Vanguard

Vanguard research | Megatrends

Estimating neutral rates

Why the era of ultra-low rates may be coming to an end

About the Megatrends series

Megatrends have accompanied humankind throughout history. From the Neolithic Revolution to the Information Age, innovation has been the catalyst for profound socioeconomic, cultural, and political transformation. The term "Megatrends" was popularized by author John Naisbitt, who was interested in the transformative forces that have a major impact on both businesses and societies, and thus the potential to change all areas of our personal and professional lives.

Vanguard's "Megatrends" is a research effort that investigates fundamental shifts in the global economic landscape that are likely to affect the financial services industry and broader society. A megatrend may bring market growth or destroy it, increase competition or add barriers to entry, and create threats or uncover opportunities. Exploring the long-term nature of massive shifts in technology, demographics, and globalization can help us better understand how such forces may shape future markets, individuals, and the investing landscape in the years ahead.

Vanguard Investment Strategy Group's Global Economics Team

Joseph Davis, Ph.D., Global Chief Economist

Americas

Roger A. Aliaga-Díaz, Ph.D., Chief Economist
Andrew J. Patterson, CFA
Joshua M. Hirt, CFA
Asawari Sathe, M.Sc.
Adam J. Schickling, CFA

Europe

Jumana Saleheen, Ph.D., Chief Economist
Shaan Raithatha, CFA
Roxane Spitznagel, M.Sc.
Lulu Al Ghussein, M.Sc.

Asia-Pacific

Qian Wang, Ph.D., Chief Economist
Alexis Gray, M.Sc.
Maximilian Wieland

Megatrend

Estimating neutral rates: Why the era of ultra-low rates may be coming to an end

- We estimate that the median neutral (or equilibrium) interest rate across developed markets has fallen by about 4 percentage points since the 1980s. Demographic forces were the key driver, accounting for nearly half the decline.
- Our latest estimates of the real neutral rate are –0.25% to 0.25% in the U.S. and the euro area, 0.75% to 1.25% in the U.K. and Australia, 0% to 0.5% in Japan and Canada, and –0.75% to –0.25% in Switzerland.
- Policy rates may need to rise above the neutral rate in some markets this cycle, given the higher inflation environment. This will help dampen demand and anchor inflation expectations.
- Neutral rates are expected to rise by around 110 basis points over the next 10 years. The green transition could boost the U.S. neutral rate by around 60 additional basis points. (A basis point is one-hundredth of a percentage point.)
- For investors, higher neutral rates likely mean short-term pain, as rising rates tend to crimp equity and fixed income returns. However, once rates reach their new, higher equilibrium, long-term expected returns will be modestly higher.

Authors

Alexis Gray, M.Sc.

Roxane Spitznagel, M.Sc.

Adam J. Schickling, CFA

Part I: Motivation and background

Over recent decades, both short- and long-term real (or inflation-adjusted) interest rates have declined across developed economies (see **Figure 1**). This suggests that equilibrium interest rates, which are unobservable, have fallen, pulling observable interest rates down as well. Our aim in this paper is to identify the key drivers of equilibrium interest rates, also known as neutral rates, and determine how far they have fallen since the 1980s. In addition, we provide a forecast for the expected path of neutral rates over the next decade.

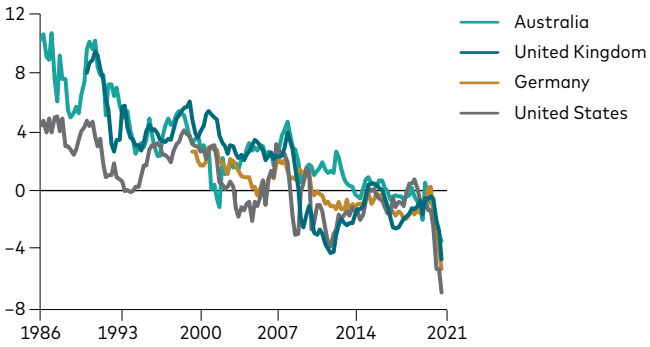
The neutral interest rate (also referred to as r*, pronounced "r star") is the real interest rate that would prevail when the economy is at full employment with stable inflation. In this environment, monetary policy should be neither expansionary nor contractionary.

One challenge for policymakers in moving to a neutral stance is that the neutral rate is unobservable—similar to potential GDP, we can estimate but will never know for certain the true value. Nevertheless, neutral rate estimates provide an important indication, although imperfect, of whether the current monetary stance is accommodative or restrictive. They serve as an anchor for where policy rates will settle in the future once there are no distortions, such as the COVID-19 pandemic.

FIGURE 1.

Short- and long-term real rates have declined

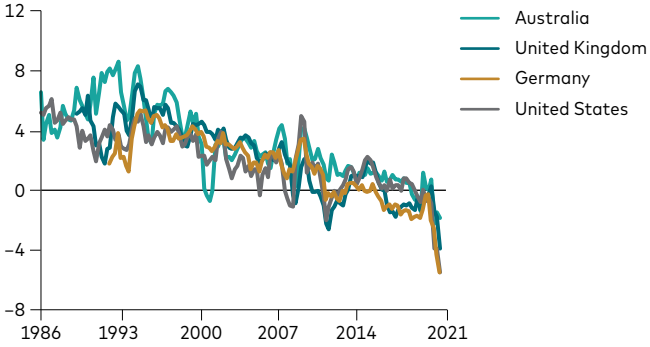
a. Real short rate



Note: Real short-term interest rates are calculated as the policy rate minus headline inflation (year-on-year).

Source: Vanguard calculations, based on data from Bloomberg.

b. Real 10-year government bond yields



Note: Real 10-year yields are calculated as the 10-year yield minus headline inflation (year-on-year).

Source: Vanguard calculations, based on data from Bloomberg.

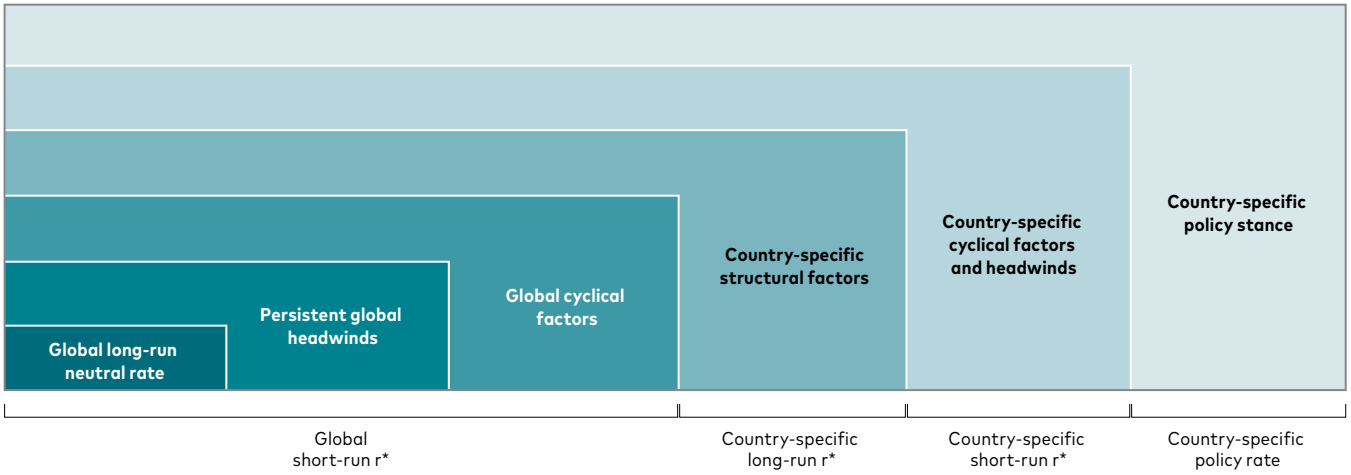
The neutral rate can be defined along two dimensions: global versus country-specific, and short-term versus long-term. **Figure 2** illustrates the link between these dimensions of the neutral rate.

