The Natural Rate of Interest – Concepts and Appraisal for the Euro Area

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Real interest rates in the euro area fluctuated sharply between −4.2% and +7.7% over the past half century. A key question for monetary policy makers and economic agents is: What is the "neutral," "equilibrium" or "natural" real interest rate to which current rates might eventually move back? In the long run, the natural rate of interest is influenced by productivity developments, population growth and the time preference for consumption over saving. In the medium run, the natural rate may also be influenced by fiscal policy, the structure of financial markets, and inflation risk premiums. Globalization should over time contribute to an international convergence of natural rates. Empirical estimates of the natural rate differ considerably and are associated with large error margins; estimates in "real time" suffer from additional uncertainty. Monetary policy rules based on the natural rate (e.g. Taylor rules, real interest rate gap) should thus be treated with great caution. Monetary policy might use the natural rate to consider appropriate responses to technological and demographic shocks. The majority of recent estimates for the euro area points to a fall in the natural rate to a level as low as 1.5%. This may reflect a more credible monetary policy and deep euro area financial markets, but also slowing productivity growth and a decline in the working-age population. In the future, the growing need for private savings for retirement might lower the natural rate, whereas "fiscal consolidation fatigue" might raise the natural rate.

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1 Introduction: Revived Attention on the Natural Rate of Interest (NRI)

A key question for monetary policymakers and any economic agent making long-term investment decisions is: Where are interest rates heading to? Are they going to remain at the current level, fall or rise in the future? Underlying this question is another one: Is the current level of real interest rates similar to, lower or higher compared to some average or "neutral" value? And what is this neutral value of interest rates toward which current rates are believed to be moving back sooner or later?

Over the past few years, interest in the theoretical notion of a "neutral" or "natural" rate of interest has been revived. Two developments contributed to this phenomenon: First, central banks nowadays use the level of the (nominal) short-term interest rate as their primary policy instrument; given that prices react sluggishly to changes in the policy rate, in practice the central bank also steers the short-term real interest rate. Second, monetary policy rules based on steering the interest rate around its neutral level have become very popular over the past decade. Inflation targeting rules steer the real rate around its neutral rate depending on whether the inflation rate is forecast to be at, below or above its target level. Taylor rules in addition take into account whether output is, or is forecast to be, at, below or above the economy's potential. The difference between the actual and the neutral rate (the "real interest rate gap") should, according to these rules, have predictive power for future inflation. The usefulness of all these rules crucially depends, among other things, on knowledge about the "natural rate."

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This paper first provides definitions of, and draws distinctions between, concepts of the NRI for various time horizons. Starting from a historical overview of real interest rates in the euro area, it proceeds to analyze the effects of structural changes and shocks, including globalization, on the euro area NRI. Various empirical estimates proposed in the economic literature are supplemented with some estimates by the authors for the most recent past. The paper concludes on a cautious note on the use of the NRI and derived monetary policy rules or indicators for actual monetary policy and discusses possible influences on the further evolution of the euro area NRI.

2 The Natural Rate of Interest: Definitions and Time Horizons

A major contribution to the definition of the NRI and its application to monetary policy goes back to the Swedish economist Knut Wicksell,[4] who stated:

"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" (Wicksell, 1898, p. 102).

"So long as prices remain unaltered, the [central] bank's rate of interest is to remain unaltered. If prices rise, the rate of interest is to be raised; and if prices fall, the rate of interest is to be lowered; and the rate of interest is henceforth to be maintained at its new level until a further movement of prices calls for a change in one direction or the other." (Wicksell, 1898, p. 189)

"It is not a high or low rate of interest in the absolute sense which must be regarded as influencing the demand for raw materials, labor, and land or other productive resources, and so indirectly determining the movement of prices. The causative factor is the current rate of interest on loans as compared with what I shall be calling the natural rate of interest on capital. This natural rate is roughly the same thing as the real interest of actual business." (Wicksell, 1898, p. xxv.)

Since Wicksell, various definitions of the NRI have been proposed. Before describing them, let us point out that from a theoretical viewpoint the distinction between the actual real interest rate and some natural real interest rate is only relevant in an economy with rigid prices or expectations based on incomplete or incorrectly processed information, such that prices are not fully aligned with real economic circumstances. By contrast, in a – hypothetical – world of fully flexible prices and rational expectations, the actual and natural interest rates coincide (see Deutsche Bundesbank, 2001, p. 37).

The economic literature is quite ambiguous when it comes to definitions on the natural interest rate. For the purpose of this survey, we distinguish between a long-run and a medium-run definition of the NRI.[5] The former views the concept from the

[4] *Other economic thinkers who contributed to developing the concept of the "natural rate of interest" – not necessarily with the same meaning attached to the term, though – include Thornton, 1802, Meade, 1933, Keynes, 1936, as well as members of the Austrian school of economics.*

[5] *We do not include the very short-term concept proposed by Archibald and Hunter (2001), which extends to the time that it takes for changes in interest rates to affect inflation. A short-term natural rate thus defined would be comparable in terms of time horizon with the policy rate derived from monetary policy rules such as the Taylor rule or inflation targeting rules.*

perspective of growth theory, the latter from a business cycle and monetary policy point of view.

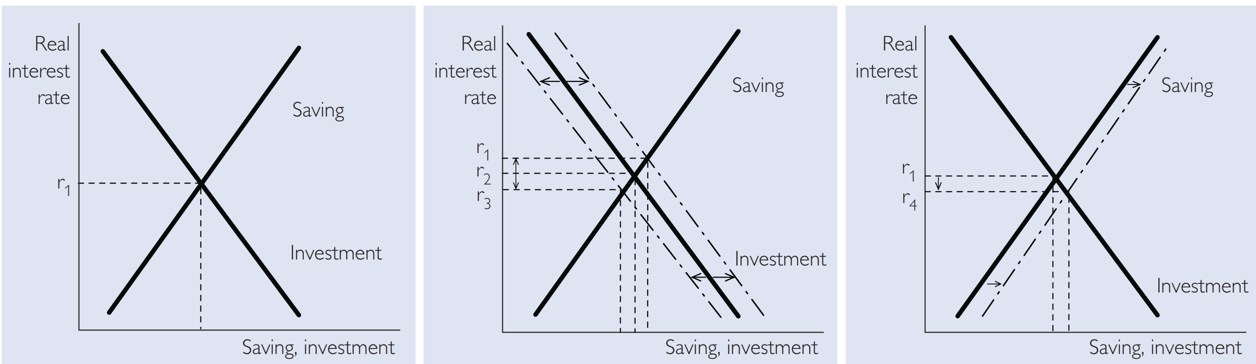
The "*long-run NRI*" is commonly defined as the real interest rate where "all markets are in equilibrium and there is therefore no pressure for any resources to be redistributed or growth rates for any variables to change" (Archibald and Hunter, 2001). In this – hypothetical – steady state, the long-run NRI depends on the structural features that influence an economy's long-term growth potential, which in turn depends on the rate of *technical progress, population growth* and households' *time preference of consumption today over saving for tomorrow.*[6]

