Invited Editorial “The challenges imposed by low interest rates”

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Introduction

Jean-Michel Beacco, CEO of the Institut Louis Bachelier

More than 10 years after the worst financial crisis of the post-war period, it is clear that the global economy and the global financial system are still vulnerable. Admittedly, the unconventional monetary arsenals deployed massively by the central banks of the major developed countries have been very effective, but the offensive strategy of quantitative easing is not without risks for finance and the real economy. In fact, at the end of January the International Monetary Fund (IMF) expressed concern about the economic slowdown in advanced countries and China, as well as the high volatility of stock markets.

More recently, the OECD (Organization for Economic Co-operation and Development) has published figures showing that indebtedness is steadily increasing. Between 2007 and 2018, the debt-to-GDP ratio increased from 49.5 to 72.6% in OECD countries. New sovereign bond issues will be in excess \$2 trillion this year. At the same time, the reduction in asset purchases by central banks is likely to complicate countries' situation with regard to financing. On the corporate side, the picture is not much better, in view of the higher risk profile of companies compared to sovereign states. Thus, OECD figures show that the value

of outstanding bonds issued by non-financial companies reached an all-time high of \$13 trillion at the end of 2018.

And in this regard, if we are to believe the OECD, the situation is fraught with dangers. “The risks and vulnerabilities in the corporate debt market are also significantly different from that of the previous pre-crisis cycle. The share of lowest quality investment grade bonds stands at 54%, a historical high, and there has been a marked decrease in bondholder rights that could amplify negative effects in the event of market stress. At the same time, in the case of a financial shock similar to 2008, USD 500 billion worth of corporate bonds would migrate to the non-investment grade market within a year, forcing sales that are hard to absorb by non-investment grade investors”.

Given these growing concerns, a rise in interest rates, already implemented in the USA and expected in Europe at the end of the year, or now next year, could create additional disruption. In this finely balanced context, scientific research can provide answers and recommendations for regulators and actors in the sector. In fact, the 2019 edition of the Financial Risks International Forum focussed on low-interest rate environment. During the event, academic researchers from around the world and financial professionals discussed how to improve the sector's practices, with a view to limiting risks and seeking out opportunities. Echoing this theme, five researchers specialized in interest rates and systemic risk offer analyses. Their contributions provide particularly pertinent explanations for understanding the current situation and for getting a clearer outlook on future developments.

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Supply and demand effects play a much larger part than previously in explaining the low levels of long-term rates

Catherine Lubochinsky, professor at the University of Paris 2

With the monetary policies adopted by Central Banks after the 2008 financial crisis, interest rates in Western countries fell to unprecedented levels. While the financial markets and investors have done relatively well and the economy has held up, the main factors accounting for interest rates are not the same as in the past. And future rate increases are grounds for concern for the world of finance. To clarify the situation, Catherine Lubochinsky answers to questions.

ILB: Before addressing the central issue, could you first give us a definition of interest rates?

Catherine Lubochinsky: An interest rate is an intertemporal relative price. It is the price of a good in relation to itself for a deferred exchange over time. Each good has its own interest rate, but since we are in a system of instantaneous relative prices expressed in monetary units, the same applies to interest rates. In other words, a euro today does not have the same value as a euro at a future date (provided that the interest rate is not zero). Moreover, the interest rate is a crucial variable, since it always affects decision-making and has an impact on real economic elements (investment, consumption, housing) and all monetary and financial assets.

ILB: What are the classic determinants of interest rates? And what does economic theory say on this topic?

CL: Before answering in detail, we should first recall the distinction made by Fisher in 1930. He was the first to point out that the nominal interest rate, the rate we observe, has two components: the real interest rate and expectations regarding inflation. All subsequent economic theories have sought to explain the level of real interest rates. For classical and neoclassical economics, the interest rate results from the confrontation between investment and savings. At equilibrium, the real interest rate makes it possible to equalize the marginal productivity of capital with the marginal rate of intertemporal substitution of consumption. This rate is known as the natural rate. Such thinking focuses on the real determinants of interest rates. Keynesian inspired theories, on the other hand, focus on monetary determinants, with the interest rate emerging from the balance between the supply of and demand for money. The supply of money is exogenous because it is controlled by the central bank. The demand for money, which is partly linked to the impact of speculation, depends on the interest rate. In this reasoning,

speculation is to be understood in the Keynesian sense, as a trade-off between monetary and financial assets. These two traditional approaches do not contradict each other, but can be complementary. Subsequently, in the light of further research, the focus shifted from a single interest rate to interest rate curves, mainly by distinguishing short and long-term rates, because their formation mechanisms are not quite same.