For small, open economies such as Australia or Canada, the neutral rate is heavily influenced by the global neutral rate. Therefore, the global neutral rate can be thought of as an anchor point where country-specific neutral rates converge in the long run. Over shorter time horizons, cyclical headwinds or tailwinds can push the neutral rate above or below its long-term average. This is the key difference between short- and long-term neutral rates.

FIGURE 2.

There are various ways to measure the neutral rate

Relationship between the global neutral rate and country-specific r*



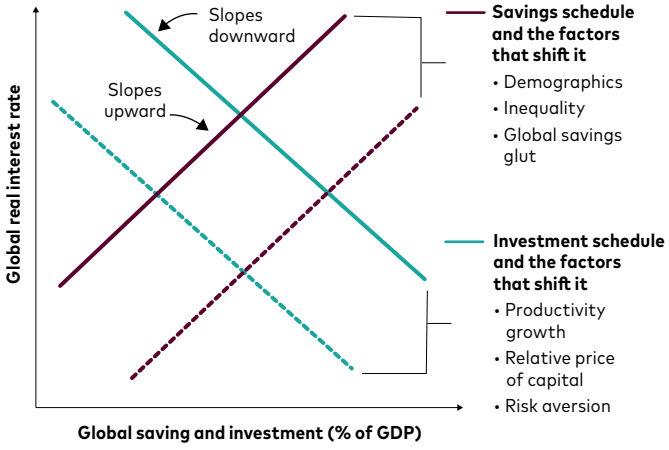
Source: *Secular Drivers of the Global Real Interest Rate*, Rachel and Smith (2015).

Drivers of the long-term neutral rate

The interest rate that equates savings and investment in the long run is the equilibrium interest rate, or the long-run neutral rate (see **Figure 3**). (All subsequent references to the neutral rate in this paper are to the long-run neutral rate.) The savings schedule represents the desired savings rate, which tends to rise as real rates increase, hence the schedule slopes upward. The investment schedule represents the desired investment rate, which tends to fall as real rates increase because it becomes more costly to invest—hence the investment schedule slopes downward.

FIGURE 3.

The neutral rate is the rate that equates savings to investment



Note: Figure 3 is a theoretical diagram only and is not based on underlying data or analysis.

Source: Vanguard.

The neutral rate will rise or fall as the savings and investment schedules shift. For this reason, it is critical to understand the underlying drivers of the savings and investment schedules. In Figure 3 and **Figure 4**, we focus on six key drivers: demographics, inequality, the global savings glut, the relative price of capital, risk aversion, and productivity growth (see Rachel and Smith, 2015, for a more detailed overview). We provide a brief discussion of the relationship between the drivers and the neutral rate, which we test in Part II of this paper.

In the academic literature, there are, broadly, four cited approaches to estimate neutral rates, which are detailed in **Figure A-1** in the Appendix. These are: reduced form models, semi-structural models, macro-finance models, and dynamic stochastic general equilibrium (DSGE) models.

In this paper, we adopt a reduced form approach for several key reasons. First, the model is relatively simple to estimate compared with the other three approaches.

Second, the standard errors are smaller than for other approaches, such as the more popular semi-structural approach. This means that we have an improved degree of conviction in our estimates.

And finally, unlike the other approaches, reduced form models can provide an attribution for neutral rates so we can better understand their key drivers.

FIGURE 4.

Six key drivers of the neutral rate

Schedule	Factors	Correlation to r*
Investment	**Productivity growth** Higher productivity growth boosts demand for capital as it creates more investment opportunities. This shifts the investment schedule and the neutral rate upward.	Shifts up ▲
	Relative price of capital A rise in the relative price of capital implies that a given investment project now costs more to pursue. Investment volumes now have to be maintained by committing a larger share of GDP. This shifts the investment schedule and neutral rate upward.†	Shifts up ▲
	Risk aversion Greater risk aversion increases the demand for safe and liquid assets, instead of riskier (and potentially more productive) assets. This shifts the investment schedule and the neutral rate downward.	Shifts down ▼
Savings	**Demographics** A decrease in the size of the young working-age population boosts the savings rate, because this cohort tends to save less than the rest of the population. This shifts the savings schedule outward and pushes down the neutral rate.	Shifts down ▼
	Income inequality Higher income inequality boosts the savings rate, because higher-income cohorts tend to have a higher savings rate than lower-income cohorts. This shifts the savings schedule outward and pushes down the neutral rate.††	Shifts down ▼
	Global savings glut A rise in global savings, led by China and other emerging-market economies, shifts the savings schedule outward and pushes down the neutral rate.†††	Shifts down ▼

Notes: † This offsets the effect of costlier capital leading to less investment. See for instance Rachel and Smith (2017). †† See Eggertsson and Mehrotra (2014), Kumhof, Rancière, and Winant (2015), or Rachel and Smith (2017). ††† See Bernanke (2005).

Source: Vanguard.

Part II: Model estimation and results

We estimate the neutral rate for 24 developed-market economies. These include Australia, Canada, Germany, Japan, Switzerland, the U.K., and the U.S. (For a full list of markets in our analysis, please refer to Developed Markets in Our Study in **Figure A-2** in the Appendix.) We focus on developed-market economies because these markets possess similar characteristics that lend themselves more readily to a multivariate model. Our estimates are on a yearly basis, from 1982 to 2019.

We model the neutral rate in real terms as a function of the six drivers discussed in Part I (see Figures 3 and 4). Since we are interested in the long-run neutral rate, we remove short-term cyclical fluctuations. Specifically, we estimate the long-run cointegrating relationship between those drivers and interest rates. This long-run cointegrating relationship is the source of our neutral rate estimate. Our neutral rate is therefore affected only by slow-moving developments in those six structural drivers, consistent with the definition of long-run neutral rates. (For more details on our empirical approach, please refer to Estimation in **Figure A-4** in the Appendix.)

