises's uncertain profit rate in a growing economy.[49] So, short of modelling such risk, an approximation of the equity risk premium from Jordà, Schularick, and Taylor (2017) and Chen et al. (2022) may be computed as the gap between risky and safe assets (nominal). This measure of risk rose from about 2.4 percent in the period 1980–2008 to 8.0 percent in the period 2009–20, which is similar to estimates in Caballero, Farhi, and Gourinchas (2017).

45 Mihai Macovei (2021) has a similar approach in a paper that criticizes Lawrence Summers's (2014) defense of the use of quantitative easing and expansionary fiscal policy to address both the decline in the natural rate of interest down to zero and stagnation in advanced economies as a result of excess savings together with feeble investment.

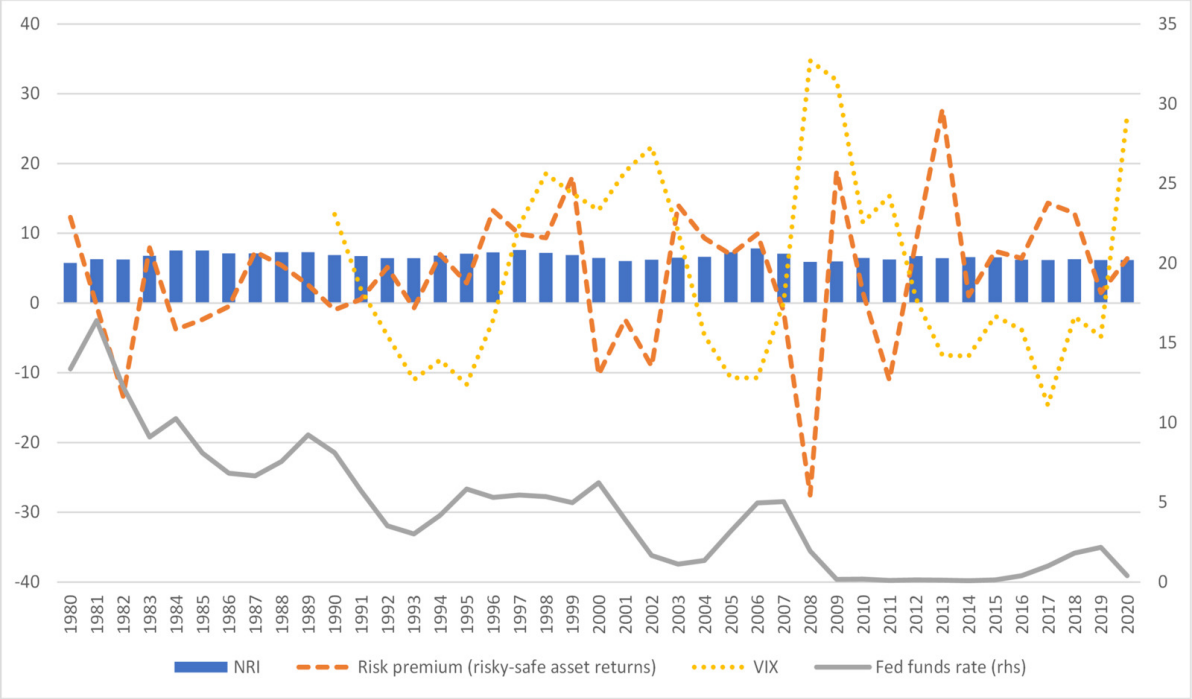
46 For comparison with figures 1 and 2 as well with Caballero, Farhi, and Gourinchas (2017), the NRI average in the period 1999–2016 was 6.4 percent.

47 This point is fully addressed in Nadal De Simone (2024).

48 As discussed in section 2.3.1, for Mises, the NRI is uniform and coincides with households' discount rate β *only* in the stationary state with neutral money.

49 The uncertainty inherent in predicting the future constellation of prices when goods will be ready for consumption.

Figure 4. The US NRI (percent), the fed funds rate (right-hand scale), the risk premium, and the VIX



Sources: Jordà, Schularick, and Taylor (2017); Chen et al. (2022); and author's calculations.
Note: VIX is available beginning in 1990. VIX is the ticker symbol and the name for the Chicago Board Options Exchange's CBOE Volatility Index, a widely used measure of the stock market's expectation of volatility based on S&P 500 index options.

3.1. What about the Wedge between Real Returns on Bonds and the Real Return on Physical Capital?

As discussed in section 1, the DSGE models used to estimate the NRI identify a "risk premium shock" as the main driver of the decline in the NRI. Using Fisher (2015), the so-called risk premium shock can be interpreted as a shock to demand for safe and liquid assets. However, Fisher (2015, 514) himself suggests relabeling the so-called risk premium shock as a "safety and liquidity premium," a "liquidity preference," or a "money demand" shock. Fisher warns that *this structural interpretation of the shock is possible only for certain values of an exogenous stationary disturbance term* affecting the demand for liquid assets. Under other circumstances, however, there can be a serious mismeasurement of the liquidity demand shock in the Smets-Wouters model (2007), on which Neri and Gerali (2019) based their own model. In addition, as argued by Fisher (2015), in such circumstances, the first-order condition for risk-free bonds will lack a variable that represents the *supply* of safe and liquid assets, a point also forcefully made in Borio, Disyatat, and Rungcharoenkitkul (2019).[50] Therefore, when the decline in the NRI is attributed to the so-called risk premium shock of Neri and Gerali (2019) or the "capital risk" of Caballero, Farhi, and Gourinchas (2017), these

50 Borio, Disyatat, and Rungcharoenkitkul (2019) discuss several other drawbacks of the "safe-asset shortage hypothesis."

may not be based on structural parameter values that provide a narrative consistent with widely accepted measures of risk premium and volatility. Appendix 3 displays the behavior of US house prices and the S&P 500 cyclically adjusted price-to-earnings ratio, often used as a proxy to forecast returns. Despite the decline in the time series around 2008–9, they display an upward trend which is inconsistent with a narrative suggesting that there is a low demand to hold risky assets. Instead, the upward trend is more consistent with, for example, Thomas Mayer and Gunther Schnabl's (2021) narrative of a "monetary overhang" since the mid-1980s that accelerated since the end of the 1990s and lifted financial asset prices on the back of low interest rates. In the Gordon model (Gordon and Shapiro 1956) used also by Caballero, Farhi, and Gourinchas (2017), equity dividends are discounted by the difference between the real interest rate and the dividend growth rate. As monetary policy lowered the real interest rate and dividend growth increased, so did equity prices.

An additional technical consideration is that DSGE models used to estimate the NRI may require household utility functions that are not time separable—that is, utility functions in which risk aversion is not simply the opposite of the elasticity of intertemporal substitution. The two parameters have been estimated in the literature (see Outreville 2014 for a survey of risk aversion estimates and Thimme 2017 for the elasticity of intertemporal substitution). Results vary significantly across studies. Risk aversion estimates range from 55 percent in Mehra and Prescott (1985) to 0–10 percent in Haliassos and Hassapis (2001). Estimates of the elasticity of intertemporal substitution vary from 0.05–2.00 in Hung (1994) to 0.01–0.06 in Chapman (2002). Given the wide range of estimates for these deep parameters, DSGE evidence on the drivers of the decline in the NRI is to be taken with caution, in particular because the models in figure 2 use time-separable functions. To illustrate this fundamental point, using option prices and an Epstein-Zin utility function (Epstein and Zin 1989); Blackburn (2008) finds that *the risk-free rate is affected positively by risk aversion and negatively by the elasticity of intertemporal substitution*. However, Blackburn finds, risk aversion mostly affects the risk premium. It is the elasticity of intertemporal substitution—and not risk aversion—that affects volatility negatively. These results confirm Kandel and Stambaugh's (1991) theoretical model.[51]

Since the ratio of the equity risk premium to the risk-free rate increased from about 1 percent to about 2 percent in 2008, the enduring fall in the NRI estimated using semistructural and DSGE models may result from a rise in the elasticity of intertemporal substitution. This increase may explain the fall in volatility observed in the VIX from 2008 at least until 2017, the

51 Risk aversion is positively associated with the risk-free rate and the risk premium, possibly indicating that households do not optimize a portfolio composed only of a safe asset and a risky asset as assumed in the model, but rather over a large set of assets and consumption.

end of the sample period used by many estimates (e.g., Caballero, Farhi, and Gourinchas 2017). In addition, the increase in the elasticity of intertemporal substitution may be the main driver for the decline in the estimated real rates of interest (real yields). These arguments reinforce the view that monetary policy may affect the NRI as suggested by the writings of Mises as well as Borio, Disyatat, and Rungcharoenkitkul (2017) and other observers in the tradition of Wicksell.

4. The Transmission of US Monetary Policy and Returns on Assets

This section explores the hypothesis that monetary policy may have played an important role in increasing the wedge between the return on safe assets and the return on physical capital. To that end, it uses Korobilis's (2013) time-varying parameter dynamic factor model to study the domestic and international transmission of US monetary policy shocks using a large set of macroeconomic variables, notably those included in the discussion about the possible explanation for the gap between the real return on physical capital and returns on financial assets. As Korobilis's model is well known, and to conserve space, it is not described.