According to an economist at the Bank of England, the interest rates of the last few years are at their lowest point in 5000 years. Do you share this view?

CL: In 2015, Andrew Haldane, Chief Economist of the Bank of England, showed a chart representing interest rates over the last 5000 years. And it is true, nominal interest rates have never been so low. We can also see that the highest ever interest rates in Western countries were recorded following the second oil shock. However, when we look at the recent situation, we need to emphasize Fisher's distinction. For long-term nominal rates, the situation is very clear, since they have never been so low. On the other hand, for long-term real interest rates, the situation is rather different, since there have been past episodes in which they were very low, or even negative, during periods of rising inflation, especially in the 1970s, due to errors in inflation expectations.

In recent years, real interest rates have been negative despite low inflation. How can this atypical phenomenon be accounted for?

CL: It is true that the current situation is very different from what we have seen in the past: real interest rates are negative in the absence of inflation. This is due to the severity of the 2008 financial crisis and the responses of central banks, which massively injected liquidity and sharply lowered their policy interest rates to 0% (the zero lower bound).

Is economic theory able to account for this situation?

CL: Short-term rates are driven by central banks, through their policy rates. Prior to the monetary tightening by the US Federal Reserve in recent months, they were close to zero. On this side of the Atlantic, In Europe, they are still close to 0%. Adding a little inflation, even 1%, to these near-zero rates means that real short-term rates are negative. For long-term rates, it is another matter. Traditionally, the explanation was based on two distinct lines of thinking.

- The first is based on expectations theory, in which long rates result from short rates plus expected future short rates. If agents anticipate higher future short rates, long rates will necessarily be higher than current short rates.
- The second is based on risk premiums. In the case of sovereign bonds, deemed to be free of default risk and (market) liquidity risk, there is what is known as the "term premium". For Keynesians, this amounts to a renunciation of the liquidity service provided by money, which must be remunerated. Another consideration is that when

an investor or a saver buys a long-term security, the variability of interest rates, and therefore of prices, creates a risk of losses that requires a risk premium. In addition, there is also the risk related to inflation (when there is any), in view of errors in anticipation, which can also generate a further risk premium. Nevertheless, these factors do not really explain the current level of long-term rates.

Why is that?

CL: Because the direct quantitative effects are very large. The explanatory variable for the level of long-term interest rates is simply linked to the very high demand for sovereign debt. This demand has been fuelled by massive sovereign debt buy-backs by central banks combined with quantitative easing, which has led to higher bond prices and thus lower long-term rates. Central banks have intervened directly to reduce long-term rates because these correspond to the cost of financing investment and public deficits. Supply/demand effects play a much larger part than previously in explaining the low levels of long-term rates. Indeed, despite the rise in short-term rates in the USA, long-term interest rates remain low and are still falling, particularly in the last quarter of 2018. In recent months, it appears that risk aversion has returned and that investors are turning away from equities and corporate bonds in favour of sovereign debt, thereby accentuating the weakness of long-term rates. It should be pointed out, however, that this phenomenon of falling long-term rates had begun before the financial crisis, with the marked disequilibria of some countries' current account balances, as in the early 2000s when China was directly purchasing massive amounts of US debt.

What are the main risks stemming from rising US interest rates? And what can be expected in the coming months in Europe?

CL: As of early 2019, the stock of negative-rate public debt amounted to more than \$8 trillion. When interest rates rise, investors' portfolios will inevitably suffer capital losses. For debt-issuing countries, the cost of financing themselves will be higher, which could in turn have repercussions for the sustainability of their debts, since this factor is dependent on a growth rate higher than the real interest rate.

Do you consider that these unconventional monetary policies have been effective?

CL: Without unconventional monetary policies, the recessions on both sides of the Atlantic would have been deeper. In this regard, we can say that the actions of central banks have worked, despite the adverse effects associated with them.