Using this definition of the NRI, the dependence of this concept on the three above-mentioned components can be easily demonstrated graphically. Following Archibald and Hunter (2001, pp. 21f.), chart 1 panel A illustrates in a highly stylized and simplified way how the long-run NRI can be thought of being determined by the intersection of "investment" and "saving" schedules.

– The downward-sloping investment schedule shows that the demand for loanable funds falls as the cost of borrowing increases, since fewer investment projects yield enough return to cover financing costs. The upward-sloping savings schedule illustrates that the supply of loanable funds increases with the real interest rate, as people save more, the higher the (expected) return on their savings. Equilibrium is reached where the supply of and demand for loanable funds match, i.e. at the intersection of the savings and investment schedules, at the level of r_1.

Chart 1

Stylized View of Savings, Investment and the Natural Rate of Interest (NRI)



Panel A: The NRI is determined by matching saving and investment.

Panel B: A decrease (increase) in the return on capital shifts the investment schedule to the left (right), reducing (increasing) the NRI.

Panel C: An increased preference for saving shifts the saving schedule to the right, reducing the NRI.

Source: Archibald and Hunter (2001, pp. 21f.), adapted.

– The position of the *investment schedule* depends on how profitable investment is, in other words: on the productivity of capital, which is influenced by how efficiently and in what combination with other production factors capital is used. For example, technical progress raises total factor productivity and makes the existing stock of capital more profitable, shifting the investment schedule to the right

[6] *This relationship is also referred to as the "modified golden rule" in growth theory.*

and raising the equilibrium real interest rate to r_2 in chart 1 panel B. Conversely, if, for example due to lower birth rates or ageing, less labor is available for a given level of the capital stock, less output can be produced with that capital. The investment schedule would then shift to the left, and the long-run equilibrium real rate of interest will fall to r_3 in chart 1 panel B.

– The position of the *savings schedule* depends, other things being equal, on consumers' willingness to delay consumption at any given real interest rate. A general shift in time preference between consuming today and saving for the future shifts the savings schedule. For example, if people feel that public pensions might be reduced or that they will spend more years in retirement due to higher life expectancy, they might react by saving more, irrespectively of the prevailing level of the real interest rate. The savings schedule would then permanently move to the right, and the long-run equilibrium real interest would fall to r_4 in chart 1 panel C.[7]

The "*medium-run NRI*" can be defined as the real short-term interest rate consistent with real GDP at its potential level, in the absence of transitory shocks to demand. Potential GDP, in turn, is defined as the level of output with stable inflation, in the absence transitory shocks to supply. Therefore, the natural rate of interest is the level of real interest rates that is consistent with stable inflation in the absence of temporary shocks to demand and supply (see Williams, 2003, p. 1). This medium-run definition does not require all economic variables to be at their long-run, steady state levels. For example, public debt, the current account or the level of the real exchange rate could be in a state which is not sustainable in the long run.

The medium-run NRI broadly corresponds to business cycle frequencies. Thus, it is also comparable in terms of time horizon to the equilibrium real interest rates in Taylor monetary policy rules, around which the policy rate fluctuates depending on the deviation of inflation and output from their target and potential.

In the economic literature, a number of further factors which might influence the evolution of the NRI in addition to the basic determinants associated with the long-run growth model described above have been proposed (see e.g. ECB, 2004, and Björksten and Karagedikli, 2003):

– Structural shifts in *fiscal policy* can affect the NRI. Governments are very large borrowers or lenders (depending on whether the budget is in deficit or in surplus). Their action might thus affect the aggregate savings of the economy as a whole. If private agents do not fully adjust their private savings to counter any change in public savings,[8] an increase in the budget deficit, for example, would require a rise in the natural rate of interest. Empirical studies confirm a positive relationship between the level of long-term real interest rates and public debt or deficit levels.

[7] *A change in time preference could also alter the slope of the savings schedule – a movement that would also affect the NRI.*

[8] *Ricardian equivalence would predict that in response to an increase in public debt, private agents would increase private savings one for one to provide for anticipated future tax increases. However, the empirical evidence on the relevance of the Ricardian equivalence proposition is mixed in its results for both developed and developing countries (see for example Evans, 1993, Khalid, 1996, and Crespo Cuaresma and Reitschuler, 2004).*

– The *structure of financial markets* can influence the NRI in various ways. Efficient financial markets facilitate the optimal allocation of savings across investment projects and over time. A broader range of savings products, which better suits savers' needs and preferences in terms of return, risk and liquidity and achieves more efficient combinations of these features, may encourage households to save more, thereby lowering the equilibrium real interest rate. By contrast, financial liberalization also implies easier access to credit for households and businesses, thereby increasing the demand for loanable funds, which would raise the natural rate of interest.
– *Finally, risk considerations* may affect the noninflationary level of the real interest rate. In particular, lack of a credible commitment to price stability may put upward pressure on inflation expectations, thus requiring the central bank to keep real interest rates higher to maintain price stability.

Combining the various definitions of the NRI over different time horizons depicts an NRI that fluctuates in response to permanent shocks but converges toward a steady-state value in the (shock-free) long run.