4.1. Data and Data Treatment

The database is from Jordà, Schularick, and Taylor (2017); Chen et al. (2022); and Jordà et al. (2019). The sample period includes annual data from the last four decades (i.e., 1980–2020), during which estimates of the NRI show a declining trend. According to Borio, Disyatat, and Rungcharoenkitkul (2017), this is the only period when the stability in the link between real interest rates and saving-investment determinants that is always assumed in models that estimate the NRI has existed.[52] Data availability justifies the selection of fifteen out of the eighteen countries in the database: Australia, Belgium, Denmark, Finland, France, Germany, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

All nominal variables are deflated by the corresponding consumer price indices. Variables expressed in percent and in ratios to gross domestic product (GDP) are not modified. All asset rates of return are defined in and Jordà et al. (2019) and briefly presented in appendix 4. The risk premium is computed as the difference between the returns on risky and safe assets from and Jordà et al. (2019). In addition, real rates of interest for three-month, one-year and ten-year US government bonds are from FRED, the database maintained by the Federal Reserve Bank of St. Louis. Real effective exchange rates are from the International Financial Statistics dataset of the

52 As mentioned above, Borio, Disyatat, and Rungcharoenkitkul (2017) use a nineteen-country database comprising the period 1870–2016.

International Monetary Fund. Following Mayer and Schnabl (2021), the marginal productivity of real capital is proxied by the change in real GDP relative to the previous year divided by the real investment of the current year, and monetary overhang is defined as the increase of accumulated M1 relative to accumulated nominal GDP with year 1980 = 100. The ratios of the US nondurable and durable consumption to investment goods prices, of nondurable and durable consumption to intermediate goods prices, and of intermediate to investment goods prices are from the Organisation for Economic Co-operation and Development Producer Prices by Production Type database. The NRI time series is the estimate discussed in section 3.

Finally, following the insight—not the methodology—of Miranda-Agrippino and Rey (2020), the common components of the time series of all countries (except the US) are computed using the Forni et al. (2005) one-sided generalized dynamic factor model (GDFM).[53] These common components encapsulate the global forces driving the fourteen-country time series. These time series are the common components of real GDP, Consumer Price Index (CPI) inflation, short- and long-term interest rates, general government revenue and expenditure, general government debt-to-GDP ratios, private domestic credit, total equity return, total government bonds return, total housing return, equity capital gain, government bonds capital gain, housing capital gain, equity dividend return, bonds coupon return, housing rent return, capital or wealth return, risky assets return, safe assets return, banks' capital ratio (leverage), banks' loan-to-deposit ratio, and banks' noncore funding ratio. The policy rate is the Wu-Xia shadow rate (Wu and Xia 2016), which is justified by the main focus of this section—that is, to explore the domestic and global effects of US monetary policy independently of whether it takes a conventional or unconventional form. Appendix 5 contains the list of the eighty-nine time series used in the estimation.

Time-series nonstationarity is eliminated using the ideal band-pass filter (Corbae and Ouliaris 2006) masking periodicities longer than sixteen years, which allows the analysis of business cycles—periodicities between two and eight years—and the financial cycle.[54] This approach avoids ad hoc decisions given the frequent conflicting results for pretests for the degree of integration and, crucially, avoids first-differencing, which is a *high-pass filter* with a gain function "that deviates substantially from the squared gain function of an ideal high-pass filter" (Koopmans 1974).[55]

53 The GDFM common component has been widely used in the literature (e.g., Neely et al. 2014; Szafranek 2021).

54 Drehmann, Borio, and Tsatzaronis (2012) estimate the duration of the financial cycle to be on average sixteen years in a sample covering seven advanced economies, including the US, and spanning the period 1960–2016.

55 Igan et al. (2017) has a detailed discussion.

Several statistical tests are run to determine the number of factors for the model estimation. Stock and Watson's (2005), Bai and Ng's (2007), and Onatski's (2009) procedures suggest two dynamic factors, while Hallin and Liška's (2007) IC_1 procedure suggests one to three dynamic factors. Therefore, two factors are chosen for the estimation. The Bayesian information criterion suggests one lag with two static factors.[56]

4.2. Estimation and Results

Given possible changes in the data-generating process, the time-varying parameter dynamic factor model of Korobilis (2013) is estimated. It allows the investigation of both the potential instability in the coefficients of the VAR and stochastic volatility (as in Primiceri 2005) possibly linked to the GFC and the COVID-19 pandemic. As recently argued by Schlaak, Rieth, and Podstawsky (2023), using both a valid instrument and heteroskedasticity to estimate monetary policy shocks sharpens structural inference, leading to larger effects on production and prices than monetary shocks identified via an instrument only. Given the limited sample length, no training sample is used. Noninformative priors are used for the VAR equation with one lag. The hyperparameter priors are $K(Q) = 0.001$, $K(S) = 0.1$, and $K(W) = 0.5$, where Q denotes shocks to the VAR and S denotes shocks to the systematic part of monetary policy (i.e., shocks that are correlated within each equation). The value for Q is tighter than the one used by Giorgio Primiceri (2005): 0.5 as opposed to 0.01; and the value for S is the same: 0.1.[57] Shocks represented by W are potentially correlated across equations and could therefore affect the monetary policy equation. The main result is that the data provide no evidence of a significant change in the parameters of the model or those determining the distribution of shocks affecting the policy response to inflation and output.

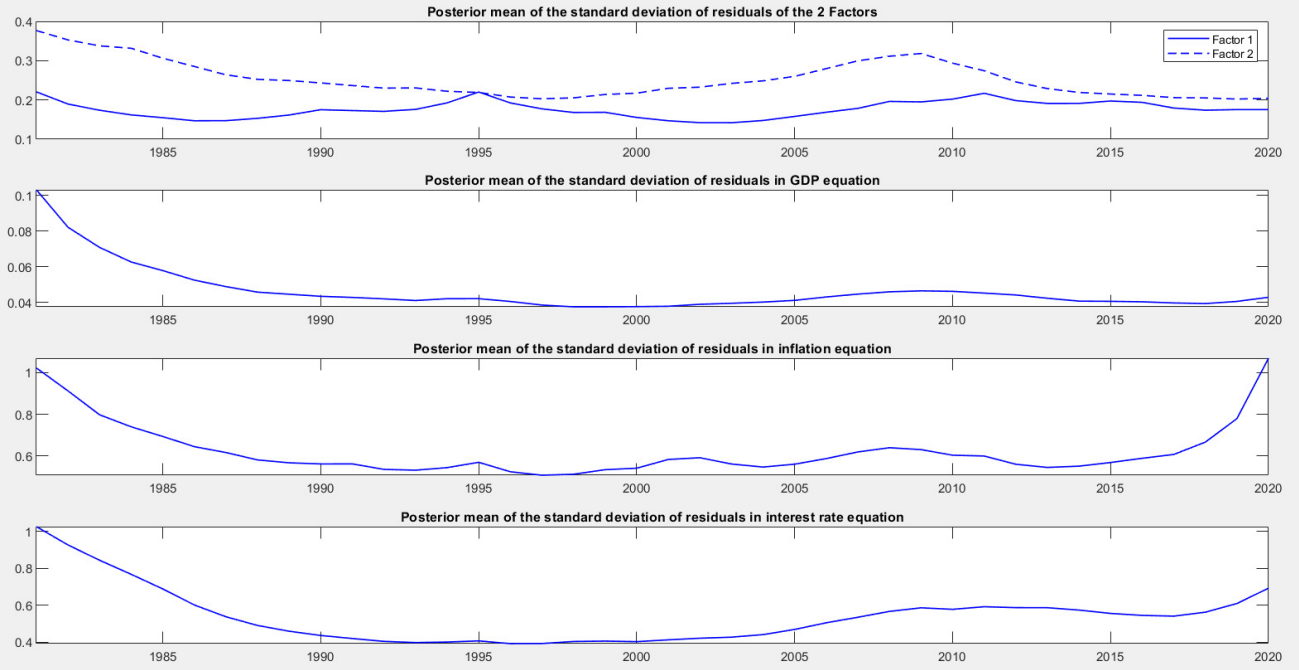
The use of a tighter parameter for Q suggests that accounting for multivariate stochastic volatility is important for capturing possible heteroskedasticity and nonlinearities. This is not surprising given that the sample comprises two major shocks: the GFC and the COVID-19 pandemic. Indeed, figure 5 shows that there are no significant changes in volatility over time except for in the interest rate residuals following the GFC and around the pandemic (bottom graph). The same pattern appears for the inflation equation (third graph), which also shows the weakness in the economy of the United States in 1995 and 2002.

The estimated responses of US monetary policy shocks on US output and inflation for 2008 and 2020 do not differ (figure 6). In both periods, following a one-standard-deviation reduction of the policy rate, real GDP

56 Alessi, Barigozzi, and Capasso (2010) suggest one to four static factors, and Onatski (2010) suggests two static factors.

