

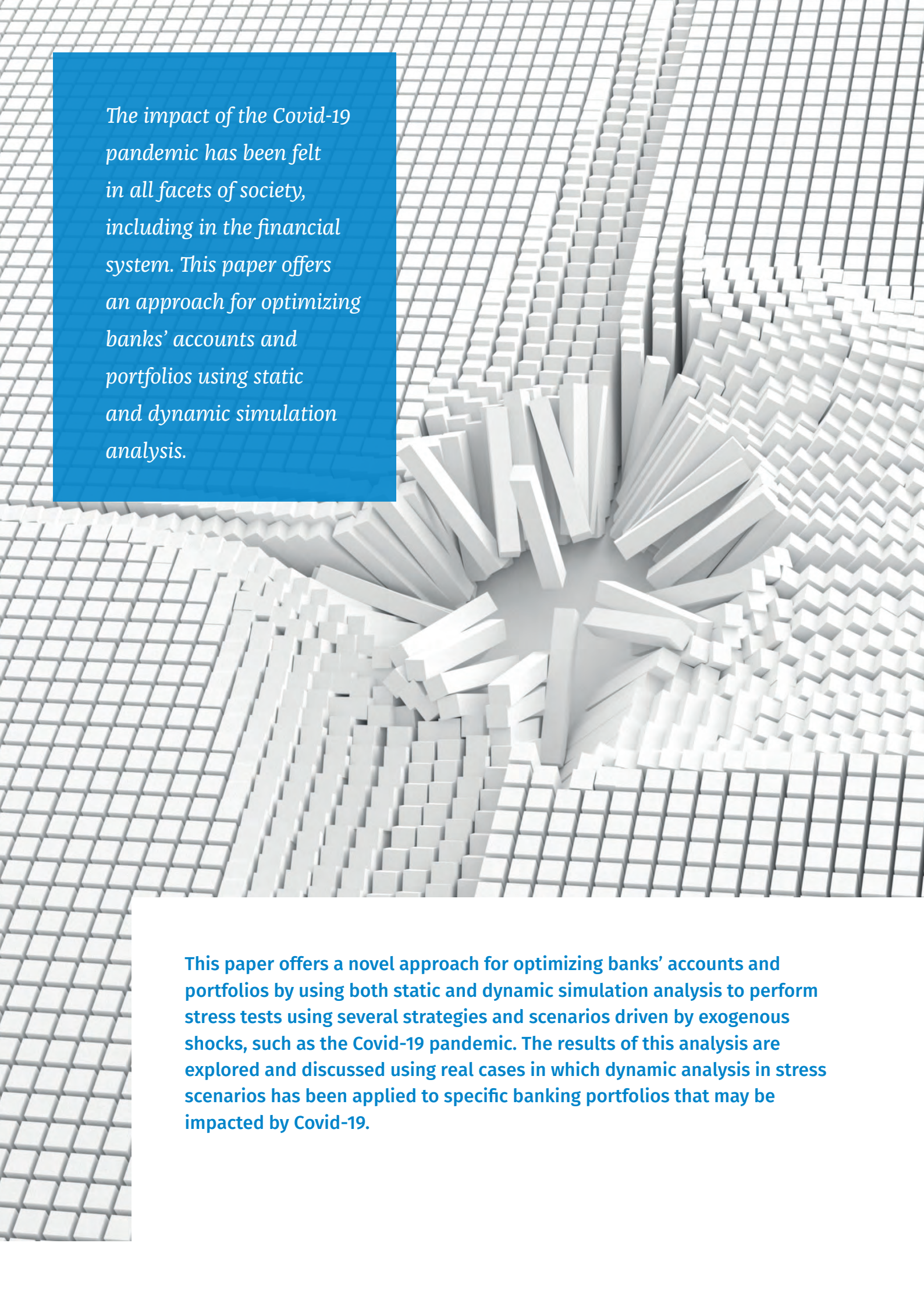
Optimizing banks' accounts and portfolios using static and dynamic simulation analysis.

Financial Services

*How to maximize profitability and minimize risk with dynamic stress testing*

WHITE PAPER

By Ioannis Akkizidis

The background of the entire page is a 3D grid of white cubes. In the center, there is a large, circular depression or crater. The edges of this depression are raised, and the cubes within the depression are tilted inward, creating a funnel-like shape. The perspective is from a slightly elevated angle, looking down into the center of the depression.