Figure 5a shows that neutral rates across countries have fallen over the last four decades. In particular, the median neutral rate across all 24 developed-market economies in our data set has declined by about 400 basis points since 1982. The estimates exhibit a similar downward trend across countries. Our latest estimates of the neutral rate in real terms are –0.25% to 0.25% in the U.S. and the euro area, 0.75% to 1.25% in the U.K. and Australia, 0% to 0.5% in Japan and Canada, and –0.75% to –0.25% in Switzerland.

As real rates can be harder to grasp than nominal rates, we convert our real estimates of the neutral rate into nominal ones.[1] Our latest estimates of the nominal neutral rate are 2% to 2.5% in the U.S. and Canada, 1% to 1.5% in the euro area and Japan, 2.5% to 3% in Australia and the U.K., and 0% to 0.5% in Switzerland. (For a complete list of our nominal and real neutral rate estimates for all 24 countries, please refer to **Figure A-6** in the Appendix.)

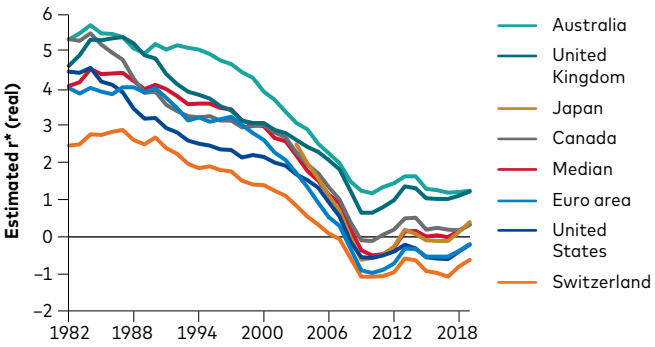
Figure 5b shows the contribution of each driver to the 400-basis-point fall in the median real neutral rate since 1982. Demographic factors (primarily a declining number of new entrants to the workforce) were the driving force, accounting for about 200 basis points of this decline. Increased risk aversion is estimated to have contributed about 90 basis points, followed by the global savings glut (70 basis points) and a rise in income inequality (22 basis points). The decline in the price of capital and lower productivity growth over the last decades seem to have played only minor roles in driving down neutral rates.

Neutral rates across countries appear to have been driven lower by similar forces (see **Figure 6a**). In the 1990s, demographic factors started to exert downward pressure on neutral rates, as savings rates increased. Population growth started to decline substantially during that time, after the baby boom in advanced economies saw the global population surge in the second half of the 20th century. This decline has reflected a fall in the proportion of young dependents[2] primarily because of the fall in fertility rates. (**Figure 6b** drills down on estimates across countries.)

FIGURE 5.

Developed-market neutral rates have declined because of multiple factors

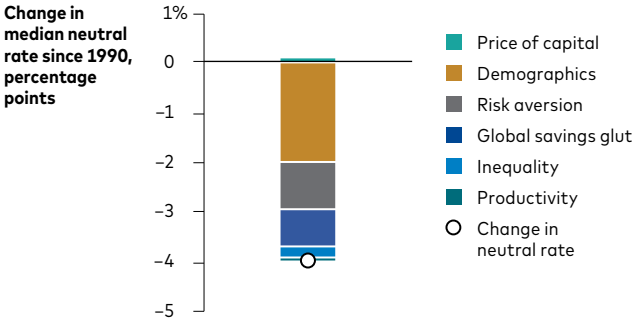
a. Neutral rates have fallen across developed markets



Note: The euro area neutral rate estimate is an aggregate of the countries that are part of the euro area.

Source: Vanguard; for underlying data see Figure A-2 and **Figure A-3** in the Appendix.

b. Demographic forces were the key driver



Source: Vanguard, as of April 2022.

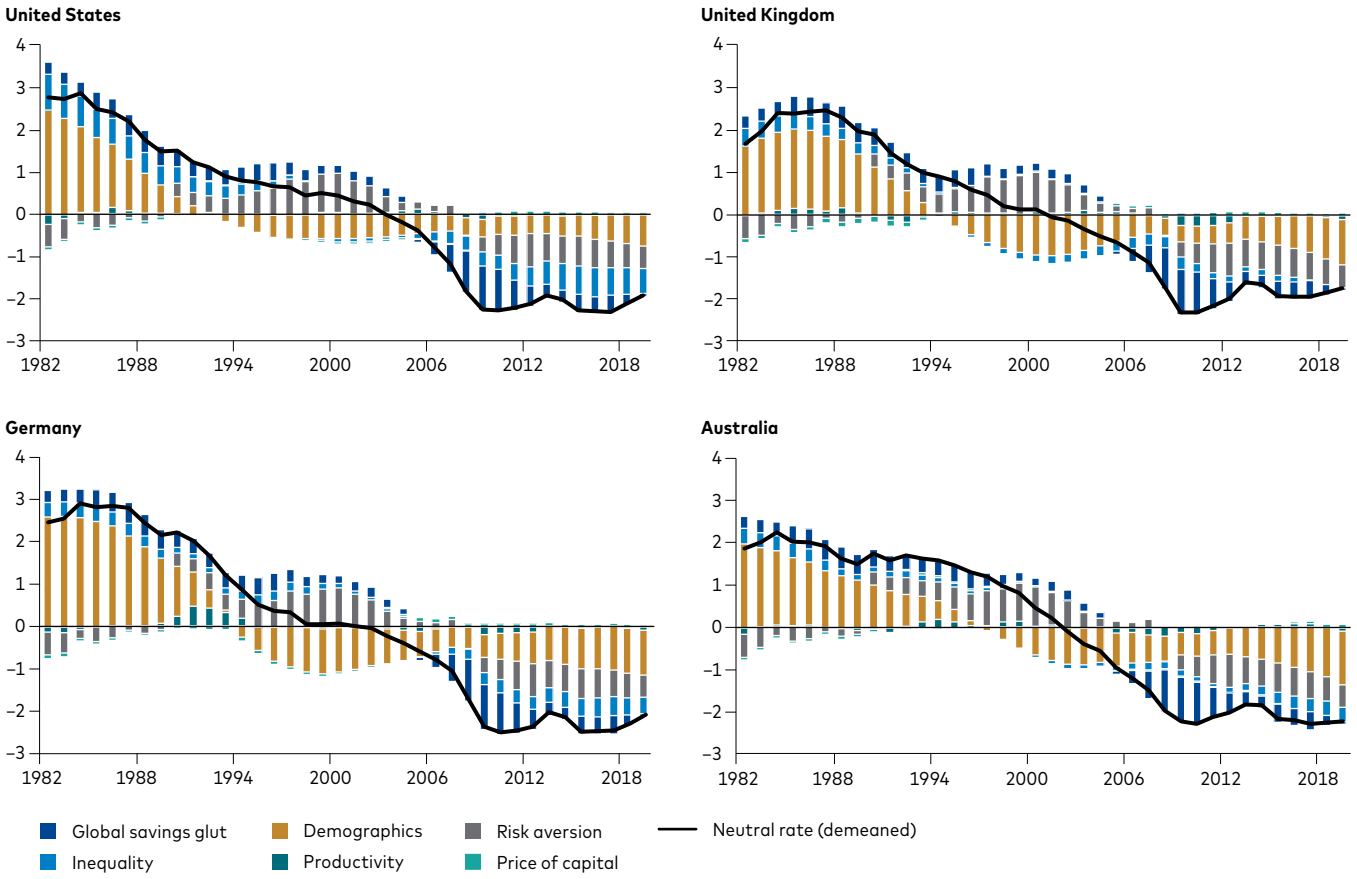
1 To arrive at the nominal neutral rate, we add realized inflation to the real neutral rate estimate. In particular, we use the four-year moving average of realized inflation. This is consistent with our approach of using four-year moving averages for all six driver variables.