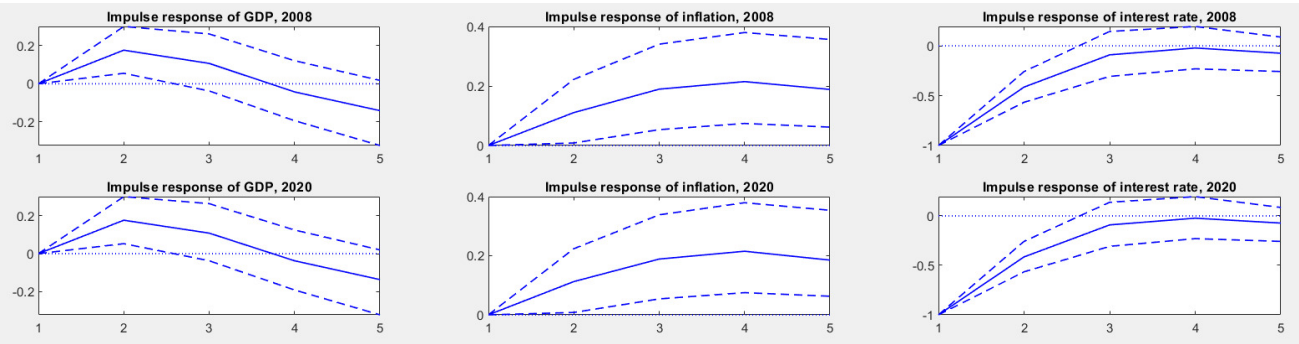
57 For the US, Primiceri (2005) studied 1953Q1–2001Q3, a period before the GFC and the start of unconventional monetary policy.

Figure 5. US stochastic volatility estimates



Note: Time-varying standard deviations of residuals in the time-varying parameters FAVAR model.

Figure 6. Impulse responses of the effects of US monetary policy shocks on domestic output and inflation, 2008 and 2020

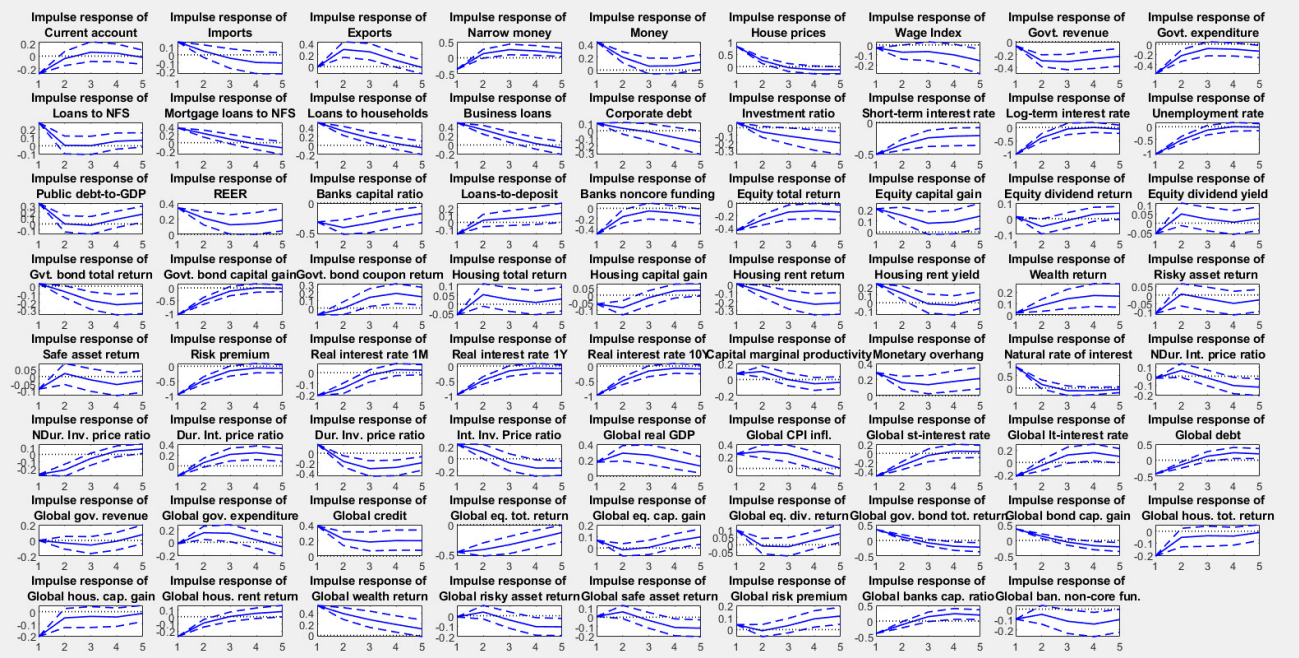


Note: IRFs display the median response and its 16th and 84th percentile confidence intervals over five years.

increases during the first year, with the expansion lasting for three years. Inflation increases during the second year and is more persistent. These results broadly match accepted results in the literature (e.g., B. S. Bernanke 2020; Dou et al. 2020).

All variables are standardized, which facilitates comparability across shocks. All impulse response functions (IRFs) in figure 6 display the median response and its 16th and 84th percentile confidence intervals over five years—the standard length in empirical analysis. Results for US real and nominal variables as well as for global variables accord well with the methodical analysis of the domestic and global dimensions of US monetary policy in Obstfeld (2020) (figure 7).

Figure 7. Impulse responses of the domestic and international effects of US monetary policy shocks, 2008 and 2020



Note: IRFs display the median response and its 16th and 84th percentile confidence intervals over five years. Global variables are the common component of the time series of all countries (except the US) and are computed using the Forni et al. (2005) one-sided GDFM. The estimated responses of US monetary policy shocks on US output and inflation for 2008 and 2020 do not differ.

As shown in figure 7, the accommodative US monetary policy shock lowers both ends of the yield curve, but especially the long end. The monetary policy shock leads to a decline in real interest rates on government bonds at all maturities available in the dataset, but especially at maturities of one and ten years. Domestic private credit to households and nonfinancial corporations increases.[58] Banks experience an expansion in liquidity as their loan-to-deposit ratios decline (the money stock rises) and consistently reduce their recourse to noncore funding sources. There is evidence of a "liquidity preference" shock à la Fisher (2015) as (real) money increases for about two and a half years, and (real) narrow money displays a persistent, albeit small, rise after a short-term decline. Accordingly, the monetary overhang measure remains positive throughout. Banks' capital ratio drops as a result of banks' increase in leverage. Real house prices rise over about one and a half years. The current account balance displays a deficit in the short term, and the real effective exchange rate appreciates. These last results accord well with the Obstfeld and Rogoff (1995) model, in which a large economy such as the

58 There is a vast theoretical and empirical literature since B. S. Bernanke (1983) and B. Bernanke and Gertler (1989) where the concepts of the "external finance premium" and the "financial accelerator" are developed and the importance of the "credit channel" of monetary policy transmission is discussed (e.g., the review by Mishkin 1996). According to Bernanke and Gertler's (1995) original view about the credit channel, in fact the channel is not a freestanding alternative to the traditional channels, but a set of factors that amplify and propagate conventional interest rate effects. Therefore, what matters for this article is that a decline in the cost of external funding as a result of accommodative monetary policy leads liquidity-constrained banks to lend more (a channel often referred to as the "lending channel"). In addition, on the demand side, lower interest rates decrease debt service while raising the present value of collateral and the demand for credit (a channel often referred to as the "balance-sheet channel").

US experiences a real effective exchange rate appreciation following a decline in their policy rate, which generates a global *positive output* effect (via the expenditure-switching channel of monetary policy).

In addition, the IRFs in figure 7 show that the accommodative monetary policy shock produces a decrease in total return on equity and a persistent decline in total return on government bonds. The decrease in total return on equity is not entirely compensated by the highly persistent capital gains, while the dividend yield displays a small reduction.[59] The decline in the total return on government bonds is driven by a persistent and material negative capital loss and a smaller coupon return. Total return on wealth shows a persistent increase. Finally, the accommodative monetary policy shock reduces the return not only on safe assets but also on risky assets, so that the risk premium—the difference between returns on risky and safe assets—declines over about two and a half years. These results are consistent with the hypothesis that accommodative monetary policy has a lasting effect, raising the return on equity relative to that on government bonds via a significant increase in capital gains that more than offsets a small decline in the dividend yield. The decline in the dividend yield matches the decline in the profit rate well.

The IRF of the NRI displayed in figure 7 increases during the first two years and follows a pattern that is similar to the pattern of the marginal productivity of capital (it becomes insignificant after two years).[60] Clearly, the NRI is an aggregate measure for the US. However, according to Mises's originary interest concept and his theory of the business cycle, changes in the NRI need to be linked to changes over time in the relative producer prices of goods at different stages of production. The pattern of relative price changes is captured by the IRFs of five relative prices: the relative prices of durable and nondurable consumption goods compared to intermediate and investment goods, as well as the relative price of intermediate compared to investment goods.[61] Specifically, the price of intermediate goods increases relative to that of durable consumption goods for one and a half years, and the price of investment goods increases relative to that of nondurable consumption goods for two and a half years. These two relative price increases could be interpreted as a decline in Mises's originary interest rate. There is also a rise in the price of durable consumption goods relative to that of investment goods for one and a half years and a rise in the price of intermediate goods relative to that of investment goods for two years. These two relative price changes suggest an increase in Mises's originary interest rate. However, the net effect

59 The database distinguishes between the dividend yield and the dividend return, as the former is deflated by the same year's price level while the latter is deflated by the previous year's price level. So real dividend yields fall somewhat.

60 After 1990, the positive correlation between the NRI computed in this article and the federal funds rate is significant at the 1 percent significance level.