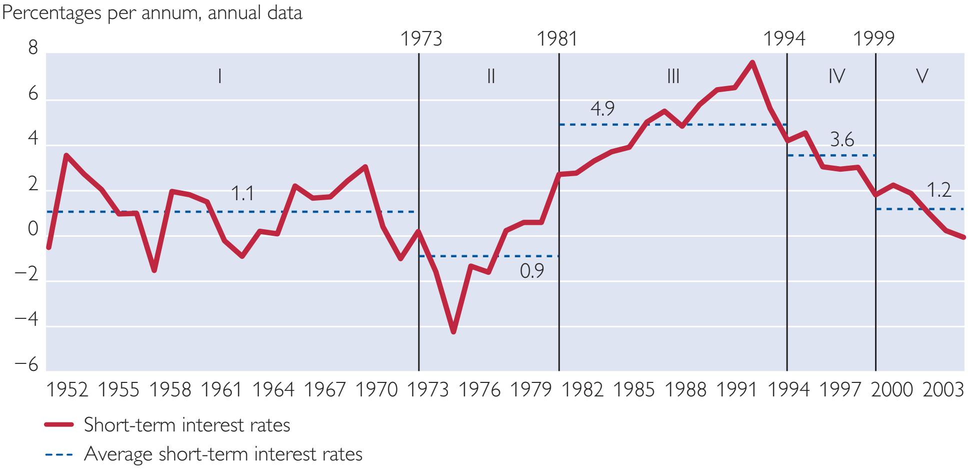
3 A Brief History of the Short-Term Real Interest Rate in the Euro Area

Often, as a starting point for analyzing the NRI, authors look at the historical evolution of the real interest rate. The rationale is that the real rate is assumed to have fluctuated around its natural level.

Chart 2

Short-Term Real Interest Rates in the Euro Area

Percentages per annum, annual data



Source: ECB.
Note: Three-month interbank interest rates or closest available substitutes deflated by annual consumer price inflation up to 1990 and by annual HICP inflation thereafter.

Following ECB (2004) and Deutsche Bundesbank (2001), we can distinguish *five phases* in the evolution of short-term real interest rates in the euro area since the 1950s. During the *first phase* up to 1973, real interest rates fluctuated between –1.5% and +3.6%,[9] with an average of 1.1%.

[9] *All figures in this section refer to annual averages.*

The rather moderate average real interest rate – with episodes of even negative rates – at a time of high real growth was attributable to restrictions on the international mobility of capital and volatile inflation rates in some euro area countries.

The *second* phase was *initiated* by the breakdown of the Bretton Woods System of fixed exchange rates, coupled with the oil price shock *in 1973*. In an already overheated economy, at a time of falling potential growth, monetary and fiscal policies used the new freedom generated by flexible exchange rates and responded through expansionary demand policies. The resulting substantial rise in worldwide inflation rates entered economic history books as the "Great Inflation." With nominal interest rates lagging behind the surge in inflation, real interest rates dropped dramatically to –4.2% in 1975 and recorded a negative average during the period from 1973 to 1980 of –0.9%.

During the *third* phase, *between 1981 and 1993*, euro area real interest rates surged to historical highs, reaching close to 7.7% in 1992 and an average of 4.9% over that period. The reasons for this development ranged from increased inflation premiums and monetary authorities' disinflation policies in response to the Great Inflation to soaring public deficits in many Western industrialized countries. In addition, the ERM exchange rate tensions in the first half of the 1990s entailed considerable exchange rate risk premiums.

The *fourth* phase, *starting in 1994,* was marked by a sharp decline in real interest rates. Around this time, many national central banks were granted a high degree of independence as required by the Maastricht Treaty ("legal Maastricht convergence criterion"), which made these central banks' commitment to the primary goal of price stability increasingly credible. In parallel, the future euro area countries underwent decisive fiscal consolidation programs to meet the Maastricht fiscal convergence criteria. The widening of ERM exchange rate bands as from August 2, 1993, in combination with increasing expectations of future EMU participation ("convergence plays") contributed to discouraging speculative attacks and diminishing exchange rate risk premiums.

The *fifth and hitherto last phase* started with *Stage Three of EMU in 1999* and was marked by a further decline in real interest rates to 0%, with the period average so far coming to 1.2%. The firm anchoring of inflation expectations below 2% reflected the rapid public recognition of the Eurosystem's credible commitment to price stability. Moreover, modest or weak GDP growth and inflation rates prompted low official interest rates. The adoption of the euro contributed crucially to the development of a large and deep, more competitive euro financial market. More recently, rising private savings and hesitant private investment contributed to further reducing market real interest rates.

This historical account shows that the level of the short-term real interest rate has varied sharply over time, also reflecting structural changes in underlying forces. Apart from its obvious analytical limitations, such a backward-looking, descriptive historical approach may be particularly misleading with respect to current and future levels of the NRI, given that forces driving past real interest rate levels may no longer be relevant and new shocks may have occurred. Thus, the following section investigates more sophisticated methods to estimate the NRI.

4 Estimates of the Natural Rate of Interest in the Euro Area

Since the NRI is a theoretical concept and is not directly observable, it needs to be estimated. Various estimation methods have been employed, which can be summarized under three categories (see Bomfim, 2001).

a) *Structural economic models* can be used to estimate measures of the NRI. For the euro area, Smets and Wouters (2003) and Giammarioli and Valla (2003) have provided estimates of NRIs using dynamic stochastic general equilibrium (DSGE) models. An advantage of this approach is that the estimates thus derived can be given an economic interpretation regarding the sources of changes in real interest rates. Moreover, since they seek to capture the underlying dynamic decision-making behavior of consumers and firms, these estimates are often claimed to be less subject to the Lucas critique.[10] Model-based approaches have the disadvantage that the estimates crucially hinge on the assumptions made by the model builder. Substantial progress has been made over past years in DSGE modeling; still, the models currently used are continuously being developed further. Therefore, "intermediate" approaches of a combination of small models with some structure with statistical filtering techniques have been proposed e.g. by Laubach and Williams (2003), whose method was applied to the euro area by Mésonnier and Renne (2004).

Browne and Everett (2004, 2005) propose to use the rate implied by the consumption-based capital asset-pricing model (CCAPM) as the natural rate. Using a CCAPM augmented with liquidity constraints, the observed intertemporal consumption behavior of agents is used to obtain an estimate of the rate prevailing in the absence of nominal frictions and informational asymmetries.