What are these effects?

CL: Bubbles have been created in some equity markets and corrections can be expected, as occurred in December 2018. Real-estate prices are starting to rise again:

households took out loans to purchase property in response to the low interest rates. At the same time, the short-term supply stock is inelastic, more specifically in some areas like central Paris, which automatically raises prices per square metre. Finally, some companies, especially in the USA, have become heavily indebted in order to buy back shares and pay their shareholders higher dividends, instead of making value-creating investments.

In conclusion, how do you see the future evolution of interest rates?

CL: Despite the rise in short-term rates in the USA and their likely rise in Europe by next year, there is little reason for long-term rates to rise, as the overall productivity of the factors of production (capital and labour) is not very high. The authorities are concerned about the weakness of potential growth. Moreover, in the USA, where there is full employment, we see that long-term rates are not rising. On the other hand, we can expect a rise in investors' risk aversion and therefore a rise in risk premiums, with a widening of the gap between sovereign debt rates and corporate bond rates, with corporate indebtedness having increased significantly in the context of slowing economic activity.

How are institutional investors reacting to low interest rates?

Marie Brière, Head of the Investor Research Centre at Amundi and affiliate professor at PSL Paris-Dauphine University

The low-interest rate environment is a challenge for investors who need to reorient their investment strategies towards more profitable asset classes. This difficult situation, by no means devoid of financial risks, is addressed by Marie Brière, whose standpoint is particularly interesting in lying between the professional and academic spheres.

ILB: The current low level of interest rates seems to be unprecedented. Is this really so?

Marie Brière: The decline in long-term interest rates has been a trend since the 1980s. We have moved from a very high-interest rate regime in the 1970s, marked by two inflationary events (the 1973 and 1979 oil shocks), to a new regime in which rates are structurally lower. This gradual and generalized shift began in the 1980s during the «Great Moderation», during which the main macroeconomic variables, including growth and inflation, were less volatile. Today, 17% of all bonds issued come with negative rates (Deutsche Bank, 2018). This exceptional situation, a consequence of the subprime crisis and the unconventional monetary policies that followed, may well continue.

What are the implications of low interest rates for institutional investors?

MB: The performance of the traditional asset classes, namely equities and bonds, has been reduced due to lower risk-free interest rates and the compression of risk premiums, related in particular to investors' search for yield. Investors are opting for riskier and less liquid assets, thus increasing prices and squeezing their expected returns. The low-interest rate environment also affects the balance sheets of institutional investors, in particular insurers and pension funds, which have commitments embodied in their liabilities.

To what extent are the balance sheets of institutional investors under pressure?

MB: In the balance sheet of insurance companies and pension funds, the assets invested are performing less well, while the fall in rates automatically increases the value of liabilities, discounted at market value with the current accounting and prudential regulations. According to the latest stress tests on pension funds in Europe, carried out in 2017 by the European Insurance and Occupational Pensions Authority (EIOPA), the overall underfunding of occupational pension funds was estimated at 349 billion euros, or an average deficit of around 20% of the value of liabilities, with significant disparities from country to country.

Are the regulations at fault?

MB: The regulators are not the cause of the current difficulties faced by pension funds. Rather pension funds balance sheets have deteriorated because of low interest rates, as well as from the increasing life expectancy of beneficiaries. However, prudential regulations that require regulatory capital to be set aside in the event of an imbalance between assets and liabilities, together with accounting standards oriented towards marked-to-market valuations, naturally accentuate the problems, even though they did not trigger them.

So how are insurance companies and pension funds reacting?

MB: We are seeing is a structural shift towards a reduction in the guarantees offered, with a transfer of risks to individuals. This is evident with insurance companies, which now prefer to sell unit-linked contracts rather than euro funds with guaranteed capital. It is similar with regard to pension funds. In some countries (US, UK, Switzerland), there has been a shift from funds with defined benefits to defined contributions pension funds. In the Netherlands and the UK, we are witnessing the creation of «hybrid» funds, where risks are shared between the pension funds-sponsoring company and the contributing employees, who are the future beneficiaries. In such cases, retirement pensions may depend on the performance of the financial markets or on changes in longevity. This sharing of risks can be quite effective and even relatively attractive for individuals (on this topic see Boon et al. Boon 2018),¹ and it limits financial institutions' costly requirement for regulatory capital.