61 Terminology and definitions are from the Organisation for Economic Co-operation and Development Producer Prices database.

of all relative price changes is a clear decline in Mises's originary interest rate (NRI), as the relative price changes that reduce it are 15 percent larger and last longer than the relative price changes that increase it.[62]

As discussed in section 2.3.2, these opposing forces echo Mises's view that there may be no uniform NRI and that one must consider the time structure of capital and not just the time-varying value of the capital stock. Furthermore, the pattern of relative price changes is reminiscent of the Austrian view that more roundabout methods of production imply a higher marginal productivity of capital. In fact, as stated in Mises's business cycle theory, intermediate goods prices rise first and more than durable consumption goods prices; investment goods prices increase more than nondurable goods prices and the increase is more persistent (Mises 1998, 554–58). In addition, intermediate and durable goods prices rise relative to investment goods prices, a characteristic that seems a stylized feature of the data as reported by Karabarbounis and Neiman (2014).[63] Overall, these results are consistent with Mises's suggestion (finally accepted by Wicksell) that following the monetary policy shock there is likely to be a short period of "forced saving" which accompanies the expansion of the production process until the necessary consumption goods are available (i.e., before real savings increase).

Regarding the international transmission of US monetary policy, both global real GDP and global CPI rise (figure 7). Short- and long-term global interest rates drop, and global private credit increases persistently. The response of global asset returns is also similar to that of domestic asset returns. These findings agree with research suggesting the existence of a *global financial cycle* led by the US (e.g., Nadal De Simone and Tongzon 1997; Rey 2013; Dées and Galesi 2019; Miranda-Aggripino and Rey 2020).

Overall, the IRFs support the hypothesis that the wedge between low real yields on US treasuries and the quite stable real return on physical capital is largely attributable to persistently accommodative monetary policy. This does not necessarily exclude the possible contribution from the decline in labor share discussed by Caballero, Farhi, and Gourinchas (2017), but it is inconsistent with their conclusion of an increase in capital risk premia. The results also seem to support Mises's theory of relative price changes during the business cycle.

62 There is no statistically significant change in the relative price of intermediate goods compared to nondurable consumption goods during the first four years. There is a decline in year five.

63 This is not to argue that monetary policy is the driver of the observed fall in the relative price of investment goods, but that it may be also a factor which is not usually taken into consideration.

5. Concluding Remarks and Implications

Recent NRI estimates derived from semistructural, structural, and DSGE models (Brand, Bielecki, and Penalver 2018) based on the investment-saving curve, the Phillips curve, and a monetary policy equation assume that investment equals savings in every period, that monetary policy does not affect the NRI, that investment misallocations do not disturb potential output or savings, and that money, even though endogenous as in Wicksell's pure credit economy, is neutral in the long run. With no persistent saving-investment imbalances, a positive gap between Wicksell's NRI—not Woodford's interpretation of Wicksell's NRI—and the loan market interest rate is excluded by assumption, and the capital market may be decoupled from the real economy.

However, if saving is not equal to investment, this may explain the positive gap between the return on securities and the return on physical real capital. Interpreting Wicksell's NRI in a manner consistent with his writings, considering the outcome of Wicksell's disagreement with Mises, and considering the latter's business cycle theory all lead to a plausible explanation of the observed wedge between asset price returns and the return on real capital. Capital formation through forced saving, together with Mises's dynamic analysis of the business cycle, provide a consistent narrative to possibly explain the discrepancy between the NRI and yields. They also explain how monetary policy could affect the NRI through the time-varying and uneven impact that a credit expansion may have on the distribution of income and wealth.

If monetary policy has lowered the NRI (Mises's concept of the NRI), it may have perpetuated low real rates, as suggested by Borio, Disyatat, and Rungcharoenkitkul (2017, 2019), Levrero (2021), Mayer and Schnabl (2021) and others. Low and negative policy rates together with quantitative easing since 2009, especially intermediated by banks, may have exacerbated the downward pressure on the NRI by reducing returns on US government bonds, and increasing equity capital gains, two of the three stylized features identified by Caballero, Farhi, and Gourinchas (2017). At the same time, these policies may have delayed the adjustment process required for real yields and the NRI to converge on a new equilibrium.

Woodford-style models are not adequate to represent Wicksell's NRI concept or to consider the possibility that monetary policy may affect the NRI. Using these models to guide monetary policy may lead to a stance that is inconsistent with price stability. Both these models' neglect of the possibility that monetary policy could persistently alter the time dimension of the capital stock, leading to investment misallocation, and their assumption of complete financial markets make them unsatisfactory for addressing concerns

stemming from the interaction of the financial sector and the real economy. In particular, Woodford-style models are inadequate to address the interaction between financial stability and price stability.[64]

All these concerns require useful and not just elegant models. As this article suggests, such models need to include the financial sector explicitly and to recognize that financial markets need not be complete. Moreover, the probability of default should be able to diverge from zero under certain states of the economy; "excessive" maturity transformation must be a distinct possibility; and the interplay between leverage and asset prices should be relevant not just for the value of firms, but also for the transmission of monetary policy. Inefficient equilibria could occur in these settings, which would justify policy intervention with potential welfare-enhancing effects.

If Woodford (2003) had the undesirable result of misrepresenting Wicksell's views on the NRI and throwing confusion into the areas discussed in this article, it also returned attention to the profound work of Wicksell and the comprehensive analysis of Mises, perhaps leading the profession to revisit paradigms such as the long-run neutrality of money and the Cambridge capital controversy. Such positive outcomes could improve current economic models.

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64 Jonung (2022) discusses how to modify modern inflation targeting frameworks to address financial stability concerns within the Wicksellian tradition.

REFERENCES

Ajevskis, Viktors. 2018. "The Natural Rate of Interest: Information Derived from a Shadow Rate Model." Working Paper 2/2018, Latvijas Banka, Riga, Latvia. https://www.bank.lv/images/stories/pielikumi/publikacijas/petijumi/wp_2_2018_en.pdf.

Alessi, Lucia, Matteo Barigozzi, and Marco Capasso. 2010. "Improving Penalization When Determining the Number of Factors in Approximate Static Factor Models." *Statistics and Probability Letters* 80 (23–24): 1806–13. https://doi.org/10.1016/j.spl.2010.08.005.

Amato, Jeffrey D. 2005. "The Role of the Natural Rate of Interest in Monetary Policy." BIS Working Papers 171, Bank for International Settlements, Basel, March 1. https://doi.org/10.2139/ssrn.699221.

Ampudia, Miguel, Marco Lo Duca, Mátyás Farkas, Gabriel Pérez-Quirós, Mara Pirovano, Gerard Rünstler, and Eugen Tereanu. 2021. "On the Effectiveness of Macroprudential Policy." ECB Working Paper Series 2559, European Central Bank, Frankfurt, May. https://doi.org/10.2139/ssrn.3855931.

Bai, Jushan, and Serena Ng. 2007. "Determining the Number of Primitive Shocks in Factor Models." *Journal of Business and Economic Statistics* 25 (1): 52–60. https://doi.org/10.1198/073500106000000413.

Bellofiore, Ricardo. 1998. "Between Wicksell and Hayek: Mises's Theory of Money and Credit Revisited." *American Journal of Economics and Sociology* 57 (4): 531–78. https://doi.org/10.1111/j.1536-7150.1998.tb03380.x.

Bernanke, Ben, and Mark Gertler. 1989. "Agency Costs, Net Worth, and Business Fluctuations." *American Economic Review* 79 (1): 14–31. https://www.jstor.org/stable/1804770.

Bernanke, Ben S. 1983. "Nonmonetary Effects of the Financial Crisis in the Propagation of the Great Depression." *American Economic Review* 73 (3): 257–76. https://www.jstor.org/stable/1808111.

———. 2020. "The New Tools of Monetary Policy." *American Economic Review* 110 (4): 943–83. https://doi.org/10.1257/aer.110.4.943.

Bernanke, Ben S., and Mark Gertler. 1995. "Inside the Black Box: The Credit Channel of Monetary Policy Transmission." *Journal of Economic Perspectives* 27 (4): 27–48. https://doi.org/10.1257/jep.9.4.27.

Blackburn, Douglas W. 2008. "Option Implied Risk Aversion and Elasticity of Intertemporal Substitution." Unpublished paper, May 15. https://doi.org/10.2139/ssrn.927440.

Böhm-Bawerk, Eugen von. 1884. *Geschichte und Kritik der Kapitalzins-Theorieen*. Innsbruck. https://archive.org/details/kapitalundkapit00bhgoog/page/n6/mode/2up.

———. 1889. *Positive Theorie des Kapitals*. Innsbruck.

Boianovsky, Mauro. 1995. "Wicksell's Business Cycle." *European Journal of the History of Economic Thought* 2 (2): 375–411. https://doi.org/10.1080/09672569508538575.

———. 2006. "Woodford's Interest and Prices from the Perspective of the History and Methodology of Economic Thought: A Mini-Symposium." *Journal of the History of Economic Thought* 28 (2): 139–42. https://doi.org/10.1080/10427710600676223.

Boianovsky, Mauro, and Hans-Michael Trautwein. 2001. "Wicksell's Lecture Notes on Economic Crises (1902/05)." *Structural Change and Economic Dynamics* 12 (3): 343–66. https://doi.org/10.1016/S0954-349X(01)00026-1.

———. 2004. "Haberler, the League of Nations, and the Quest for Consensus in Business Cycle Theory in the 1930s." *History of Political Economy* 38 (1): 45–89. https://doi.org/10.1215/00182702-38-1-45.