*The impact of the Covid-19 pandemic has been felt in all facets of society, including in the financial system. This paper offers an approach for optimizing banks' accounts and portfolios using static and dynamic simulation analysis.*

**This paper offers a novel approach for optimizing banks' accounts and portfolios by using both static and dynamic simulation analysis to perform stress tests using several strategies and scenarios driven by exogenous shocks, such as the Covid-19 pandemic. The results of this analysis are explored and discussed using real cases in which dynamic analysis in stress scenarios has been applied to specific banking portfolios that may be impacted by Covid-19.**

# Introduction

The arrow of cause and effect seldom flies in one direction in a complex structure like the economy or financial system. It goes back and forth, and sometimes it heads off on the most unpredictable tangents.

That reality underpins much of modern banking regulation, particularly the ever more stringent stress testing procedures that banks must follow. Stress testing used to be a simple exercise in simulating potentially dangerous conditions: If X happens, what is the impact on Y, where X might be a sudden rise in interest rates or the default of one of a bank's major counterparties, and Y might be some aspect of the bank's capital position?

A sudden stress in the economy can develop from threats large and small, foreseen and unforeseen. Covid-19 is an obvious example of the large and unforeseen variety. Since the outbreak of the pandemic, authorities have been under pressure to adjust stress testing approaches to better assess the vulnerability of the banking sector and, if needed, adjust capital or liquidity positions at an individual institution. Supervisors have also drawn attention to the adjustments of assets, liabilities and off-balance-sheet positions over time.

The pandemic has persuaded credit institutions in various European Union countries, on their own initiative, to validate and adjust their models to reflect changes to underlying risk factors and enhance strategies related to their credit and investment portfolios. This is crucial for ensuring portfolio stability over multiple timeframes. Securing portfolio stability under stress scenarios helps evaluate the conditions under which a bank can continue providing credit and investing in the best mix of assets. The strategies it adopts must be robust so that it can optimize profitability under different forward-looking stress scenarios and react quickly when a certain scenario applies.

*Since the outbreak of the pandemic, authorities have been under pressure to adjust stress testing approaches to better assess the vulnerability of the banking sector and, if needed, adjust capital or liquidity positions at an individual institution.*



## Methodology: a blueprint for building a stress test

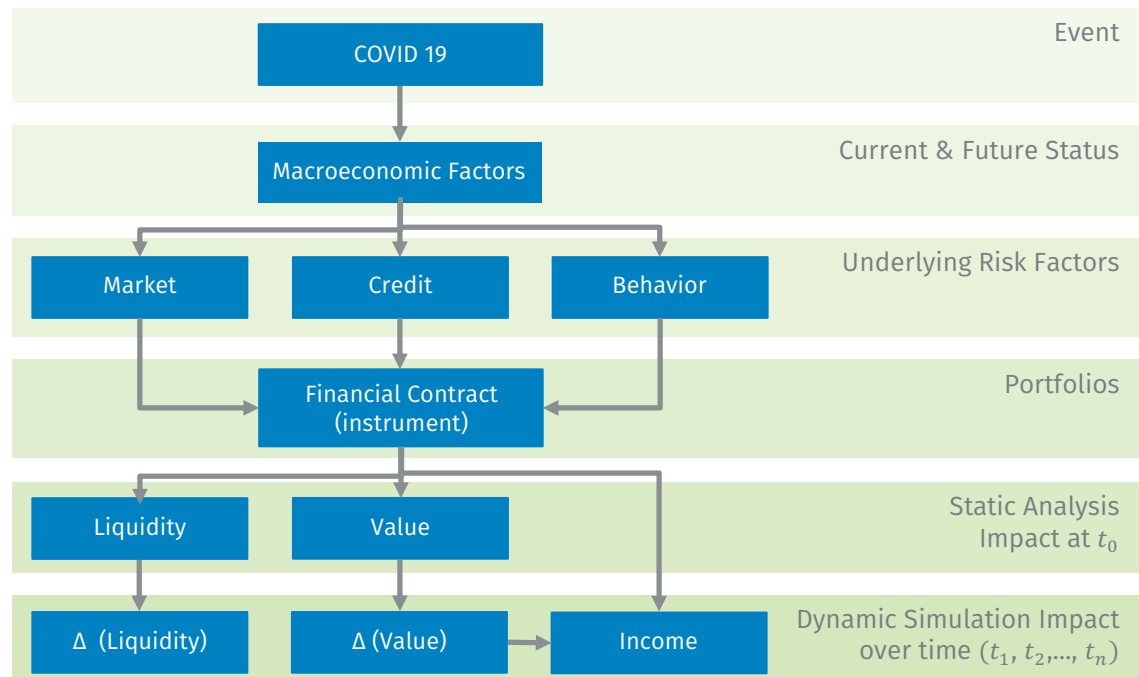
Before considering the shock provided by Covid-19, a stress testing scenario must include certain elements to provide an institution with useful information for analysis and forecasting. *Figure 1* below depicts the broad outline of the design of a stress analysis. It should be a useful starting point in considering the impact of Covid-19.