What are the consequences for individuals?

MB: The consequence of this phenomenon is a reallocation of risks towards individuals, since financial institutions play the role of financial intermediation and distribute financial products with more limited risk of loss. The low rates also have implications for intergenerational risk sharing, with a potential reduction of benefits larger for younger generations compared to older generations. Lastly, we can expect an increase in the supply of work and savings demand and a redistribution of wealth (see the paper by Horneff and Mitchell (2018)² presented at the Financial Risks International Forum).

Let us go back to institutional investors. What are their strategies for generating returns?

MB: Investors have been turning much more towards alternative assets since the financial crisis. In recent years, real estate and private equity have benefitted. According to the work of Ivashina and Lerner (2018)³ also presented at the Financial Risks International Forum, there has been a large reallocation towards alternative assets, which are supposed to be more remunerative, because they are less liquid. There is, however, a debate within the academic community about this asset class. Does the extra return over liquid assets remunerate a liquidity premium or instead a higher risk that is poorly measured because of the relative lack of transactions data? Although this question has not been settled, investors nonetheless are moving massively in this direction, as evidenced by the rise in outstanding assets invested on this asset class in developed countries, which increased by 63% between 2008 and 2017, according to the study mentioned above. Another investor trend is the adoption of active systematic smart beta or factor strategies that outperform passive strategies. Active strategies are, in fact, supposed to capture additional risk premiums and therefore higher returns.

Do these new strategies generate more risk?

MB: Passive strategies based on traditional indexes weighted by market capitalization induce hardly any portfolio turnover, unlike systematic active strategies. The risk lies in investors' possible herd behaviour (the crowding effect). If they adopt similar active strategies in buying and selling the same securities, this may accentuate funding risk in the case of coincident clients' redemption requests, and hence potentially stronger coincident price declines in the markets. As shown by the work of Fontaine et al. (2016),⁴ and Cho (2019),⁵ equity markets have been more exposed to such funding risk since the mid-1990s.

Are the risks of contagion higher?

MB: Yes, this can generate new correlations between certain securities that were not linked at all previously.

To conclude, are these investment strategies resulting from low interest rates bubble vectors?

MB: It is always very difficult to show the existence of a bubble before it bursts. Nevertheless, when investors move

simultaneously and massively into an asset class, it is obvious that valuations increase sharply, which can result in bubbles that may subsequently burst

Econometrics in the face of low interest rates

Alain Monfort, honorary professor at ENSAE-CREST

The low-interest rate environment raises many problems for researchers in econometrics, one of whose objectives is to develop interest rate models that correspond better to reality. This situation calls for models reflecting the possibility that short-term interest rates may be negative. To address this complex and crucial subject, Alain Monfort answers questions.

ILB: What are the main challenges faced by econometricians in modelling interest rates?

Alain Monfort: Interest rates behave in a variety of ways depending on residual maturities. It is not easy to find a parsimonious model, that is to say a model with a reasonable number of variables and parameters, that can account for the heterogeneity of interest rates. There is a delicate balance to be struck between the capacity of models to reproduce relatively detailed phenomena that are close to reality, on the one hand, and ease of estimation and use, on the other. These difficulties are illustrated, for example, by the long-standing situation in Japan, and more recently in Europe, where short-term rates may be relatively stable at low or even negative levels, while average or long-term rates continue to fluctuate, with, in addition, volatilities that depend on maturity dates.

What decisive choices do econometricians have to make in modelling interest rates?

AM: The first key decision in the econometric modelling of interest rates is the choice of factors, or state variables, that are supposed to represent the economic environment. In particular, we need to determine whether these factors are observable or latent. For observable factors, we have to decide whether or not they are solely functions of the rate curve. In the first case, a "yield only" approach is chosen and the most frequently factors used are: the mean level of the curve, a measure of its slope and a measure of its curvature. In the second case, certain factors are macroeconomic variables (GDP growth rate, inflation, unemployment), which lead to a macro-finance model.