2 Rachel and Smith (2015) show that the decline in the proportion of young dependents (reflecting a slowdown in demographic growth) has more than offset the gradual rise in the proportion of old-age dependents (linked to aging societies).

FIGURE 6.

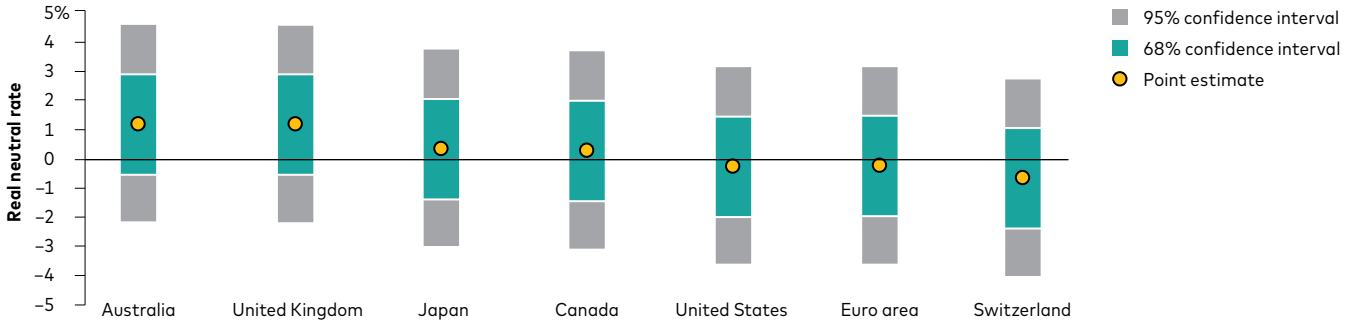
How neutral rates look across various economies

a. Neutral rates across countries appear to have been driven by similar forces



Source: Vanguard, as of April 2022.

b. Neutral rates across countries are not statistically different from one another



Note: The chart shows our latest real neutral rate estimates, including 1 standard error (68% confidence interval) and 2 standard error bands (95% confidence interval).

Source: Vanguard, as of April 2022.

The global savings glut has added to that downward pressure on neutral rates across countries from the mid-2000s onward. Following the Asian financial crisis in the late 1990s, many emerging markets significantly increased their foreign exchange reserves as a precaution to better manage capital flows. This flooding of capital markets with an increased supply of savings has lowered neutral rates.

Inequality appears to have played a more crucial role in some countries than in others. In the U.S. in particular, rising inequality has contributed an increasing share over the last decade to the decline in the neutral rate, accounting for about a third of the downward pressure in 2019. By contrast, rising inequality has had a more limited impact on neutral rates in the U.K., Australia, and Germany.

It is important to highlight that there is uncertainty around these estimates. **Figure A-5** in the Appendix shows the standard error bands around our point estimates for key regions. While these error bands are noticeable, our reduced form approach allows us to estimate the neutral rate with more conviction, leading to smaller error bands than with other approaches. Moreover, while the exact point estimate might be inherently uncertain, the error bands still serve as an anchor for where policy rates will settle in the long run.

We also recommend caution when it comes to the ordering of the country-specific neutral rates. As Figure 6b shows, the difference between our estimates is statistically insignificant. This applies to our latest estimates and to our 2030 projections of the neutral rate as analyzed in Part III. This is consistent with the notion of a global long-run neutral rate at which country-specific neutral rates converge, absent shocks and distortions, as highlighted in Figure 2.

Part III: Forecasts

Over the next decade, we forecast a modest rise in neutral rates across developed economies. For investors, this likely means short-term pain during the transition period, because rising rates tend to crimp equity and fixed income returns. However, once rates reach their new, higher equilibrium, long-term returns will be modestly higher.

Our neutral rate forecast depends on developments for underlying variables, some of which, like demographics, we can be quite certain of, while for others, like risk aversion and inequality, we accept more humility in forecasting.

In **Figure 7**, we present an overview of past and future expected drivers of the neutral rate. The first point to note is that many of the trends observed since the 1980s are expected to reverse over the next decade. Hence, we expect neutral rates to rise modestly from current low levels. In terms of the underlying drivers, we expect changes in productivity growth, risk aversion, demographics, and the global savings glut to place modest upward pressure on neutral rates this decade, based on the reasons outlined in the column on the right in Figure 7.

FIGURE 7.

Multiple factors are expected to place upward pressure on neutral rates

		1982–2020		Next 10 years		
Shifting factors		**Trend**	**Impact on r***	**Trend**	**Impact on r***	**Reasoning**
Investment	Productivity growth	Lower	Lower ▼	Higher	Higher ▲	Idea multiplier suggests a return to 1990s productivity growth†
	Relative price of capital	Lower	Lower ▼	Flat	Flat ◆	Rising labor costs offset higher business capital expenditures††
	Risk aversion	Higher	Lower ▼	Lower	Higher ▲	Lower expected returns = lower risk aversion†††
Savings	Demographics (share of young dependents)	Lower	Lower ▼	Higher	Higher ▲	Young working-age population increases for most countries
	Income inequality	Higher	Lower ▼	Flat	Flat ◆	Strong wage growth for low-wage workers suspends structural trends of increasing inequality
	Global savings glut	Higher	Lower ▼	Lower	Higher ▲	Slowdown in trade and declining trend growth for China‡

Sources: † Davis et al. (2020), †† Curtis et al. (2021), ††† Lian, Ma, and Wang (2019), and ‡ Lemco et al. (2021).

When we introduce these variable assumptions in our model, our estimation is for a modest increase in real neutral rates across our country set, ranging from approximately 0% in Switzerland in 2030 to approximately 2% in Australia (**Figure 8a**). These are median forecasts with a standard error band of plus or minus 175 basis points, but a few things jump out.

First, a return to 1980 or even 1990 neutral rates is highly unlikely considering the demographic landscape, a variable with a high degree of predictability. Such a return would require a huge positive fertility shock, on the scale of the post-World War II baby boom, and even then, the impact would not be felt for almost 20 years. As **Figure 8b** demonstrates, demographics are expected to contribute about 20 basis points to the overall median developed-market neutral rate increase of 110 basis points.