Covid-19 has been influencing macroeconomic conditions that affect the underlying market, credit and behavior risk factors. These factors are the inputs in financial analysis and the design of the stress scenarios. They are used to calculate the elementary outputs in financial analysis, including expected cash flow, and the value and income of the financial contracts making up a bank's accounts and portfolios. Stressing the input factors as defined at the analysis date  $t_0$ , changes in the outputs indicate the risk of those factors to the liquidity and value of the existing portfolio. When the input factors are simulated and stressed over

*Although macroeconomic conditions are considered underlying factors in stress scenarios, when calculating values and cash flow, only stress due to standard market risk factors is considered.*

future time buckets,  $t_1, t_2, \dots, t_n$ , banks evaluate the impact in terms of changes ( $\Delta$ ) to the liquidity, value and income of portfolios.

*Figure 1: Framework in stress scenarios*



# Stressing market risk factors

Although macroeconomic conditions are considered underlying factors in stress scenarios, when calculating values and cash flow, only stress due to standard market risk factors is considered. As illustrated in *Figure 2*, the main risk factors are prices, interest rates expressed as term structures of yield, as well as product rates and spread curves. The basis of credit spread curves is credit and counterparty risk factors driven by the markets. Stressing credit spreads will directly impact the values of expected income and market liquidity; the high probability of defaults and the resulting low credit ratings indicate cancellation of the contractual cash flows, credit losses and loss in value.

## Stressing credit and counterparty risk factors

Credit exposures may become volatile due to market and counterparty behavior risks, resulting in credit losses. For instance, the value of a loan may change due to underlying market risk factors, such as credit spreads and the yield curve used to discount cash flows. Moreover, the availability of a credit line may change the exposure's value size. Yet most credit exposures are collateralized, fully or partially, and so banks must stress the collateral's value and the guarantor's rating status. Finally, stressing credit exposures can lead to systemic risk.

Stress scenarios also must model a counterparty's default probability. One way to measure the likelihood of default is to observe macroeconomic factors, such as the unemployment rate, together with counterparty-specific indicators, such as income. But the industry has chosen other paths, as this observation may become too complex and volatile, demanding an additional data layer that hardly can be up to date. One method that is often used is to estimate credit ratings and their probability of change over a certain time, for instance by using migration matrices. *Figure 3* illustrates credit risk factors, together with their interdependencies with other factors considered in the design of credit stress scenarios.