Another important decision is the choice of the dynamics of these factors, which may be continuous time or discrete time. Central Banks have generally chosen discrete-time models, for various reasons. First, continuous-time models have to be discretized in any case in order to be estimated. Second, discretized versions of classical continuous-time models are often approximations and have difficulty taking into account that features are easily handled by discrete-time

models, such as interaction delays between variables or switching regimes stemming from the onset or ending of crises. In addition, discrete-time models can directly integrate advances in econometric methods, which are always developed in discrete time. Finally, discrete-time affine models can meet the challenges arising from low rates, through certain well-adapted technical properties.

What are the advantageous properties of these discrete-time affine models?

AM: Discrete-time affine models offer various possibilities such as: the ability to generate trajectories that remain constant for a certain time, the introduction of flexible specifications of rate volatilities, ease of calculation of forecasts and of their accuracy, calculation of "lift-off" probabilities (such as the probability that a rate leaves a given area), the relatively simple estimation of parameters even when the observation frequencies are different, and the filtering or smoothing of the latent factors.

Could you tell us more about these discrete-time affine models?

AM: Contrary to what the term affine might suggest, this class of models is very extensive. It includes, for example, Gaussian autoregressive models, Gamma autoregressive models (which have positive values), compound Poisson models (with integer values) and Wishart processes (with values in the set of positive definite symmetric matrices). It also includes Markov chains, which allows regime changes to be introduced into the above-mentioned models. In addition, by increasing the initial size of the factors, it is possible to take into account non-Markov models, such as certain GARCH (generalized autoregressive conditional heteroscedastic) models.

Do these affine models enable financial assets to be priced over time?

AM: Yes, but it is necessary to specify a stochastic discount factor that takes into account risk aversion, in particular. This variable allows us to bridge the historical dynamics of factors and their "risk-neutral" dynamics, which is the central tool of valuation. If the stochastic discount factor, whose existence is implied by the hypothesis of the absence of arbitrage opportunities, is specified as an affine exponential function of the factors, and if the historical dynamics of the factors is affine, then their risk-neutral dynamics is also affine. Moreover, if the short rate is an affine function of the factors, the prices of many financial products are quasi-explicit functions of these factors. For example, the price of a zero coupon bond with a given residual maturity is an affine exponential function of the factors. Consequently, the corresponding interest rate is an affine function with coefficients, which are recursively calculable functions of maturity.

How has the academic literature evolved with regard to the affine modelling of rates?

AM: The most popular affine rate models are Gaussian with one or more factors, in particular the basic Vasicek one-factor model. In these models, the historical and risk-neutral dynamics of the factors are Gaussian VAR (vector autoregression). These models have obvious defects: the volatility of the factors, and therefore of the rates, is constant over time, which is in blatant contradiction with what is really observed. In addition, rates can take implausible negative values in all periods. To remedy this problem, a “shadow rate” academic literature has developed. In this literature, the short rate is assumed to be equal to the maximum of a shadow rate provided by a Gaussian model and a non-stochastic lower bound, which is often set to zero. This approach is relatively ad hoc. It destroys the affine character of the model and therefore its manoeuvrability, while always imposing constant volatilities for the shadow rate.

However, another approach allows us to stay in the affine world. This postulates that the short rate is equal to the sum of a lower bound and one or more positive or zero factors. These factors are embedded in an affine model, in which they are caused by other factors. These two characteristics make it possible both to generate short rates bonded to the lower bound during certain periods, while the other rates continue to fluctuate with stochastic volatility depending on their residual maturity. They also make it easy to calculate lift-off probabilities, in particular probabilities that the short rate leaves the lower bound or rises above a certain threshold.

How can discrete-time affine models reflect negative rates and what are the impacts on econometric forecasts?

AM: To take account of the negative rates observed recently, particularly in Europe, some researchers have proposed replacing the lower theoretical econometrics and financial econometrics. Bound of the short rate by a non-stochastic and piecewise constant negative bound. Because the exogenous nature of this bound does not allow predictions to be made, a new class of affine models with an endogenous lower bound has been introduced. This bound may, for example, be taken as equal to the European Central Bank’s (ECB) deposit facility rate. Currently negative, this rate determines the amount banks receive when they deposit cash for twenty-four hours with the ECB. The affine nature of these new models guarantees the good properties mentioned above, to which can be added the possibility of evaluating “forward guidance” policies, that is to say, communication by the central bank, consisting, for example, of announcements regarding future values of the deposit facility rate.