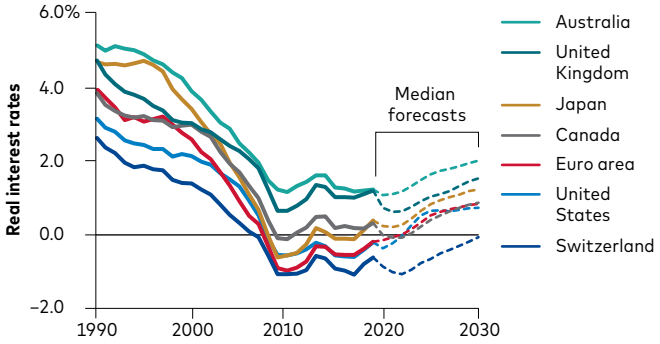
The other primary contributors, the global savings glut and risk aversion, constitute another 65 basis points and there are natural limits to any potential upside in these underlying variables. (For the increase that green investment could provide, see "Green investment could boost U.S. neutral rate by around 60 basis points by 2030" on page 14.)

While the COVID-19 pandemic had little effect on 2020 long-term neutral rates because of the remarkable economic and financial recovery, we anticipate that 2030 neutral rates will be 25 basis points higher because of productivity gains and a reduction in income inequality following the pandemic.[3]

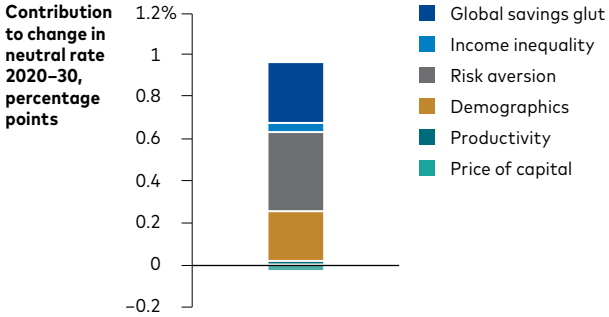
FIGURE 8.

How neutral rates might look in coming years

a. Neutral rates are expected to rise modestly this decade



b. Demographic contributors to rate increase



Sources: Vanguard model estimates, based on data from Penn World Tables, the Organisation for Economic Co-operation and Development, Our World in Data, the International Monetary Fund, the World Inequality Database, and the St. Louis Federal Reserve Database.

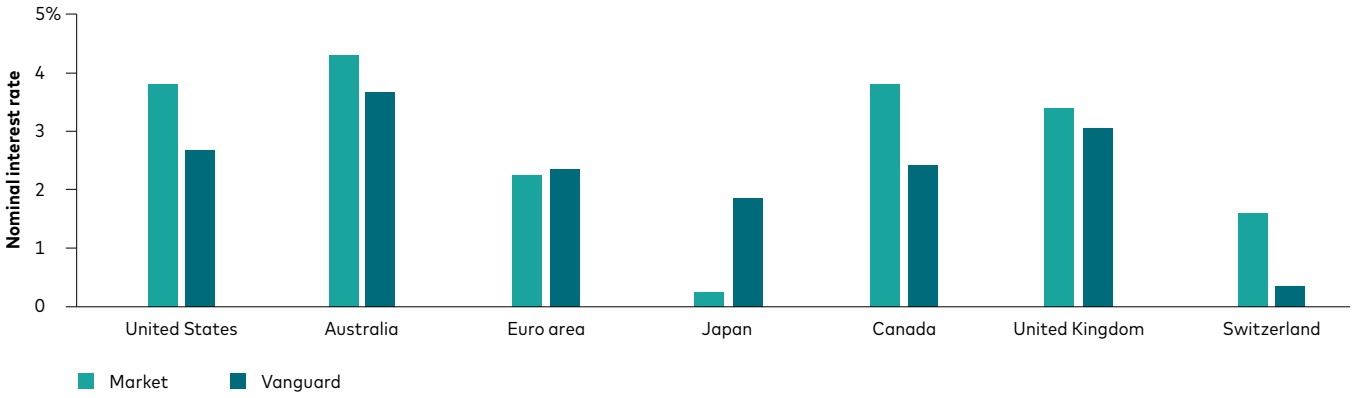
3 See Clark, D'Ambrosio, and Lepinteur (2020). We estimate that COVID-19 will have a negative net effect on intra-country income inequality (less inequality) for most developed economies over the 2020 decade but will raise inter-country inequality.

Recall that the neutral rate is the interest rate at which policy is neither expansionary nor contractionary. In the inflationary environment that most developed economies currently face, central bankers would desire to make fast progress toward contractionary policy to slow aggregate demand and restore supply/demand equilibrium.

This is precisely what current market pricing is suggesting, with the terminal rate for most economies above our neutral rate estimates, as shown in **Figure 9**. This suggests that the market believes that short-term headwinds will not impede further monetary tightening, as central banks' inflation mandate takes top priority.

FIGURE 9.

Markets are pricing a terminal rate higher than our neutral rate estimate this cycle



Notes: Vanguard neutral rate estimates are based on a 2025 real neutral rate forecast plus a 2% inflation assumption for the U.S., Australia, and Canada; a 1.8% assumption for the euro area; and a 1% assumption for Switzerland and Japan. The market terminal rate is the maximum overnight indexed swap implied rate between 2022 and 2027 as of June 17, 2022.

Sources: Vanguard calculations, based on data from Bloomberg.

Green investment could boost U.S. neutral rate by around 60 basis points by 2030

Green investments made to combat the damaging effects of climate change have the potential to raise neutral rates. We've analyzed the likely impact of green investment on the U.S. neutral rate in a scenario consistent with the goal of net zero carbon dioxide emissions by 2050 under a given set of assumptions.[4]

Estimates of the additional annual investment required to reach net zero by 2050 range from 0.5% to 3.0% of GDP, according to various studies.[5] This is consistent with our view outlined in Westaway et al., 2022.

We use these estimates to quantify the impact of the green transition on neutral rates. This is based on the empirical relationship between investment (percent of GDP) and neutral rates, as found by Rachel and Smith (2015).

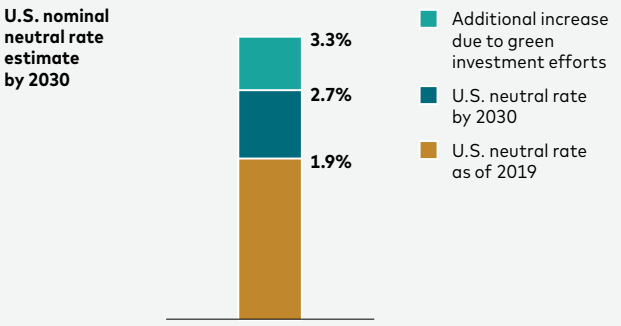
There are reasons to argue for a higher impact for green investment on neutral rates than implied by these estimates, because these were based on "traditional" investment needs. Green-spending multipliers are estimated to be potentially twice as large as for traditional carbon-based spending (see Batini et al., 2021). This would imply a steeper investment schedule for green investment, and in turn a larger effect on equilibrium neutral rates.