———. 2006. "Wicksell after Woodford." *Journal of the History of Economic Thought* 28 (2): 171–85. https://doi.org/10.1080/10427710600676447.

Borio, Claudio. 2014. "The Financial Cycle and Macroeconomics: What Have We Learnt?" *Journal of Banking and Finance* 45:182–98. https://doi.org/10.1016/j.jbankfin.2013.07.031.

Borio, Claudio, Piti Disyatat, and Phurichai Rungcharoenkitkul. 2017. "Why So Low for So Long? A Long-Term View of Real Interest Rates." BIS Working Papers 685, Bank for International Settlements, Basel. https://doi.org/10.2139/ssrn.3092149.

———. 2019. "What Anchors for the Natural Rate of Interest?" BIS Working Papers 777, Bank for International Settlements, Basel.

Brand, Klaus, Marcin Bielecki, and Adrian Penalver, eds. 2018. "The Natural Rate of Interest: Estimates, Drivers, and Challenges to Monetary Policy." Occasional Papers 217, European Central Bank, Frankfurt. https://doi.org/10.2139/ssrn.3328536.

Brand, Klaus, and Falk Mazelis. 2019. "Taylor-Rule Consistent Estimates of the Natural Rate of Interest." ECB Working Paper Series 2257, European Central Bank, Frankfurt. https://doi.org/10.2139/ssrn.3361496.

Brunnermeier, Markus, Thomas Eisenbach, and Yuliy Sannikov. 2013. "Macroeconomics with Financial Frictions: A Survey." In *Advances in Economics and Econometrics II*, edited by Daron Acemoglu, Manuel Arellano, and Eddie Dekel, 4–94. New York: Cambridge University Press. https://doi.org/10.1017/CBO9781139060028.002.

Caballero, Ricardo J., Emmanuel Farhi, and Pierre-Olivier Gourinchas. 2017. "Rents, Technical Change, and Risk Premia Accounting for Secular Trends in Interest Rates, Returns on Capital, Earning Yields, and Factor Shares." *American Economic Review* 107 (5): 614–20. https://doi.org/10.1257/aer.p20171036.

Carvalho, Carlos, Andrea Ferrero, and Fernanda Nechio. 2016. "Demographics and Real Interest Rates: Inspecting the Mechanism." *European Economic Review* 88:208–26. https://doi.org/10.1016/j.euroecorev.2016.04.002.

Cerutti, Eugenio, Stijn Claessens, and Luc Laeven. 2017. "The Use and Effectiveness of Macroprudential Policies: New Evidence." *Journal of Financial Stability* 28:203–24. https://doi.org/10.1016/j.jfs.2015.10.004.

Chapman, David A. 2002. "Does Intrinsic Habit Formation Actually Resolve the Equity Premium Puzzle?" *Review of Economics Dynamics* 5 (3): 618–45. https://doi.org/10.1006/redy.2001.0155.

Chen, Xiaoting, Sherifa Elsherbiny, Ricardo Duque Gabriel, Òscar Jordà, Chi Hyun Kim, Moritz Schularick, and Alan M. Taylor. 2022. *Documentation on the JST Database Update 2016–2020*, 6th Release, July 2022. Berlin: MacroFinance and MacroHistory Lab, Kiel Institute for the World Economy. https://www.macrohistory.net/database/.

Corbae, Dean, and Sam Ouliaris. 2006. "Extracting Cycles from Nonstationary Data." In *Econometric Theory and Practice: Frontiers of Analysis and Applied Research*, edited by Dean Corbae, Steven N. Durlauf, and Bruce E. Hansen. New York: Cambridge University Press. https://doi.org/10.1017/CBO9781139164863.008.

Davidson, David. 1909. "Om stabiliseringen af penningens värde" [Concerning stabilization of the value of money]. *Ekonomisk Tidskrift* 11 (1): 1–25. https://doi.org/10.2307/3437779.

De Fiore, Fiorella, and Oreste Tristani. 2011. "Credit and the Natural Rate of Interest." *Journal of Money, Credit and Banking* 43 (2–3): 407–40. https://doi.org/10.1111/j.1538-4616.2010.00379.x.

Dées, Stéphane, and Alessandro Galesi. 2019. "The Global Financial Cycle and US Monetary Policy in an Interconnected World." Banque de France Working Paper 744, Banque de France, Paris. https://doi.org/10.2139/ssrn.3507497.

Del Vecchio, Gustavo. 1917. "Questioni fondamentali sul valore della moneta." *Giornale degli economisti e rivista di statistica*, 3rd ser. 55 (3): 117–74. https://www.jstor.org/stable/23225467.

Dempsey, Bernard W. 1943. *Interest and Usury*. Washington, D.C.: American Council on Public Affairs.

Dou, Winston W., Andrew W. Lo, Ameya Muley, and Harald Uhlig. 2020. "Macroeconomic Models for Monetary Policy: A Critical Review from a Finance Perspective." *Annual Review of Financial Economics* 12:95–140. https://doi.org/10.1146/annurev-financial-012820-025928.

Drehmann, Mathias, Claudio Borio, and Kostas Tsatzaronis. 2012. "Characterising the Financial Cycle: Don't Lose Sight of the Medium Term!" BIS Working Paper 380, Bank for International Settlements, Basel.

Epstein, Larry G., and Stanley E. Zin. 1989. "Substitution, Risk Aversion, and the Temporal Behavior of Consumption and Asset Returns: A Theoretical Framework." *Econometrica* 57 (4): 937–69. https://doi.org/10.2307/1913778.

ESRB (European Systemic Risk Board). 2022. *Vulnerabilities in the Real Estate Sector in the EEA Countries*. Frankfurt: ESRB. https://www.esrb.europa.eu/pub/pdf/reports/esrb.report220211_vulnerabilities_eea_countries~27e571112b.en.pdf.

Farhi, Emmanuel, and Jean Tirole. 2012. "Collective Moral Hazard, Maturity Mismatch, and Systemic Bailouts." *American Economic Review* 102 (1): 60–93. https://doi.org/10.1257/aer.102.1.60.

Festré, Agnès. 2006. "Knut Wicksell and Ludwig von Mises on Money, Interest, and Price Dynamics." *Journal of the History of Economic Thought* 28 (3): 333–57. https://doi.org/10.1080/10427710600857856.

Fiorentini, Gabriele, Alessandro Galesi, Gabriel Pérez-Quirós, and Enrique Sentana. 2018. "The Rise and Fall of the Natural Interest Rate." Documentos de Trabajo 1822, Banco de España, Madrid. https://doi.org/10.2139/ssrn.3210707.

Fisher, Jonas D. M. 2015. "On the Structural Interpretation of the Smets-Wouters 'Risk Premium Shock.'" *Journal of Money, Credit and Banking* 47 (2–3): 511–16.

Fontana, Giuseppe. 2007. "Why Money Matters: Wicksell, Keynes, and the New Consensus View on Monetary Policy." *Journal of Post Keynesian Economics* 30 (1): 43–60. https://doi.org/10.2753/PKE0160-3477300102.

Fontana, Giuseppe, and Riccardo Realfonzo. 2005. *Monetary Theories of Production*. London: Palgrave Macmillan. https://doi.org/10.1057/9780230523074.

Forni, Mario, Mark Hallin, Marco Lippi, and Lucrezia Reichlin. 2005. "The Generalized Dynamic Factor Model: One-Sided Estimation and Forecasting." *Journal of the American Statistical Association* 100 (471): 830–40. https://doi.org/10.1198/016214504000002050.

Friedman, Milton. 1964. "The Monetary Studies of the National Bureau." In *The National Bureau Enters Its Forty-Fifth Year: Forty-Fourth Annual Report: A Record for 1963 and Plans for 1964*, 7–25. New York: National Bureau of Economic Research. https://www.nber.org/books-and-chapters/national-bureau-enters-its-forty-fifth-year.

FSB (Financial Stability Board). 2021. *Promoting Financial Stability: 2021 FSB Annual Report*. Basel: FSB. https://www.fsb.org/2021/10/2021-fsb-annual-report/.

Galí, Jordi, and Tomasso Monacelli. 2008. "Optimal Monetary and Fiscal Policy in a Currency Union." *Journal of International Economics* 76 (1): 116–32. https://doi.org/10.1016/j.jinteco.2008.02.007.

Garnier, Julien, and Bjørn-Roger Wilhelmsen. 2005. "The Natural Real Interest Rate and the Output Gap in the Euro Area—a Joint Estimation." ECB Working Paper Series 546, European Central Bank, Frankfurt. https://doi.org/10.2139/ssrn.836428.

Garrison, Roger W. 2004. "Overconsumption and Forced Saving in the Mises-Hayek Theory of the Business Cycle." *History of Political Economy* 36 (2): 323–49. https://doi.org/10.1215/00182702-36-2-323.

———. 2006. "Natural and Neutral Rates of Interest in Theory and Policy Formulation." *Quarterly Journal of Austrian Economics* 9 (4): 57–68. https://doi.org/10.1007/s12113-006-1024-y.

Gertler, Marc, Simon Gilchrist, and Fabio M. Natalucci. 2007. "External Constraints on Monetary Policy and the Financial Accelerator." *Journal of Money, Credit and Banking* 39 (2–3): 295–330.

Gordon, Myron, and Eli Shapiro. 1956. "Capital Equipment Analysis: The Required Rate of Profit." *Management Science* 3 (1): 102–10. https://doi.org/10.1287/mnsc.3.1.102.