The point estimates of the NRI according to Giammarioli and Valla (2003) corresponding to the EMU sample (up to end-2002) are presented in panel A of chart 3, the estimates corresponding to the work of Mésonnier and Renne (2004) are presented in panel B and those by Browne and Everett (2005) are plotted in panel C. While the NRI estimates by Giammarioli and Valla (2003) fluctuate slightly around 3%, the NRI obtained by Mésonnier and Renne (2004) presents a sharp decline from a level of approximately 4% to 1% in the period from 1999 to 2001. The same type of dynamics is observed for the estimates in Browne and Everett (2005), with the point estimates of the NRI remaining between 1% and 2% since end-2001.

b) A second strain of the literature employs *pure statistical econometric methods*. Basically, these methods attempt to derive estimates of the equilibrium real rate from past developments of the real interest rate itself ("univariate filtering") or from the joint behavior of the real interest rate, output and inflation rates. The advantage of such approaches lies in "letting the data speak for themselves," without interference through possibly wrong theoretical assumptions, and in their simplicity and ease of frequent updates. An obvious disadvantage is that esti-

[10] *Lucas (1976) pointed out that when predicting the effects of major policy changes, relations estimated from past data may be very misleading. Models derived from "deep" economic relationships are therefore widely held to be less subject to the Lucas critique than purely empirical relationships. However, Estrella and Fuhrer (2003) provide evidence that partly contradicts this view by showing that forward-looking, optimizing models may be less stable in the face of monetary regime changes than their backward-looking counterparts.*

mates so derived cannot strictly be interpreted in economic terms.

Crespo Cuaresma et al. (2004a) provide an example of this type of research. Panel D in chart 3 presents the estimates of the NRI obtained using a multivariate structural time series model[11] for the real interest rate, inflation and industrial production using risk premium-adjusted interest rate data[12] in the period from January 1991 to April 2005. The NRI estimated this way declined slowly over time in the first part of the EMU period, reaching a level of approximately 1% by 2002 and maintaining that level thereafter.

c) A third group of methods seeks to extract *financial market views* on the NRI from financial market indicators. On the one hand, these methods widely use the yield curve as an indicator of the monetary policy stance. This approach is based on the notion that longer-term interest rates reflect market forecasts of the future path of short-term interest rates; assuming that, on average, policy rates fluctuate around an "equilibrium level," the long end of the yield curve can be seen as a proxy of the (market expectation of the future) NRI. A steeper yield curve thus signals a currently loose monetary policy stance and vice versa. A shortcoming of this approach is that the yield curve may also be influenced by changing inflation expectations. This issue is addressed by extracting expectations on future real interest rates from inflation-indexed bonds, as in ECB (2004) for the euro area.

A method for obtaining NRI estimates (see Basdevant et al., 2004) is based on the rational expectation hypothesis, according to which the yield to maturity of a bond can be decomposed into expected one-period yields and a risk premium. As a consequence, the difference between the nominal long-term interest rate and the sum of expected inflation and the average yield spread for a given period can be thought of as an indicator of the neutral rate of interest. Panel E in chart 3 presents the result of estimating this version of the NRI. The ten-year and three-month interest rates were used as the long-term and short-term interest rates, respectively; inflation expectations were assumed to be formed as if the agents believed that inflation followed a random walk, and the average yield spread was computed on the basis of data covering the period from 1991 to 2005. For the second half of the EMU sample, the NRI estimate obtained using the term-spread approach leads to a similar qualitative assessment of the monetary policy stance in the euro area as the risk-adjusted estimates presented above, and since 2002 the estimate tends to fluctuate around a value of 1.5%.

Bomfim (2001) and Christensen (2002) present a related method to extract the NRI based on inflation-indexed bonds, and the resulting NRI from the application of this method to euro area data is presented in panel F of chart 3. The estimate fell continuously from approximately 3.5% in 1999 to about 3% by the end of the sample.

Apart from the clear differences across point estimates from different methodologies (as shown in chart 3), a great amount of uncertainty about the NRI is present also for each individual method. Mésonnier and Renne (2004), for instance, present a 90% confidence interval around the NRI

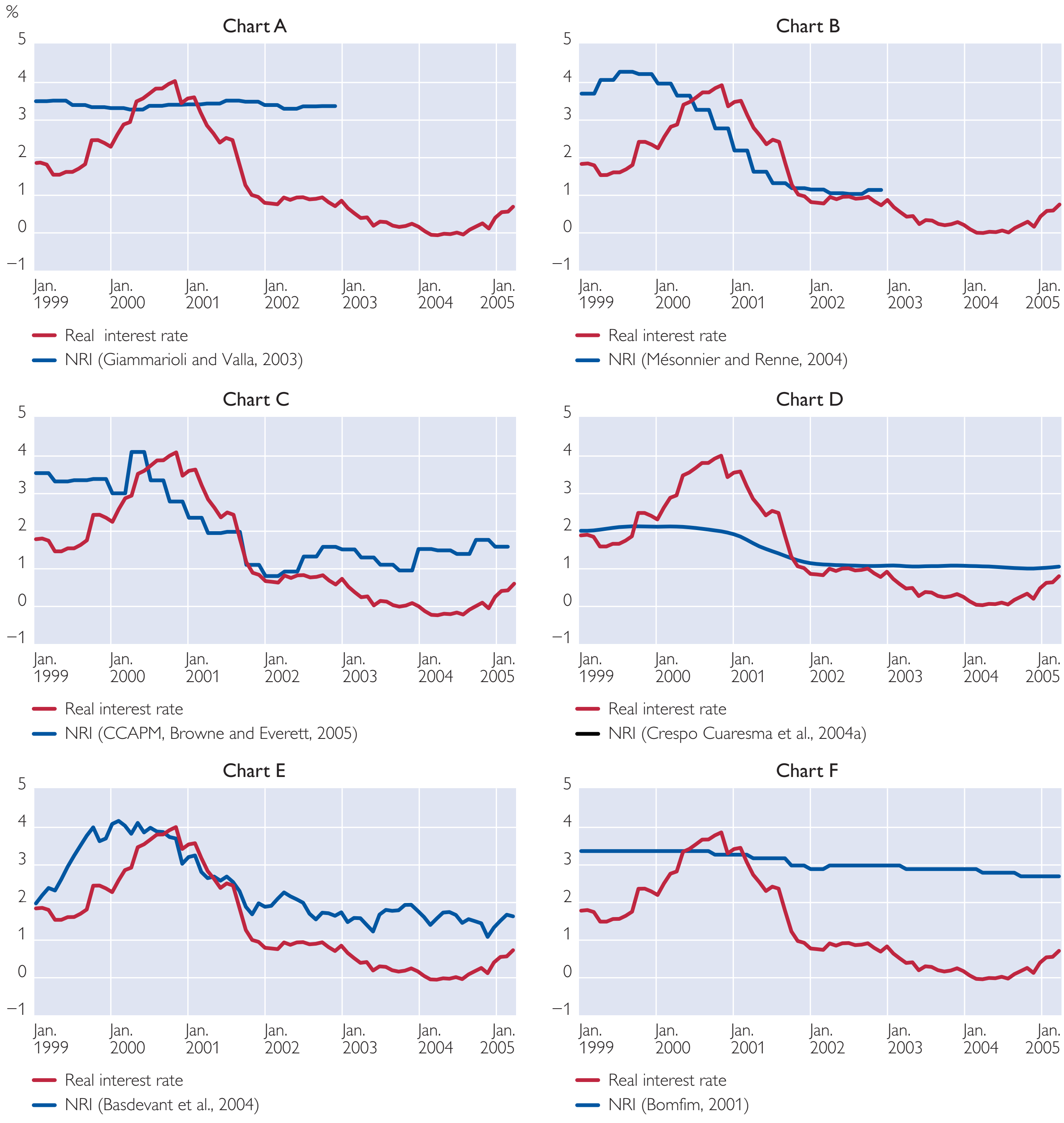
[11] *For details of the method used see Crespo Cuaresma et al. (2004a).*