There is a large degree of uncertainty in those estimates. Vanguard proprietary research found that "the extent to which additional investment boosts long-run economic growth will depend on the type of investment implemented and the degree to which the private sector is crowded out, among other factors" (Westaway et al., 2022). Additionally, the degree and speed of the decline in fossil fuel investment because of the green transition will likely also influence the effect of the green transition on neutral rates.

Overall, we estimate the green transition could boost the U.S. neutral rate by a range of 10 basis points to 100 basis points, depending on assumptions for the required investment needs. **Graph A** shows an estimated midpoint of the impact.

GRAPH A.

Green investment could boost the U.S. neutral rate by about 60 basis points



Source: Vanguard, as of April 2022.

4 The United Nations Intergovernmental Panel on Climate Change (IPCC) has formulated several Representation Concentration Pathways (RCPs). Each RCP represents a different trajectory for global warming and greenhouse gas emissions over time. RCP1.9 is consistent with global warming of up to 1.5° centigrade. This is consistent with the aspirational goal of the Paris Agreement.

5 See Lenaert, Tagliapietra, and Wolff, 2021. For instance, the International Renewable Energy Agency (IRENA) projects about 3% of GDP of additional investment needs. Also, please refer to Westaway et al. (2022).

Conclusion: Lower for not much longer

The secular decline in real interest rates over the past 40 years has been a key determinant of global economic growth, fiscal and monetary policy, and asset returns, as well as the subject of inquiry. While, in hindsight, the drivers behind lower interest rates were evident, few economists in the 1980s predicted a decline on the scale of what we've witnessed, and even fewer could have foreseen a world of negative nominal interest rates. This decline signifies a fundamentally lower interest rate for the savings and investments equilibrium, or long-run neutral rate, and reflects both regional and global factors.

Under our econometric framework, we estimate that the median developed-market neutral rate has fallen by roughly 400 basis points over the last four decades, with demographics alone accounting for almost half this decline. Along with other factors that have placed downward pressure on real neutral rates, our 2019 median estimate (the most recent year for which we have full data) for developed economies is between 0.2% and 0.6%.

The factors that have contributed to the 40-year 400-basis-point decline in real neutral rates are abating, and in some cases reversing. Therefore, we forecast a modest rise in neutral rates across developed economies ranging from 0 percentage points in Switzerland in 2030 to 2 percentage points in Australia. While not a direct component of our econometric model, additional green investment to reach carbon neutrality could boost rates by another 60 basis points.

While a modest rise in interest rates may create short-term headwinds for equity and bond prices—higher interest rates result in price declines for bonds and, all else equal, reduce equity valuations—higher rates also suggest higher forward-looking asset returns via higher yields on bonds and greater potential equity valuation expansion.

References

Bai, Jushan, and Serena Ng, 2004. *A Panic Attack on Unit Roots and Cointegration*. Boston College Working Paper No. 519. Chestnut Hill, Mass.: Department of Economics, Boston College.

Batini, Nicoletta, Giovanni Melina, Mario di Serio, and Matteo Fragetta, 2021. *Building Back Better: How Big Are Green Spending Multipliers?* International Monetary Fund Working Paper No. 2021/087. Washington, D.C.: International Monetary Fund.

Bernanke, B.S., 2005. *The Global Saving Glut and the U.S. Current Account Deficit*. Remarks at the Sandridge Lecture, Virginia Association of Economists, Richmond, Va., March 10, 2005.

Brand, Claus, Marcin Bielecki, and Adrian Penalver, 2018. *The Natural Rate of Interest: Estimates, Drivers and Challenges to Monetary Policy*. Occasional Paper Series No. 217. Frankfurt am Main, Germany: European Central Bank.

Christensen, Jens H.E., and Glenn D. Rudebusch, 2019. *A New Normal for Interest Rates? Evidence From Inflation-Indexed Debt*. Federal Reserve Bank of San Francisco Working Paper 2017–07. San Francisco, Calif.: Federal Reserve Bank of San Francisco.

Clark, Andrew E., Conchita D'Ambrosio, and Anthony Lepinteur, 2020. *The Fall in Income Inequality during COVID-19 in Five European Countries*. Working Papers 565, ECINEQ, Society for the Study of Economic Inequality.

Curtis, E. Mark, Daniel G. Garrett, Eric C. Ohrn, Kevin A. Roberts, and Juan Carlos Suárez Serrato, 2021. *Capital Investment and Labor Demand*. National Bureau of Economic Research Working Paper No. w29485. Cambridge, Mass.: National Bureau of Economic Research.

Davis, Joseph, Qian Wang, Andrew Patterson, Adam J. Schickling, and Asawari Sathe, 2020. *The Idea Multiplier: An Acceleration in Innovation Is Coming*. Valley Forge, Pa.: The Vanguard Group.

Eggertsson, Gauti B., and Neil R. Mehrotra, 2014. *A Model of Secular Stagnation*. National Bureau of Economic Research Working Paper No. 20574. Cambridge, Mass.: National Bureau of Economic Research.

Fiorentini, Gabriele, Alessandro Galesi, Gabriel Pérez-Quirós, and Enrique Sentana, 2018. *The Rise and Fall of the Natural Interest Rate*. Banco de España Working Paper No. 1822. Madrid, Spain: Banco de España.

Gerali, Andrea, and Stefano Neri, 2017. *Natural Rates Across the Atlantic*. Bank of Italy Working Paper No. 1140. Rome, Italy: Bank of Italy.

Holston, Kathryn, Thomas Laubach, and John C. Williams, 2017. Measuring the Natural Rate of Interest: International Trends and Determinants. *Journal of International Economics* 108(1): S59–S75.

Kumhof, Michael, Romain Rancière, and Pablo Winant, 2015. Inequality, Leverage, and Crises. *American Economic Review* 105(3): 1217–45.

Laubach, Thomas, and John C. Williams, 2003. Measuring the Natural Rate of Interest. *The Review of Economics and Statistics* 85(4): 1063–70.

Lemco, Jonathan, Asawari Sathe, Adam J. Schickling, Maximilian Wieland, and Beatrice Yeo, 2021. *The Deglobalization Myth(s)*. Valley Forge, Pa.: The Vanguard Group.

Lenaerts, Klaas, Simone Tagliapietra, and Guntram B. Wolff, 2021. *How Much Investment Do We Need to Reach Net Zero?* Blog post. Bruegel.org. Brussels, Belgium: Bruegel.

Lian, Chen, Yueran Ma, and Carmen Wang, 2019. Low Interest Rates and Risk-Taking: Evidence from Individual Investment Decisions. *The Review of Financial Studies* 32(6): 2107–2148.