In conclusion, is it possible to include default risk in these new models?

AM: The foregoing explanations concern the rates associated with risk-free zero coupon bonds, that is to say, providing with certainty a monetary unit at maturity. While this approach may be considered reasonable for certain

“sovereign” rates, the risk of default should be incorporated into the modelling of many countries’ rates, as has always been the case for corporate rates. In this area again, recent affine modelling, including during periods of low interest rates, can take into account important phenomena such as default risk, liquidity risk, systemic risk and contagion, as well as interactions between financial variables and real variables such as consumption. In the latter case, it is particularly important to be able to take account of variables whose observation frequencies are different, as is possible with discrete-time affine models.

How can the modelling of long-term interest rates be improved?

Caroline Hillairet, professor of finance and insurance, and head of the actuarial methods programme at ENSAE-CREST

The modelling of long-term interest rates is an essential issue for the financing of projects whose benefits will only be felt in the long term, such as retirement savings or environmental projects. Nevertheless, the low-interest rate policy introduced to revive the economy after the crisis is hardly compatible with the development of long-term projects. Researchers propose an innovative technique for perfecting traditional business models.

How should the public authorities arbitrate to finance long-term infrastructure? How many growth points should be sacrificed today to reduce global warming, given that the effects of such green projects are only visible much later in the future? More generally, what tools are available to the public authorities for assessing policies whose impact will only be felt several decades later? These various, non-exhaustive issues are the subject of debate, because traditional approaches, based on the theory of general equilibrium, are not always flexible and adaptive enough to apprehend the long-term. In particular, the issue of the heterogeneity of economic actors is often downplayed in concrete applications that use a simplified version of the theory. It is obvious that not all agents are homogeneous in their preference criteria and their decision-making, but the theory assumes that in equilibrium everything happens as if decisions were based on the optimal choice of a representative agent, whose preferences, measured by a utility function, take into account those of other agents.

Intuitively, it is clear that the behaviour of the representative agent is necessarily complex. For example, if the different agents are constantly risk averse (and therefore have a constant power utility), but in differing degrees because of their heterogeneity, the risk aversion of the representative agent at equilibrium will not, in general, be constant,

unless that of the various agents is the same for everyone. "As mathematicians, our primary goal was to define and understand the existing economic literature, and identify its strengths and limitations," says Caroline Hillairet. "Traditional models are based on a very simplified, often deterministic, approach based on power utilities". It is therefore difficult for the authorities to judge the financial viability of, or the increase in welfare from, long-term investments, even if reduced to a current equivalent by a discount rate, such as the development of energy infrastructure or transport to meet the objectives of the Paris Climate Agreement. In fact, simplified equilibrium models do not incorporate the possibility of changes in agent preferences over time or the uncertain evolution of the economic or financial environment. Yet in the long term, changes and upsets are even more likely than with shorter-term maturities. Furthermore, this model, whose optimal choices lead to a very linear, and at best quadratic, cost–benefit analysis over time, in relation to the initial investment, can result in an underestimation of extreme risks.

To overcome the limitations of the simplified approach and to make the public authorities aware of its weaknesses, the researchers thus turned to the recently developed mathematical concept of forward utility. This concept has a number of advantages: it allows the preferences of economic agents to be modelled over time by adapting to economic uncertainties and developments that may affect their choices. A forward utility thus means that preferences are regularly readjusted, leading to a more nuanced view of the world. "Using forward utilities to model long-term agent preferences is also more efficient, as well as being more realistic. They allow to go much further than the traditional models. This stochastic approach provides flexibility and can model more phenomena, compared to the traditional deterministic approach, particularly with regard to aggregation of heterogeneous agents and extreme risks," says CH. This framework is thus more suitable for valuing long-term derivative financial products, i.e. illiquid products with very long maturities (between 30 and 50 years) and whose values depend in particular on the evolution of long-term interest rates.