[12] *For the method of risk adjustment see Crespo Cuaresma et al. (2004b).*

estimate, which is roughly 4 percentage points wide at the end of the sample. Comparably large confidence intervals are also reported in Crespo Cuaresma et al. (2004a). Obviously, the practical usefulness of the NRI is limited by the uncertainty surrounding the point estimates.

Chart 3

NRI Estimates for the Euro Area



Source: Data for panels A to C were provided by the authors of the papers quoted in each panel; panels D to F: authors' own calculations.

Box 1: Globalization and the Natural Rate of Interest – A Survey of International NRI Estimates

In a world without risk and other frictions, matching worldwide savings and worldwide investment as described in chart 1 would result in a world long-run NRI. In reality, however, various frictions hamper cross-national savings and investment. Even in the absence of official capital controls (including discriminatory tax regulations and regulatory provisions favoring domestic investment), savers may exhibit a "home bias" as a result of information disadvantages (including the risk associated with an investment, the foreign legal framework and jurisdiction) or higher transactions costs when lending out their funds to far-away borrowers. As a result, the NRI may differ between countries or monetary areas.

The far-reaching liberalization of capital movements, which encompasses the major economic areas, and the increasing information transparency on international investment should have contributed to reducing the segmentation between national financial markets. Thus, it is plausible to assume that national NRIs are increasingly influenced by developments in the world at large and should gradually converge to a "world NRI".[1] While this assumption may be valid for all countries and monetary areas, smaller countries are more likely to be subject to external influences than larger monetary areas such as the U.S.A. or the euro area.

A survey of the international literature on NRI estimates (table 1) reveals the following broad global patterns of recent NRI developments.

- *First, the NRI has declined over the years. This result seems to be a general one. Underlying reasons might be liberalized and therefore more competitive and efficient capital markets. In addition, central banks worldwide have been granted greater independence and have been increasingly successful in achieving and maintaining low and stable inflation, providing for a substantial fall in inflation risk premiums.*
- *Second, several studies indicate that from the beginning of the 1990s, the pattern of the NRI in the U.S.A. differs from that in the euro area. While the euro area NRI has gradually declined since the mid-1990s, it was already extraordinarily low for the U.S.A., but then rose in the period from the mid-1990s up to 2000. This development may reflect, inter alia, the higher U.S. productivity growth, the very low U.S. private savings ratio and the sharp surge in the U.S. government deficit and debt ratio.*
- *Third, some authors detect a tendency that NRI estimates for smaller economies are larger than those for the big countries. For New Zealand, for instance, the OECD notes that the NRI seems to be higher than in larger OECD economies; this may reflect greater GDP and exchange rate volatility, lower liquidity of the debt denominated in New Zealand dollars or a high net foreign debt ratio (OECD, 2004). Other reasons include exchange risk premiums or a perception among international investors that financial markets in New Zealand are relatively small and peripheral.*

In the future, the NRI may be influenced by a complex set of interacting developments. For instance, technological progress and global population growth might put upward pressure on the global NRI. Global savings may be influenced, for instance, by international current account imbalances and by how these will be unwound. Global risk premiums, in turn, will be subject to e.g. political developments, global inflation and exchange rate developments and by the smooth functioning of global financial markets.

[1] The same reasoning applies even more strongly to convergence among national NRIs within the euro area. Given the high degree of market integration due to the single market and the euro, differences among national NRIs should to a large extent be leveled out through arbitrage within the euro area. Thus, it seems fair to use the approximation of a "euro area NRI" throughout this paper.