Rachel, Lukasz, and Thomas D. Smith, 2015. *Secular Drivers of the Global Real Interest Rate*. Bank of England Staff Working Paper 571. London, England: Bank of England.

Rachel, Lukasz, and Thomas Smith, 2017. Are Low Real Interest Rates Here to Stay? *International Journal of Central Banking* 13(3): 1–42.

Pedroni, Peter, 2004. Panel Cointegration: Asymptotic and Finite Sample Properties of Pooled Time Series Tests With an Application to the PPP Hypothesis. *Econometric Theory* 20: 597–625.

Smets, Frank, and Rafael Wouters, 2007. Shocks and Frictions in US Business Cycles: A Bayesian DSGE Approach. *American Economic Review* 97(3): 586–606.

Westaway, Peter, Shaan Raithatha, Haifeng Wang, Griffin Tory, and Joseph Davis, 2022. *The Economics of Climate Change*. Valley Forge, Pa.: The Vanguard Group.

Appendix

FIGURE A-1

Background: Key approaches to modeling neutral rates

Approach	Description	Example
Reduced form models	The long-term neutral rate is estimated as a function of key long-term drivers, using a univariate or multivariate linear regression.	Fiorentini et al. (2018)
Semi-structural models	The long-term neutral rate is estimated using a structural model. The most famous of these is Holston Laubach Williams, where the neutral rate is the rate at which the economy is at full strength with stable inflation.	Laubach and Williams (2003) Holston, Laubach, and Williams (2019)
Macro-finance models	Long-term neutral rate estimates are extracted from financial markets data using term-structure models.	Christensen and Rudebusch (2017)
DSGE models	The short-term neutral rate is estimated using a general equilibrium model.	Smets and Wouters (2007), Gerali and Neri (2017), or Brand, Bielecki, and Penalver (2018)

Source: Vanguard.

FIGURE A-2

Developed markets in our study

Developed-market economies	Markets
North America	United States
	Canada
Euro area	Austria
	Belgium
	Finland
	France
	Germany
	Italy
	Luxembourg
	Netherlands
	Portugal
	Slovakia
	Slovenia
	Spain
Other developed markets in Europe (EU, European Economic Area, and others) and Middle East	Denmark
	Sweden
	Norway
	Switzerland
	Israel
	United Kingdom
Other developed markets	Australia
	Japan
	New Zealand
	South Korea

Notes: Our estimates of the neutral rate are on a yearly basis, from 1982 to 2019. We estimate the neutral rate (real) for 24 developed-market economies.
Source: Vanguard.

FIGURE A-3

The variables

Variable	Description	Source
Real short-term interest rate	Nominal annual short-term interest rate (3-month) minus two-year average of annual inflation	Organisation for Economic Co-operation and Development (OECD)
Productivity growth	Total factor productivity growth, yearly and in %	Penn World Table 10.0
Demographics	Young share, defined as the share of those 15–24 compared with those 15–64	Our World in Data
Risk aversion	Average of 1) equity market spread (earnings yield minus 20-year government bond yield), 2) fixed income spread (BAA yield minus 20-year government bond yield), and 3) bank credit spread (lending minus deposit rate)	Federal Reserve Economic Data, Bloomberg (not country-specific)
Relative price of capital	Price of capital relative to consumption	OECD
Global savings glut	China current account, % of GDP	International Monetary Fund (not country-specific)
Inequality	Income of top 10% compared with that of bottom 50%	World Inequality Database

Notes: We include seven variables in our data set, all on a yearly basis. These are the short-term real interest rate, as well as the six variables that drive developments in the neutral rate in our analysis. We include four-year moving averages of the driver variables to smooth out cyclical fluctuations.

Source: Vanguard.

FIGURE A-4

Estimation

We proceed in three steps to estimate the neutral rate: i.) panel unit root testing, ii.) cointegration testing, and iii.) estimating the cointegrating relationship.

i.) Panel unit root testing

We use Bai and Ng's (2004) Panel Analysis of Nonstationarity in Idiosyncratic and Common Components (PANIC) to test for unit roots. This test belongs to the category of *second-generation panel unit root tests*, which relax the assumption of cross-sectional independence.

So-called first-generation *panel unit root tests* have assumed cross-sectional independence, which can be difficult to justify for our purposes as cross-sections will likely be influenced by common forces. The PANIC test is based on a factor model in which nonstationarity can arise from either common factors or idiosyncratic components, or both.[6] All variables in our model are nonstationary based on the PANIC test.

6 See Bai and Ng (2004). Also see http://www.eviews.com/help/helpintro.html#page/content%2Fadvtimeser-Cross-sectionally_Dependent_Panel_Unit_Root_Test.html%23ww196898

ii.) Cointegration testing

To test for cointegration between the variables, we use the Pedroni (2004) test, which extends the Engle-Granger framework to cointegration testing involving panel data. Pedroni proposes tests for cointegration that allow for heterogenous intercepts as well as trend coefficients across cross-sections. Under the null hypothesis of no cointegration, the residuals of the spurious regression should be I(0), or ρ = 1. The null is tested against two alternative hypotheses: 1) the homogenous alternative (ρ = ρ <1) and 2) the heterogenous alternative ($\rho_i = \rho < 1$). Our variables can be cointegrated according to the Pedroni test.

$$y_{i,t} = \alpha_i + \delta_{i,t} + \beta_{1i}x_{1i,t} + \beta_{2i}x_{2i,t} + \cdots + \beta_{Mi}x_{Mi,t} + e_{i,t}$$