Guerrieri, Veronica, Michala Marcussen, Lucrezia Reichlin, and Silvana Tenreyro. 2023. *Geneva 26: The Art and Science of Patience—Relative Prices and Inflation*. London: CEPR Press. https://cepr.org/publications/books-and-reports/geneva-26-art-and-science-patience-relative-prices-and-inflation.

Haavio, Markus, Michel Juillard, and Julien Matheron. 2017. "Natural Rate of Interest in the Euro Area: A DSGE Framework with Financial Frictions." Banque de France Draft Paper, Banque de France, Paris.

Hahn, Frank. 1973. "On Transactions Costs, Inessential Sequence Economies and Money." *Review of Economic Studies* 40 (4): 449–61. https://doi.org/10.2307/2296580.

Haliassos, Michael, and Christis Hassapis. 2001. "Non-Expected Utility, Saving, and Portfolios." *Economic Journal* 111 (468): 69–102. https://doi.org/10.1111/1468-0297.00589.

Hallin, Marc, and Roman Liška. 2007. "Determining the Number of Factors in the General Dynamic Factor Model." *Journal of the American Statistical Association* 102 (478): 603–17. https://doi.org/10.1198/016214506000001275.

Hayek, Friedrich A. 1935. *Prices and Production*. 2nd ed. London: George Routledge and Sons. https://archive.org/details/in.ernet.dli.2015.224105.

Hicks, John. 1967. *Critical Essays in Monetary Theory*. Oxford: Clarendon Press.

Hlédik, Tibor, and Jan Vlček. 2018. "Quantifying the Natural Rate of Interest in a Small Open Economy." CNB Working Paper Series 7/2018, Czech National Bank, Prague.

Holston, Kathryn, Thomas Laubach, and John C. Williams. 2017. "Measuring the Natural Rate of Interest: International Trends and Determinants." In "39th Annual NBER International Seminar on Macroeconomics," edited by Michael B. Devereux. Special issue and supplement, *Journal of International Economics* 108 (S1): S59–75. https://doi.org/10.1016/j.jinteco.2017.01.004.

Hung, Mao-Wei. 1994. "The Interaction between Nonexpected Utility and Asymmetric Market Fundamentals." *Journal of Finance* 49 (1): 325–43. https://doi.org/10.1111/j.1540-6261.1994.tb04433.x.

Igan, Denns, Alain Kabundi, Francisco Nadal De Simone, and Natalia Tamirisa. 2017. "Monetary Policy and Balance Sheets." *Journal of Policy Modeling* 39 (1): 169–84. https://doi.org/10.1016/j.jpolmod.2016.09.003.

Jarocinski, Marek. 2017. "VAR-Based Estimation of the Euro Area Natural Rate of Interest." ECB Draft Paper, European Central Bank, Frankfurt.

Jonung, Lars. 2022. "The Problems of Inflation Targeting Originate in the Monetary Theory of Knut Wicksell." Working Paper 2022:8, Lund University, School of Economics and Management, Department of Economics, Lund, Swdn. https://www.econstor.eu/bitstream/10419/260347/1/wp2022-008.pdf.

Jordà, Òscar, Katharina Knoll, Dmitry Kuvshinov, Moritz Schularick, and Alan M. Taylor. 2019. "The Rate of Return on Everything, 1870–2015." *Quarterly Journal of Economics* 134 (3): 1225–98. https://doi.org/10.1093/qje/qjz012.

Jordà, Òscar, Moritz Schularick, and Alan M. Taylor. 2017. "Macrofinancial History and the New Business Cycle Facts." In *NBER Macroeconomics Annual 2016*, volume 31, edited by Martin Eichenbaum and Jonathan A. Parker. Chicago: University of Chicago Press. https://doi.org/10.1086/690241.

Kandel, Shmuel, and Robert Stambaugh. 1991. "Asset Returns and Intertemporal Preferences." *Journal of Monetary Economics* 27 (1): 39–71. https://doi.org/10.1016/0304-3932(91)90004-8.

Kaplan, Greg, Benjamin Moll, and Giovanni L. Violante. 2018. "Monetary Policy According to HANK." *American Economic Review* 108 (3): 697–743. https://doi.org/10.1257/aer.20160042.

Karabarbounis, Lukas, and Brent Neiman. 2014. "The Global Decline of the Labor Share." *Quarterly Journal of Economics* 129 (1): 61–103. https://doi.org/10.1093/qje/qjt032.

Koopmans, Lambert H. 1974. *The Spectral Analysis of Time Series*. New York: Academic Press.

Korobilis, Dimitris. 2013. "Assessing the Transmission of Monetary Policy Shocks Using Dynamic Factor Models." *Oxford Bulletin of Economics and Statistics* 75 (2): 157–79. https://doi.org/10.1111/j.1468-0084.2011.00687.x.

Krustev, Georgi. 2018. "The Natural Rate of Interest and the Financial Cycle." ECB Working Paper Series 2168, European Central Bank, Frankfurt. https://doi.org/10.2139/ssrn.3212674.

Kydland, Finn E., and Edward C. Prescott. 1982. "Time to Build and Aggregate Fluctuations." *Econometrica* 50 (6): 1345–70. https://doi.org/10.2307/1913386.

Laidler, David. 2006. "Woodford and Wicksell on Interest and Prices: The Place of the Pure Credit Economy in the Theory of Monetary Policy." *Journal of the History of Economic Thought* 28 (2): 151–59. https://doi.org/10.1080/10427710600719817.

———. 2011. "The Monetary Economy and the Economic Crisis." CHOPE Working Paper 2011/04, Center for the History of Political Economy, Duke University, Durham, N.C. https://hope.econ.duke.edu/sites/hope.econ.duke.edu/files/SantiagoDuke.pdf.

Leijonhufvud, Axel. 1981. *Information and Coordination: Essays in Macroeconomic Theory*. New York: Oxford University Press.

Levrero, Enrico Sergio. 2021. "Estimates of the Natural Rate of Interest and the Stance of Monetary Policies: A Critical Assessment." *International Journal of Political Economy* 50 (1): 5–27. https://doi.org/10.1080/08911916.2021.1894829.

Lindahl, Erik. 1939. *Studies in the Theory of Money and Capital*. New York: Rinehart.

———, ed. 1958. *Selected Papers on Economic Theory*. London: George Allen and Unwin.

Ljungqvist, Lars, and Thomas J. Sargent. 2018. *Recursive Macroeconomic Theory*. 4th ed. Cambridge, Mass.: MIT Press.

Macovei, Mihai. 2021. "The Case against the New 'Secular Stagnation Hypothesis.'" *Quarterly Journal of Austrian Economics* 24 (2): 219–53. https://doi.org/10.35297/qjae.010099.

Mayer, Thomas, and Gunther Schnabl. 2021. "COVID-19 and the Euthanasia of Interest Rates: A Critical Assessment of Central Bank Policy in Recent Times." *Journal of Policy Modeling* 43 (6): 1241–58. https://doi.org/10.1016/j.jpolmod.2021.04.004.

Mazzocchi, Ronny. 2013. "Investment-Saving Imbalances with Endogenous Capital Stock." DEM Discussion Papers 114. Università degli Studi di Trento. https://doi.org/10.2139/ssrn.2416407.

McCallum, Bennett. 2003. "Monetary Policy in Economies with Little or No Money." NBER Working Paper 9838, National Bureau of Economic Research, Cambridge, Mass. https://doi.org/10.3386/w9838.

Mehra, Rajnish, and Edward C. Prescott. 1985. "The Equity Premium: A Puzzle." *Journal of Monetary Economics* 15 (2): 145–61. https://doi.org/10.1016/0304-3932(85)90061-3.

Miranda-Aggripino, Silvia, and Hélène Rey. 2020. "U.S. Monetary Policy and the Global Financial Cycle." *Review of Economic Studies* 87 (6): 2754–76. https://doi.org/10.1093/restud/rdaa019.

Mises, Ludwig von. 1981. *The Theory of Money and Credit*. Translated by H. E. Batson. Indianapolis, Ind.: Liberty Fund. https://oll.libertyfund.org/titles/mises-the-theory-of-money-and-credit.

———. 1998. *Human Action: A Treatise on Economics*. Scholar's ed. Auburn, Ala.: Ludwig von Mises Institute. https://mises.org/library/book/human-action.

Mishkin, Frederic S. 1996. "The Channels of Monetary Transmission: Lessons for Monetary Policy." *Banque de France Bulletin Digest* 27:33–44. https://doi.org/10.3386/w5464.

Myrdal, Gunnar. 1939. *Monetary Equilibrium*. London: W. Hodge.

Nadal De Simone, Francisco. 2024. "The Transmission of U.S. Monetary Policy to Small Open Economies." *Journal of International Money and Finance* 142:13038. https://doi.org/10.1016/j.jimonfin.2024.103038.

Nadal De Simone, Francisco, and José Tongzon. 1997. "Is There a Business Cycle in Singapore? Is There a Singaporean Business Cycle?" *Atlantic Economic Journal* 25 (1): 60–79. https://doi.org/10.1007/BF02298477.

Natal, Jean-Marc, and Nicolas Stoffels. 2007. "Globalization, Markups and the Natural Rate of Interest." Swiss National Bank Working Papers 2007–14, Swiss National Bank, Zurich, November 1.