Survey of International NRI Estimates

Author	Country	Type of method used	Time horizon	Range of NRI	NRI at end of sample
Bomfim (2001)	U.S.A.	Treasury inflation-indexed securities –implied equilibrium real rate series	1998–2001	Relatively stable, ranging from 3.6% in early 1998 to around 4% in the second half of 1999	3.7% in Q2/01
Brzoza-Brzezina (2004a)	U.S.A.	Structural VAR model; Laubach and Williams (2003)	1960–2002; 1980–2002	–5% to +8%, but very volatile; –5% to +8% and less volatile.	1% in mid-2002; 2% in mid-2002
Laubach and Williams (2003)	U.S.A.	Small macromodel estimated using Kalman filter	1960s–2002	2%–5%	Around 3% in mid-2002
OECD (2004)	U.S.A.	Laubach and Williams (2003)	Update Laubach et al. (2003) up to Q3/04	Further decline	2.1% in Q3/04
Manrique and Marques (2004)	U.S.A.	Laubach and Williams (2003)	mid-1960s–end-2001	1.5%–5%	In late 2001 the estimate was around 2.5%
Clark and Kozicki (2004)	U.S.A.	Laubach and Williams (2003)	1962–2003	0%–5%	Just above 2% for 2001–2003
Amato (2004)	U.S.A.	Latent variable model	1965–2001	2.5%–4%	2001: around 3%
Djoudad et al. (2004)	Canada	Kalman filter – Laubach and Williams (2003)	1985–2003	1.3%–1.6% (one-sided)	1.5% in 2003
Djoudad et al. (2004)	Canada	DSGE – Neiss and Nelson (2003)	Q2/85–Q2/04	0.0%–6.0% with considerable variability	1% in Q2/04
Lam and Tkacz (2004)	Canada	DSGE – Neiss and Nelson (2003)	Q1/84–Q1/02	4 different types of models; NRIs: lowest 0.7%, highest 7.6%	1.25%–2% in 2002
Björksten and Karagedikli (2003)	New Zealand	Yield curve approach plus Kalman filter	1992–2002	3.8%–5.8%	3.8% in 2002
Basdevant et al. (2004)	New Zealand	Several models	1992–2002	Similar downward trend in the 1990s, starting from the range of 5.2%–6.7%	End points in early 2003 lie in the range of 3.25%–4.25%
Smets and Wouters (2003)	Euro area	DSGE	1970–2000	–10% to +10%	Around –2% in 2000
Gerdesmeier and Roffia (2003)	Euro area	Different Taylor-type specifications	1985–2002	recursive estimates: 3%–7%; time-varying estimate: 1%–9%	Steep decline since 1996; 3% or 1% at end of sample
Giammarioli and Valla (2003)	Euro area	DSGE – Neiss and Nelson (2003)	1973–2000	1973–2000 up to 6%; 1994–2000 around 3.0%–3.7%	2.75% in 2000
Crespo Cuaresma et al. (2004)	Euro area	Multivariate structural time series model	1991–2002	8%–2%	1,5% – 2% in spring 2002
Mésonnier and Renne (2004)	Euro area	Kalman filter – Laubach and Williams (2003)	Q1/79–Q4/02	NRI lies between 1% and a 7% peak in 1989	Around 1% in Q4/02
Browne and Everett (2005)	Euro area	CCAPM model estimates	Q1/81–Q1/05	0,5%–4,5%	Around 1.5% in Q1/05
Amato (2005)	Germany	Latent variable model	1965–2001	2%–3%	Around 2.75% in 2001
Amato (2005)	U.K.	Latent variable model	1965–2001	–2% to +4%	Around 3.5% in 2001
Larsen and McKeown (2004)	U.K.	Kalman filtering techniques used in a small semistructural model	Q3/66–Q3/02	–6% to +8%; over the inflation-targeting period (Q4/92–Q3/00) 3.7% on average	Around 3% in 2002
Manrique and Marques (2004)	Germany	Laubach and Williams (2003)	mid-1960s–end-2001	1,5%–4%	Around 1.5% in 2002

Survey of International NRI Estimates

Author	Country	Type of method used	Time horizon	Range of NRI	NRI at end of sample
Bernhardsen (2005); Norges Bank (2004)	Norway	Not given	1995 to late 2004	3%–4%	Bernhardsen (2005): 2.5%–3.5%; Norges Bank (2004): 3%
Brzoza-Brzezina (2004b)	Poland	Kalman filter and structural vector autoregression model	1998–2003	1%–11%	Around 4% in 2003

5 Caution When Using the NRI and Derived Indicators for Monetary Policy

Chart 3 clearly illustrates the problems associated with the model-dependent nature of NRI point estimates. The estimates plotted in chart 3 present strong differences in both the level of the natural rate and in the dynamics of the NRI for the period from 1999 to 2005. While all estimates tend to present a downward sloping trend, the starting level in 1999 and the value of the NRI at the end of the sample used for the estimation differ across models. Obviously, such differences in NRI estimates can strongly affect monetary policy conclusions.[13] On the one hand, the method in Giammarioli and Valla (2003) and Bomfim (2001) yield NRI estimates that fluctuate only slightly around a value of approximately 3.5%, with a slight decreasing trend that is more visible in the case of estimates using inflation-indexed bonds. On the other hand, the estimates based on Mésonnier and Renne (2004) and Basdevant et al. (2004) present more volatile short-term dynamics, with the point estimates of the NRI falling from more than 4% to around 1% (in the case of Mésonnier and Renne, 2004) or 2% (for the estimates based on Basdevant et al., 2004) in 2000 and 2001. The methods based on the statistical features of the data present an intermediate case, with very stable short-run dynamics and a decreasing NRI from approximately 2% in 1999 to around 1% in 2005.

The results presented in chart 3, furthermore, correspond to NRI estimates obtained *a posteriori*, i.e. using the information available up to the end of the sample employed. At any given point in time, however, the information the monetary authority has at its disposal on the variables that may affect the NRI only covers the time period up to that particular moment. This fact adds yet another dimension of uncertainty to NRI estimation – a dimension that may distort the evaluation of monetary policy decisions. To illustrate the effect of this second source of uncertainty, chart 4 shows the real-time estimates and the full-sample estimates for the method used in Crespo Cuaresma (2004a), together with confidence intervals corresponding to twice the standard error of each estimate. In some cases the real-time and full-sample point estimates of the NRI even lead to opposite qualitative assessments of the monetary policy

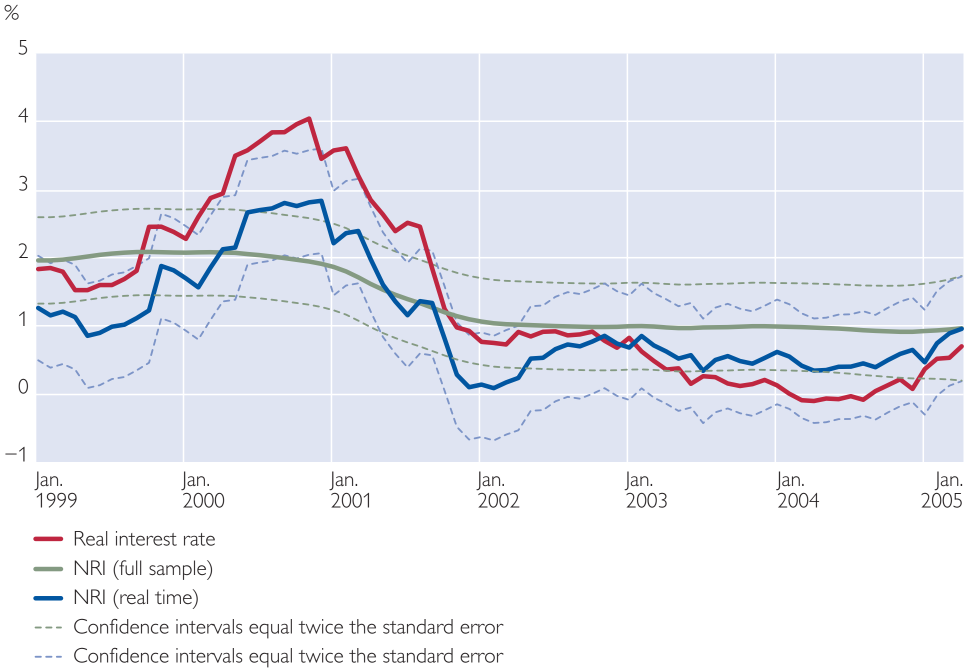
[13] *It should be noticed that differences occur not only across methods, but also depending on whether risk premium corrections are carried out prior to EMU entry or not. Crespo Cuaresma et al. (2004a, 2004b) present evidence on this issue.*