Since power utility functions, used in traditional models, have good properties in terms of the simplicity of calculations and their interpretability, with a view to presenting them to the public authorities, the researchers have retained their positive aspects and applied them to an innovative model. "The idea has been to develop power utility function mixes for preserving explicit and easily interpretable calculations, while taking into account the fact that each economic agent has his own preferences that are then aggregated, so as to go further than linearity,"

CH explains. To arrive at valuations of distant investments—calculated using a discount rate, based on the Ramsey rule—the researchers incorporated forward utilities into

their long-term rate modelling. Without going into technical details, they managed to reinterpret the Ramsey rule with a more stochastic and more flexible model, in order to better capture these phenomena, which are particularly important in the long term. The dynamic modelling of economic agents' preferences is likely to help the public authorities in their political choices with long-term consequences. "We are already having talks with the public authorities and we will continue our work along these lines when we get the data, to provide them with further support," CH says. At a time when public policies will have an ever greater impact on future generations, this innovative modelling could be helpful for decision-making.

Low rates raise questions about the efficient allocation of capital by banks

Sylvain Benoît, associate professor in finance at Université Paris-Dauphine

At the time when systemic risk was particularly threatening during the 2008 financial crisis, international regulators were keen to estimate, monitor and reduce it by establishing stricter rules for banks. Sylvain Benoît is working on this issue, which can be exacerbated by low interest rates. In this interview, he discusses the evolution of systemic risk in the banking system. ILB: How has systemic risk evolved since the financial crisis?

Sylvain Benoît: The main measures of systemic risk, taken from the academic literature, have declined in recent years. For example, the Europe-wide systemic risk measure (SRISK), which assesses banks' capital shortfall in the event of a systemic crisis, stood at more than €1.5 trillion in February 2009, compared to €650 billion in September 2018. Similarly, the CISS (Composite Indicator of Systemic Stress) of the European Central Bank (ECB) has fallen by two-thirds over the same period. Consequently, macro-prudential rules can be considered to have worked rather well, particularly with the identification of systemically important banks since 2011, which have been required to raise additional equity of more than €300 billion since January 2019. By being better capitalized, they are more solvent. These regulatory mechanisms, which include an additional equity requirement, better ability to withstand shocks (Total Loss-Absorbing Capacity) and the introduction of a Resolvability Assessment Process, aim to internalize banks' externalities, in other words the risks they pose to the entire system.

So is the financial system more stable?

SB: It is difficult to aggregate systemic risk because it can have a multitude of aspects. For example, we can model the entire network taking into account interbank lending

between the different institutions, but we cannot do it for all the assets held by the banks.

What can you tell us about the channels through which systemic risk is transmitted?

SB: There are three systemic risk transmission channels. The first concerns systemic risk-taking that may occur when actors adopt herd behaviour and invest in the same assets. This can lead to correlation and liquidity risks when there is a high level of investment in illiquid assets. The second channel can come from risk contagion, with a domino effect propagating losses in banks' balance sheets containing inter-bank loans. The third and final channel can appear when there is an amplification of risk and a banking panic in which the depositors withdraw their assets from banks. These three systemic risk transmission channels are less sensitive now than during the financial crisis, for a number of reasons: regulation, increased liquidity ratios, counter-cyclical capital buffers, the centralization of over-the-counter standardized derivatives trading, and increased transparency of institutions, which are required to provide more data to the regulators (higher supervisory expectations).

Are the balance sheets of banking institutions less risky, despite low interest rates?

SB: The effects of low interest rates on banks are moderate and related to their respective economic models. Universal banks, which include systemically important banking institutions, have seen their contributions to systemic risk (captured by SRISK) decrease with the shift to negative interest rates. In contrast, for domestic banks, which are smaller and are based on a more traditional economic model, their risk has increased.

To conclude, what is the impact of low rates on systemic risk?

SB: That is not an easy question to answer. A possible interpretive framework was suggested by the former

governor of the Bank of Finland, Erkki Liikanen, in a speech in 2016, who was alarmed by the possible return of risky yield-seeking to offset low interest rates. In fact, the purpose of low interest rates is to support long-term economic growth by encouraging banks to lend to SMEs. Even if low interest rates put pressure on banks' profitability, strong economic growth would support banking activity with more credit given to the real economy, thus creating a virtuous circle. This was the idea of the central bank, through the monitoring of non-performing loans. However, given the uninspiring current economic outlook, unpleasant surprises may be in store: low interest rates raise questions about the efficient allocation of capital by banks, measured by the percentage of non-performing loans.

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