Neely, Christopher J., David E. Rapach, Jun Tu, and Guofu Zhou. 2014. "Forecasting the Equity Risk Premium: The Role of Technical Indicators." *Management Science* 60 (7): 1772–91. https://doi.org/10.1287/mnsc.2013.1838.

Neri, Stefano, and Andrea Gerali. 2019. "Natural Rates across the Atlantic." *Journal of Macroeconomics* 62:103019. https://doi.org/10.1016/j.jmacro.2018.04.007.

Obstfeld, Maurice. 2020. "Global Dimensions of U.S. Monetary Policy." *International Journal of Central Banking* 16 (1): 73–132. https://www.ijcb.org/journal/ijcb2002_2.pdf.

Obstfeld, Maurice, and Kenneth Rogoff. 1995. "Exchange Rate Dynamics Redux." *Journal of Political Economy* 103 (3): 624–60. https://doi.org/10.1086/261997.

Onatski, Alexei. 2009. "Testing Hypotheses about the Number of Factors in Large Factor Models." *Econometrica* 77 (5): 1447–79. https://doi.org/10.3982/ECTA6964.

———. 2010. "Determining the Number of Factors from Empirical Distribution of Eigenvalues." *Review of Economics and Statistics* 92 (4): 1004–16. https://doi.org/10.1162/REST_a_00043.

Outreville, J. Francois. 2014. "Risk Aversion, Risk Behavior, and Demand for Insurance: A Survey." *Journal of Insurance Issues* 37 (2): 138–56.

Patinkin, Don. 1965. *Money, Interest, and Prices: An Integration of Monetary and Value Theory*. 2nd ed. New York: Harper and Row.

Primiceri, Giorgio. 2005. "Time Varying Structural Vector Autoregressions and Monetary Policy." *Review of Economic Studies* 5 (3): 821–52. https://doi.org/10.1111/j.1467-937X.2005.00353.x.

Ramsey, F. P. 1928. "A Mathematical Theory of Saving." *Economic Journal* 38 (152): 543–59. https://doi.org/10.2307/2224098.

Rey, Hélène. 2013. "Dilemma Not Trilemma: The Global Financial Cycle and Monetary Policy Independence." Paper presented at the Economic Policy Symposium, Federal Reserve Bank of Kansas City, Mo., August 21–23.

Rogers, C. Paul. 2006. "Doing without Money: A Critical Assessment of Woodford's Analysis." *Cambridge Journal of Economics* 30 (2): 293–306. https://doi.org/10.1093/cje/bei060.

Rungcharoenkitkul, Phurichai, Claudio Borio, and Piti Disyatat. 2021. "Monetary Policy Hysteresis and the Financial Cycle." BIS Working Papers 817, Bank for International Settlements, Basel, May 17. https://www.bis.org/publ/work817.htm.

Rungcharoenkitkul, Phurichai, and Fabina Winkler. 2021. "The Natural Rate of Interest through a Hall of Mirrors." BIS Working Papers 974, Bank for International Settlements, Basel.

Samuelson, Paul A. 1966. "A Summing Up." *Quarterly Journal of Economics* 80 (4): 568–83. https://doi.org/10.2307/1882916.

Schlaak, Thore, Malte Rieth, and Maximilian Podstawsky. 2023. "Monetary Policy, External Instruments, and Heteroskedasticity." *Quantitative Economics* 14 (1): 161–200. https://doi.org/10.3982/QE1511.

Silva, Walmir, Herbert Kimura, and Vinicius Amorin Sobreiro. 2017. "An Analysis of the Literature on Systemic Financial Risk: A Survey." *Journal of Financial Stability* 28:91–114. https://doi.org/10.1016/j.jfs.2016.12.004.

Smets, Frank, and Rafael Wouters. 2007. "Shocks and Frictions in the US Business Cycles: A Bayesian DSGE Approach." *American Economic Review* 97 (3): 586–606. https://doi.org/10.1257/aer.97.3.586.

Stock, James H., and Mark W. Watson. 2005. "Implications of Dynamic Factor Models for VAR Analysis." NBER Working Paper 11467, National Bureau of Economic Research, Cambridge, Mass., July. https://www.nber.org/papers/w11467.

Summers, Lawrence H. 2014. "U.S. Economic Prospects: Secular Stagnation, Hysteresis, and the Zero Lower Bound." *Business Economics* 49 (2): 65–73. https://doi.org/10.1057/be.2014.13.

Szafranek, Karol. 2021. "Evidence on Time-Varying Inflation Synchronization." *Economic Modelling* 94:1–13. https://doi.org/10.1016/j.econmod.2020.09.013.

Tamborini, Roberto. 2006. "Back to Wicksell? In Search of the Foundations of Practical Monetary Policy." Discussion Paper 2, Università degli Studi di Trento. https://doi.org/10.2139/ssrn.932978.

Tamborini, Roberto, Ronny Mazzocchi, and Hans-Michael Trautwein. 2014. "Wicksell, Keynes, and the New Neoclassical Synthesis: What Can We Learn for Monetary Policy?" *Economic Notes* 43 (2): 79–114.

Thimme, Julian. 2017. "Intertemporal Substitution in Consumption: A Literature Review." *Journal of Economic Surveys* 31 (1): 226–57. https://doi.org/10.1111/joes.12142.

Thomas, Brinley. 1935. "The Monetary Doctrines of Professor Davidson." *Economic Journal* 45 (177): 36–50. https://doi.org/10.2307/2224578.

Trautwein, Hans-Michael. 1997. "The Uses of the Pure Credit Economy." In *Money, Financial Institutions and Macroeconomics*, edited by Avi Cohen, Harald Hagemann, and John Smithin, 3–16. Boston: Kluwer. https://doi.org/10.1007/978-94-011-5362-1_1.

———. 2011. "From Austrian Economics to the Swedish Welfare State: Wicksellian Views on Money and Income Distribution." *Cahiers d'économie politique* 2 (61): 51–90.

———. 2020. "Leijonhufvud on New Keynesian Economics and the Economics of Keynes." *Oxford Economic Papers* 72 (4): 923–45. https://doi.org/10.1093/oep/gpaa013.

Uhr, Carl G. 1960. *Economic Doctrines of Knut Wicksell*. Berkeley: University of California Press. https://doi.org/10.1525/9780520408029.

Wicksell, Knut. 1934. *Lectures on Political Economy.* Vol. 1, *General Theory*. Edited by Lionel Robbins. Translated by E. Classen. London: Macmillan. https://archive.org/details/lecturesonpoliti0001knut/mode/2up.

———. 1935. *Lectures on Political Economy.* Vol. 2, Money. Edited by Lionel Robbins. London: Routledge and Kegan Paul. https://archive.org/details/lecturesonpoliti0002wick/page/n7/mode/2up.

———. 1936. *Interest and Prices (Geldzins und Güterpreise): A Study of the Causes Regulating the Value of Money*. Translated by R. F. Kahn. London: Macmillan. https://archive.org/details/interestandprice033322mbp/page/n5/mode/2up.

———. 1999. "The Money Rate of Interest and Commodity Prices." In *Knut Wicksell: Selected Essays in Economics*, edited by Bo Sandelin, 2:40–45. New York: Routledge.

Woodford, Michael. 2003. *Interest and Prices: Foundations of a Theory of Monetary Policy*. Princeton, N.J.: Princeton University Press. https://doi.org/10.1515/9781400830169.

Wray, L. Randall. 1990. *Money and Credit in Capitalist Economies: The Endogenous Money Approach*. Aldershot, U.K.: Edward Elgar.

Wu, Jin Cynthia, and Fan Dora Xia. 2016. "Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound." *Journal of Money, Credit and Banking* 48 (2–3): 253–91.

Appendices

Appendix 1: The Core of the New Keynesian Framework

This appendix presents the well-known core of the New Keynesian framework for a closed economy. It has three basic equations. First, the dynamic IS equation explains the current output gap as a function of next period expected output gap, which is decreased by the difference between the real interest rate and the NRI. Conventionally, the output gap is the difference between current output and the potential output of the economy. Potential or natural output and the NRI are the values that those variables would take in equilibrium if prices were fully flexible. Formally,

$$\widehat{y_t} = E_t\left(\widehat{y_{t+1}}\right) - \alpha\left[i_t - E_t\left(\pi_{t+1}\right) - r^*\right],$$

where $\widehat{y_t}$ is the output gap at time t, E_t is the mathematical expectation based on the information matrix at time t, i_t is the nominal rate, $E_t\left(\pi_{t+1}\right)$ is the mathematical expectation of inflation π at period $t + 1$ based on the information matrix at time t, and r^* is the NRI.

The second equation is the New Keynesian Phillips curve. This states that current inflation depends on expected inflation in the next period and on the output gap. It can be written as

$$\pi_t = \beta E_t\left(\pi_{t+1}\right) + \mu\widehat{y_t},$$

where β is the economic agent's discount rate.

The final equation is an interest rate rule linking the market nominal interest rate to the implementation of monetary policy. It is normally a Taylor-type rule in which nominal interest rates traditionally rise and fall based on current inflation rate and detrended output; monetary policy at a given point in time can be tighter or looser than the historical pattern. Formally,

$$i_t = \gamma_\pi \pi_t + \gamma_{y_t}\dot{y}_t + v_t,$$

where $\dot{y}_t$ refers to the deviation of output from its steady state and v_t is an exogenous stochastic process representing a monetary policy shock.