stance in the euro area. Clear examples are the results for 1999 and for the period from end-2001 up to early 2003: while the real-time point estimates of the NRI imply a positive and relatively sizeable real interest rate gap, the full-sample results indicate a contractionary monetary policy stance for the same periods.

The confidence intervals plotted in chart 4 also illustrate the high degree of uncertainty surrounding NRI estimates: for the case of the real-time estimate, for example, the real interest rate falls within the confidence interval in the period from end-2001 until the end of the available sample (April 2005).

Chart 4

Full Sample versus Real-Time NRI Estimates, Based on the Method Used in Crespo Cuaresma et al. (2004a)



Source: OeNB.

The divergence between real-time and full-sample estimates can lead to significant costs for monetary policy. Using a small macroeconomic model of the U.S. economy, Orphanides and Williams (2002)[14] show that underestimating the uncertainty surrounding natural interest rate estimates can lead to sizeable costs when using Taylor-type monetary rules.[15]

In order to illustrate the difficulties involved in extracting monetary policy advice from NRI point estimates, we perform a simple exercise by computing the implied policy rates from a stylized euro area Taylor rule using different real-time estimates of the neutral rate. We will concentrate on three methods, corresponding to each of the broad methodologies described

[14] *See also Orphanides (2001, 2003).*

[15] *As an alternative, Orphanides and Williams (2002) propose the use of difference rules for monetary policy, which do not rely on estimates of the neutral rate.*

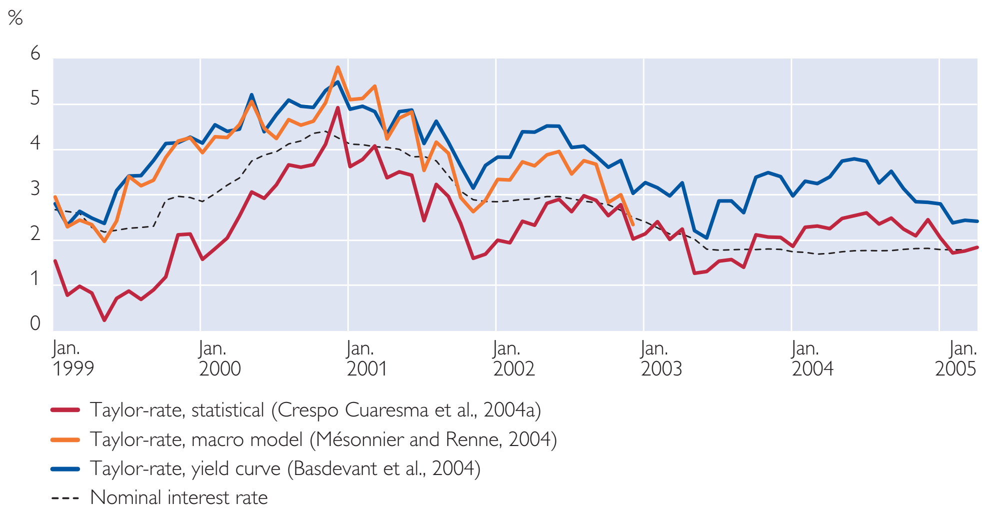
above: the model-based estimates by Mésonnier and Renne (2004), the NRI estimates based on the statistical model put forward in Crespo Cuaresma et al. (2004a) and those based on the yield-curve as in Basdevant et al. (2004). Chart 4 presents the policy rate implied by the Taylor rule given by

$$i_t^p = r_t^* + \pi^* + 1.5(\pi_t - \pi^*) + 0.5g_t,$$

where r_t^* refers to the (real-time) neutral rate of interest, π^* is the inflation objective, assumed to be equal to 2% for this exercise, and g_t is the output gap, proxied by Hodrick-Prescott filtered (logged) industrial production. We will abstract from issues of interest rate smoothing and uncertainty surrounding the output gap estimate (which is computed using the full-sample information) so as to focus on the differences driven by the real-time point estimates of the NRI.

Chart 5

Real-Time Taylor Rates and Actual Nominal Interest Rate in the Euro Area



Source: OeNB.

The implied policy rates shown in chart 5 present more evidence on the difficulties involved when using estimated NRIs in real time for monetary policy advice. During most of the sample, the monetary policy assessment based on the gap between the Taylor rate and the actual nominal interest rate does not produce the same results for the three methods. While the overall *dynamics* of the Taylor rate broadly coincide across methods, the *level* of the Taylor rate derived from the purely statistical estimate of the NRI differs from the other two estimates by more than 150 basis points on average.

The use of different NRI estimates also heavily influences the elasticities of empirically estimated Taylor rules with respect to the output gap and inflation expectations. Crespo Cuaresma et al. (2004a, 2004b) show that the parameter estimates of NRI-based Taylor rules for the euro area depend strongly on whether pre-EMU risk premiums are adjusted for or not. Specifically, the use of raw interest rate data for estimating the NRI leads to an overestimation of the monetary policy response to the output gap and also distorts the estimates of the policy rate's response to deviations from the inflation target.

The real interest rate gap, defined as the difference between the actual real interest rate and the NRI, is also a widely used measure of the monetary policy stance, which should – in theory – possess leading indicator properties for inflation. Given the substantial difference in NRI estimates documented above, the different real interest rate gaps associated with the different NRI estimates are bound to have different correlation structures with future inflation rates. Chart 6 shows the correlation between the real interest rate gap resulting from the three methods compared above and future year-on-year core inflation (leading by one to twelve months) in the euro area for the period since the introduction of EMU.