$$e_{i,t} = p_i e_{i,t-1} + u_{i,t}$$

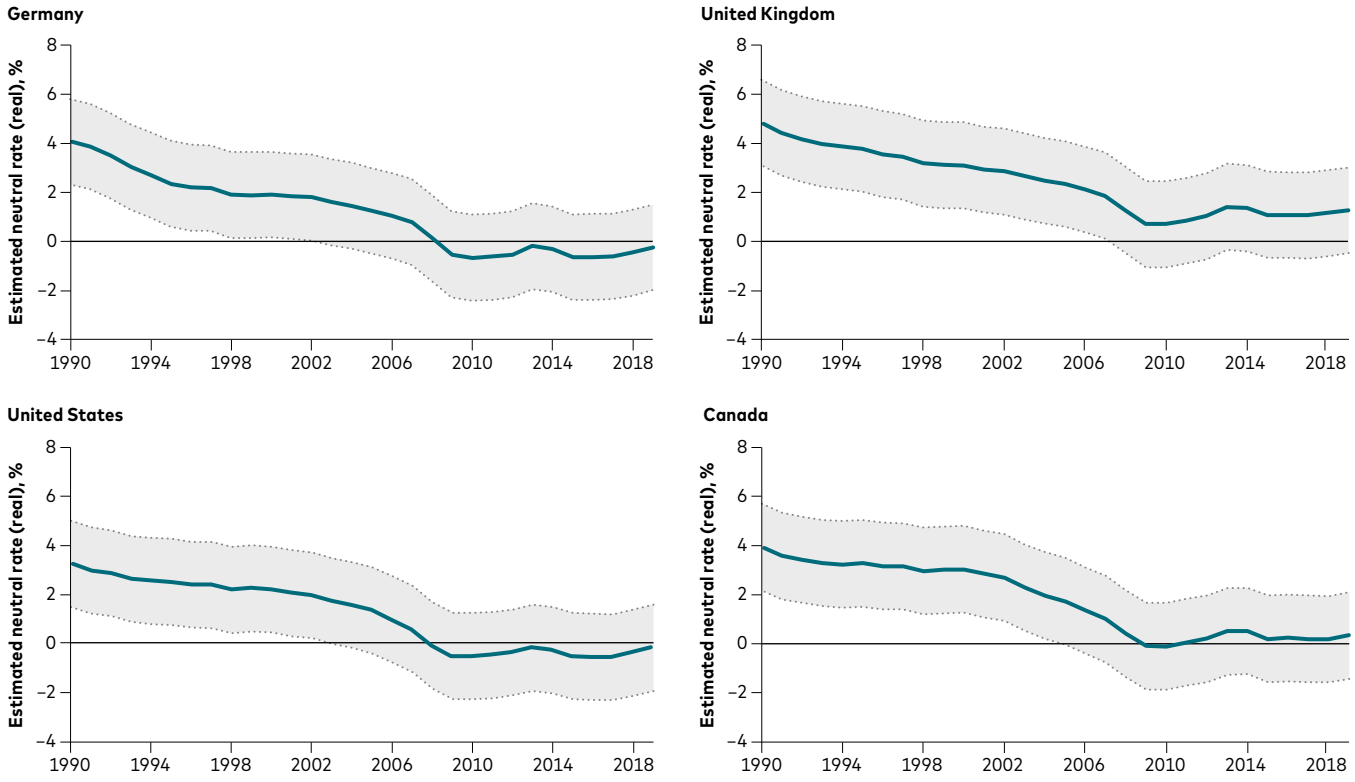
iii.) Estimating the cointegrating relationship

Finally, we estimate the cointegrating relationship between the six drivers and the real short-term interest rate. This long-run cointegrating relationship is the source of our neutral rate estimate. We use Fully Modified OLS (FMOLS) because if we estimate this via normal OLS, the associated standard errors are not consistently estimated. FMOLS employs a semi-parametric correction to eliminate this problem. It is asymptotically unbiased and has fully efficient normal asymptotics.[7]

The above implies that we are able to estimate neutral rates across countries and over time, allowing for country-specific intercepts, and assuming a homogenous cointegrating vector.

FIGURE A-5

Inherent uncertainty around neutral rate estimation



Note: One standard error (68%) confidence interval.
Source: Vanguard.

7 See Pedroni (2004). Also see http://www.eviews.com/help/helpintro.html#page/content%2Fnsreg-Estimating_a_Cointegrating_Regression.html%23ww256789

FIGURE A-6

Region-specific estimates as of the end of 2019

Top third Middle third Bottom third

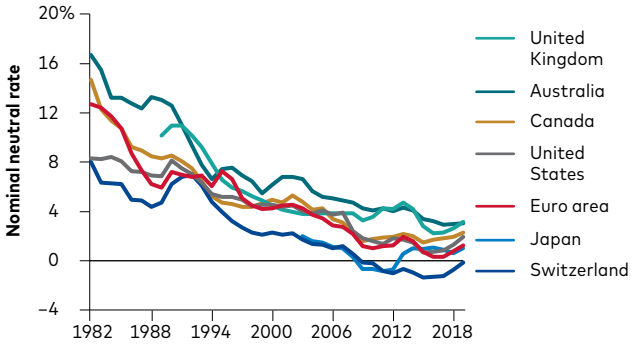
	r* (nominal)	r* (real)
Australia	**3.0** Top	**1.2** Top
Austria	**1.3** Middle	**–0.5** Bottom
Belgium	**2.1** Top	**0.3** Middle
Canada	**2.2** Top	**0.3** Middle
Denmark	**2.7** Top	**2.0** Top
Finland	**2.0** Middle	**1.0** Top
France	**1.9** Middle	**0.7** Top
Germany	**1.2** Middle	**–0.3** Bottom
Israel	**1.5** Middle	**1.1** Top
Italy	**0.7** Bottom	**–0.1** Middle
Japan	**1.0** Bottom	**0.4** Middle
Luxembourg	**1.2** Bottom	**–0.1** Middle
Netherlands	**1.9** Middle	**0.4** Middle
New Zealand	**4.4** Top	**2.7** Top
Norway	**4.1** Top	**1.6** Top
Portugal	**–0.1** Bottom	**–0.9** Bottom
Slovakia	**–1.6** Bottom	**–3.1** Bottom
Slovenia	**0.1** Bottom	**–1.0** Bottom
South Korea	**1.3** Middle	**0.1** Middle
Spain	**0.0** Bottom	**–1.0** Bottom
Sweden	**2.7** Top	**1.0** Top
Switzerland	**–0.2** Bottom	**–0.6** Bottom
United Kingdom	**3.2** Top	**1.2** Top
United States	**1.9** Middle	**–0.2** Bottom
Euro area	**1.2** Middle	**–0.2** Middle
Developed markets (Median)	**1.7** Middle	**0.3** Middle

Note: The nominal neutral rates assume a 1% steady-state inflation for Japan and a 2% steady-state inflation for all other countries in our sample.

Source: Vanguard, as of April 2022.

FIGURE A-7

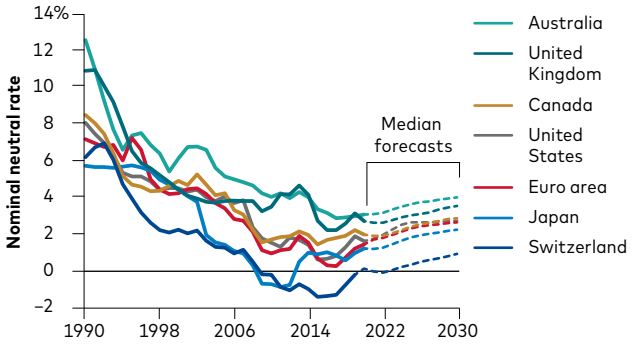
Nominal neutral rate estimates over time



Source: Vanguard; for underlying data see Figure A-2 in the Appendix.

FIGURE A-8

Nominal neutral rate forecasts



Note: There is a 2% inflation assumption for the U.S., Canada, Australia, and the U.K., a 1.8% assumption for the euro area, and a 1% assumption for Switzerland and Japan.

Source: Vanguard; for underlying data see **Figure A-2** in the Appendix.

Connect with Vanguard®
vanguard.com

Vanguard®

All investing is subject to risk, including the possible loss of the money you invest.

Investments in bonds are subject to interest rate, credit, and inflation risk.

CFA® is a registered trademark owned by CFA Institute.

ISGENRC 062022