Appendix 2: The NRI in Wicksell, Main Differences with Mises, and the NRI in Woodford and Woodford-Style Models

Table A1. Shared features of the three NRI definitions

Conceptual common features	Empirical common features
It is consistent with equilibrium between savings in natura and investment. It is a time-varying, long-run concept. The price level (inflation) is a measure of the investment-savings imbalance.	It is a conceptual reference point—an equilibrium rather than a measurable parameter.

Table A2. Main differences between Wicksell and Mises

Wicksell originally excluded from his cumulative process the possibility of capital accumulation through "forced saving" and postulated the lack of interdependence between the market rate of interest and the NRI.
Wicksell (1934, 207--18) admitted later that the market rate of interest and the NRI are interdependent and that "forced saving" could reduce the real rate of interest, prolonging the upward movement of prices, but admitted he could not contribute to a dynamic analysis.
Wicksell and Mises agreed that the NRI is time varying, but Mises rejected Wicksell's concept of a "barter" NRI and a unique NRI.
The relevant benchmark is no longer the barter NRI but the market rate that would prevail in the absence of credit expansion.
Mises built on the rates adjustment lag of Wicksell and focused on relative price changes in the time structure of capital to build his theory of the business cycle.
Like Wicksell, Mises changed his concept of the interest rate. He developed the concept of "originary interest" (i.e., the discount of future goods against present goods) in *Human Action* (1949).
For Mises, Wicksell's NRI coincides with the market rate of interest only in the stationary state of Wicksell's pure credit economy because in the stationary state money is neutral and coincides with the households' discount rate (Tamborini, Mazzocchi, and Trautwein 2014).
In a *growing economy*, the originary interest rate can be affected by changes in the economy, such as credit risk, uncertainty, and monetary policy.

Table A3. The NRI in Woodford and Woodford-style models

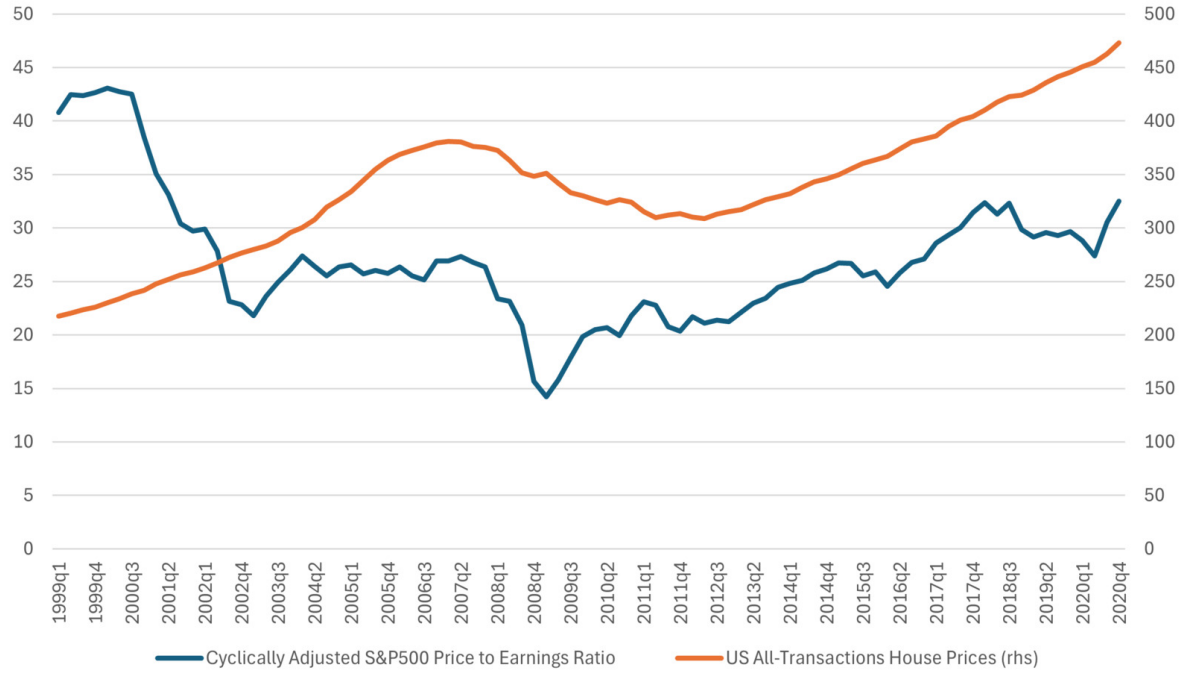
The rate is consistent with output at potential and inflation at its target (Woodford 2003).
It is a function of agents' discount factor and stochastic shocks to labor (Woodford 2003) and the capital stock (e.g., Gertler, Gilchrist, and Natalucci 2007).
In an open economy, it is also dependent on foreign output shocks (e.g., Galí and Monacelli 2008).

Table A4. Differences from Wicksell

The classical dichotomy holds that the economy's real equilibrium can be determined independently of the nominal equilibrium. Equilibrium without reference to a payment system (a perfect barter system) is essentially different from an accounting system of exchange (McCallum 2003).
In Wicksell, the classical dichotomy between money and goods prices does not exist. In Woodford it does.
Wicksell's pure credit economy is not frictionless, while Woodford's complete markets cancel history dependence with respect to idiosyncratic shocks.
In Wicksell's flexible price economy, divergences between the market rate of interest and the NRI at time t produce output and inflation gaps at t and $t + n$.
In Woodford-style and DSGE models, future output gaps depend on future interest rate gaps: there is period-by-period equilibrium.

Appendix 3: S&P 500 Cyclically Adjusted Price-to-Earnings Ratio and US Federal Finance Agency House Price Index

Figure A1. Risky assets: S&P 500 CAPE ratio (left-hand scale) and US FHFA HPI (right-hand scale)



Sources: FRED.

Appendix 4: Asset Returns as Calculated in Jordà et al. (2019)

The total annual return on any financial asset has two components: the capital gain from the change in the asset price *P*; and the yield component *Y*, which reflects the cash-flow return on an investment. The total nominal return *R* for asset *j* in country *i* at time *t* is

$$R_{i,t}^{j} = \frac{P_{i,t}^{j} - P_{i,t-1}^{j}}{P_{i,t-1}^{j}} + Y_{i,t}^{j}.$$

For safe assets, Jordà et al. (2019) assume that total public debt is divided equally into bonds and bills since there are no data on their market shares. So the safe asset return is computed as

$$R_{i,t}^{safe} = \frac{R_{i,t}^{bill} - R_{i,t}^{bond}}{2}.$$

The risky asset return is calculated as a weighted average of the returns on equity and on housing. The weights *w* represent the share of asset holdings of equity and of housing stocks in the respective country *i* and year *t*, scaled to add up to 1. Risky asset returns are calculated using stock market capitalization and housing wealth:

$$R_{i,t}^{risky} = R_{i,t}^{equity} w_{i,t}^{equity} + R_{i,t}^{housing} w_{i,t}^{housing}.$$

The return on wealth is a weighted average of returns on risky assets (equity and housing) and safe assets (bonds and bills). The weights w here are the asset holdings of risky and of safe assets in the respective country i and year t, scaled to add up to 1:

$$R_{i,t}^{wealth} = R_{i,t}^{risky} w_{i,t}^{risky} + R_{i,t}^{safe} w_{i,t}^{safe}.$$

Appendix 5: Time Series Used to Estimate the Transmission of US Monetary Policy and Returns on Assets (Figure 7)

Table A6. Time series data for figure 7

GDP per capita	Monetary overhang
GDP	Natural rate of interest
CPI infl.	AUS REER
Current account	BEL REER
Imports	CHE REER
Exports	DEU REER
Narrow money	DNK REER
Money	ESP REER
House prices	FIN REER
Wage index	FRA REER
Govt. revenue	GBR REER
Govt. expenditure	ITA REER
Loans to NFS	JPN REER
Mortgage loans to NFS	NLD REER
Loans to households	NOR REER
Business loans	SWE REER
Corporate debt	Global real GDP
Investment ratio	Global CPI infl.
Short-term interest rate	Global st-interest rate
Long-term interest rate	Global lt-interest rate
Unemployment rate	Global debt
Public debt-to-GDP	Global gov. revenue
REER	Global gov. revenue
Banks capital ratio	Global credit
Loans-to-deposit	Global eq. tot. return
Banks noncore funding	Global hous. tot. return
Equity total return	Global gov. bond tot. return
Housing total return	Global eq. cap. gain
Gvt. bond total return	Global hous. cap. gain
Housing capital gain	Global bond cap. gain
Housing rent return	Global eq. div. return
Housing rent yield	Global hous. rent return
Equity capital gain	Global bond cap. gain
Equity dividend yield	Global banks cap. ratio
Govt. bond coupon return	Global ban. noncore fun.
Govt. bond capital gain	Global wealth return
Equity dividend return	Global risky asset return
Wealth return	Global safe asset return
Risky asset return	Global risk premium
Safe asset return	NDur. Int. price ratio
Real interest rate 1M	NDur. Inv. price ratio
Real interest rate 1Y	Dur. Int. price ratio
Real interest rate 10Y	Dur. Inv. price ratio
Risk premium	Int. Inv. price ratio
Capital marginal productiv.	