Chart 6

Correlation between Different Real Interest Rate Gap Estimates and Future Inflation

Source: OeNB.

The negative correlation between the real interest rate gap and inflation, which is supported by economic theory (see e.g. Neiss and Nelson, 2003), only appears in the estimates by Crespo Cuaresma et al. (2004a), which shows the highest (negative) correlation for one-month-ahead inflation, with declining negative correlation for inflation up to nine months ahead. The other two methods lead to a *positive* correlation that reaches a peak of approximately 0.8 for ten-months-ahead inflation rates if the NRI is estimated according to Mésonnier and Renne (2004) and 0.7 for twelve-months-ahead rates according to the method used in Basdevant et al. (2004).[16]

6 Conclusions

When deciding on interest rates, most monetary policymakers implicitly take a position on at least the order of magnitude of the NRI to gauge whether and to what extent their monetary policy is neutral, restrictive or expansionary and to determine the direction and extent of interest rate changes. Thus,

[16] *Mixed results for the leading indicator property of the real interest rate gap with respect to inflation are also found for different time periods in the United Kingdom by Larsen and McKeown (2004). They argue that the vanishing leading indicator property is the result of monetary policy being geared toward keeping expected inflation constant and actual inflation close to a target. In this case, the deviation between actual and target inflation rates comes close to "white noise", with no correlation between the real interest rate gap and the inflation rate.*

the concept of the NRI is *in principle useful for monetary policy*.

However, from a practical point of view, the use of the NRI for monetary policymaking meets with several *major obstacles*. As shown above, the literature puts forward various definitions of the NRI, potentially attached to different time horizons. Linked to this fact there is a wide variety of model specifications and empirical estimation methods that may yield rather diverse results, while real-time estimates have even wider error margins. For the euro area, the additional question arises of how to address, in empirical estimation, the large-scale and time-varying risk premiums that prevailed prior to 1999. Finally, to what extent should the natural interest rate be treated as a national/regional versus a global concept? Thus, Blinder's (1998, p. 33) view that "the neutral real rate of interest is difficult to estimate and impossible to know with precision. It is therefore most usefully thought of as a concept rather than as a number, as a way of thinking about monetary policy rather than as the basis for a mechanical rule" continues to be valid. A *pragmatic approach* thus seeks to identify broad orders of magnitude for the level, and changes in the level, of the NRI in response to structural changes and (potentially permanent) shocks in the economy. More in particular, the NRI is a useful framework for thinking about appropriate monetary policy responses to productivity shocks- and their sequencing over time.[17] In this sense, the NRI and derived indicators such as the real interest rate gap can be *some among many tools* a central bank uses.

As regards *estimates of the NRI*, judging from statistical econometric and financial market data-based estimation methods, the euro area NRI has been on a downtrend since the start of EMU, reaching around 1% to 1.5% recently. By contrast, the DSGE-based estimate quoted here does not detect any noticeable downward trend, yielding a recent NRI estimate of around 3% to 3.5%. The falling trend of productivity growth since the early, and more markedly so since the mid-1990s, a downtrend in population growth, the recent rise in private savings in several euro area countries – if it were to reflect a structural change in savings over consumption preferences – as well as lower inflation risk premiums and deeper and more efficient financial markets due to the creation of the euro would all fit with the notion of a falling NRI.

A high or low level of the NRI as such is neither an advantage nor a drawback for an economy. However, the *underlying causes may be considered welcome or undesirable*. On the one hand, a falling NRI in the euro area may reflect falling inflation risk premiums that are attributable to a credible monetary policy and a larger, deeper and more efficient single euro area financial market. On the other hand, a downtrend in the NRI can also reflect a falling trend in the working age population or weak productivity growth.

Three final considerations follow from the above observations.

The first consideration relates to *monetary policy*. The establishment of EMU and of the independent Eurosystem has reduced inflation risk premi-

[17] *A typical example is the monetary policy response to a positive productivity shock. In the short term, the higher productivity increases potential output and thus reduces inflationary pressure, thus allowing a softer monetary policy stance. However, in the longer term, the higher demand for capital will raise the NRI, requiring monetary policy to hike interest rates in order to keep the monetary stance neutral.*

ums and eliminated former ERM exchange rate risk premiums and has thus lowered the real interest rate level. If the NRI had indeed declined, the current low level of real short-term interest rates in the euro area may be less exceptional than when judging from simple historical averages. That long-term real interest rates have fallen by far less than short-term rates recalls, however, that in the longer run, real interest rates are determined by the markets. Over the longer run, central bank actions are reflected in economic agents' expectations and will thus primarily change the price level and nominal interest rates. In the long run, the central bank can thus influence the real capital market rate only indirectly via inflation risk premiums that are included in the long-term real interest rate. By eliminating inflation uncertainties to the greatest extent possible, the central bank allows long-term real interest rates to approach as far as possible the risk-free equilibrium level.

The second consideration concerns *aggregate savings*. Many European countries have experienced falling private saving rates over the past two decades. More recently, the notion has been raised that consumers might – permanently – step up their savings in response to uncertainties about the future of public pension schemes or to the expectation a longer life span in retirement. Saarenheimo (2005) predicts a substantial decline in real interest rates to the order of 70 basis points or more as a result of ageing-related developments. This could substantially and for an extended period of time depress the NRI. Public savings have been moving in the opposite direction from private savings. In the run-up to EMU, European governments reduced their negative public savings rates. More recently, however, they have – partly in response to weak cyclical demand conditions, partly as a result of "consolidation fatigue" – again widened their budget deficits. The effects from recent changes in the Stability and Growth Pact remain be seen, but the odds point more in the direction of higher, rather than lower, fiscal deficits. The uncertainty is further enhanced by prevailing substantial external imbalances in major world economies. The unwinding of these external imbalances, the timing and extent of which are unknown, might substantially affect future global saving and natural rates of interest.

The third consideration states that a falling and low NRI may, other things being equal, also reflect a low *return on capital* and thus low real growth and wealth accumulation. Policies aiming at increasing the return on capital (such as investment in R&D and in education) and encouraging labor market participation would support potential growth, which would eventually exert an upward pressure on the NRI.

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