Figure 2: Market risk factors applied in stress scenarios

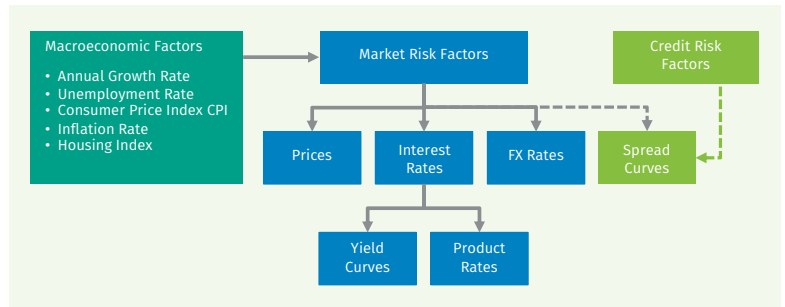
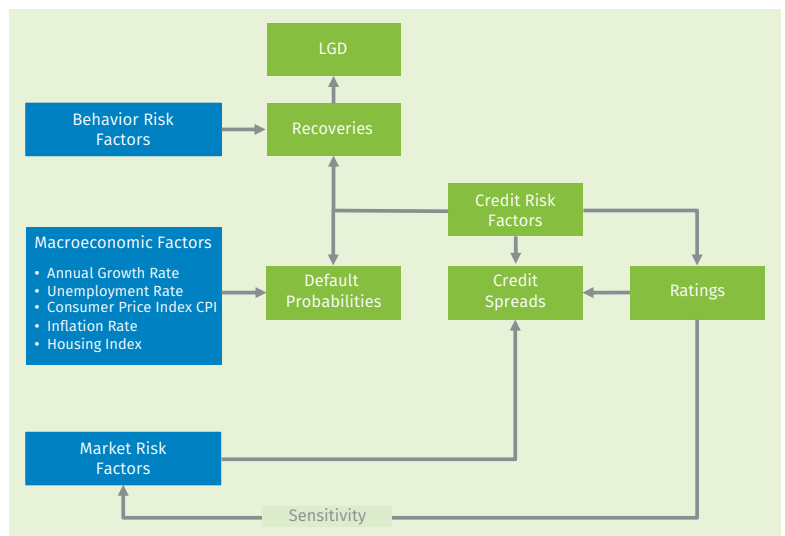


Figure 3: Interdependencies among factors applied in stress scenarios



*Behavioral elements are the most challenging factors to incorporate into stress tests because they rely on assumptions and historical data. Since behavior could have extreme domino effects in the financial industry, stress scenarios must contain behavioral elements, such as customer activity.*



#### Stressing behavior risk

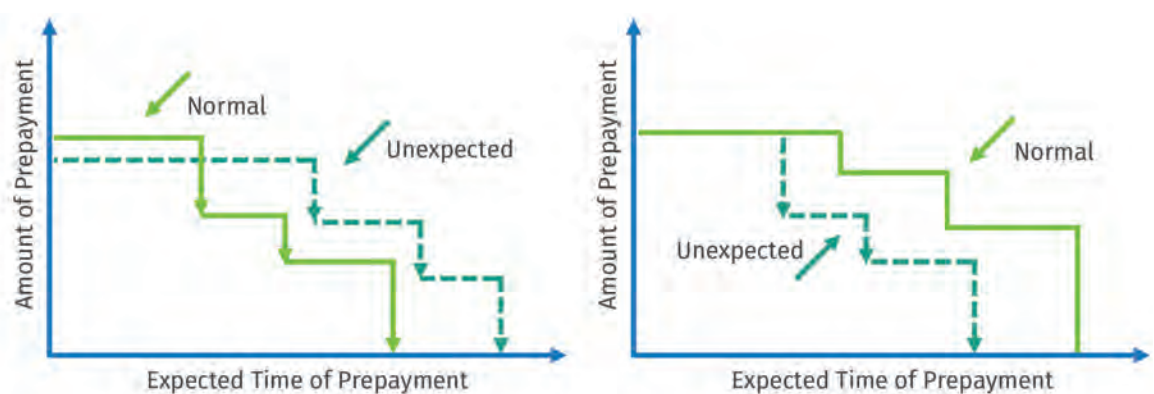
Behavioral elements are the most challenging factors to incorporate into stress tests because they rely on assumptions and historical data. Since behavior could have extreme domino effects in the financial industry, stress scenarios must contain behavioral elements, such as customer activity.

There are market-related behavior scenarios, such as the exercise of savings account withdrawals, replication, prepayment and sales. There is also credit risk-related behavior, referring mainly to expected recovery, use of credit lines and used at default. Behavior does

not always follow market and credit stress conditions, however. This is often the case with non-maturity contracts, such as savings accounts.

Behavior also can depend on the structure of a financial contract, combined with stressed market and credit conditions. In the design of behavioral stress scenarios, banks stress two dimensions: time and amount. *Figure 4* below illustrates the behavior cases of withdrawals and remaining principal. Stress behavior directly impacts the liquidity and value of credit portfolios.

*Figure 4: Prepayment behavior based on market conditions under normal and stress financial risk conditions*



## Strategies on the evolution of credit portfolios under stress conditions

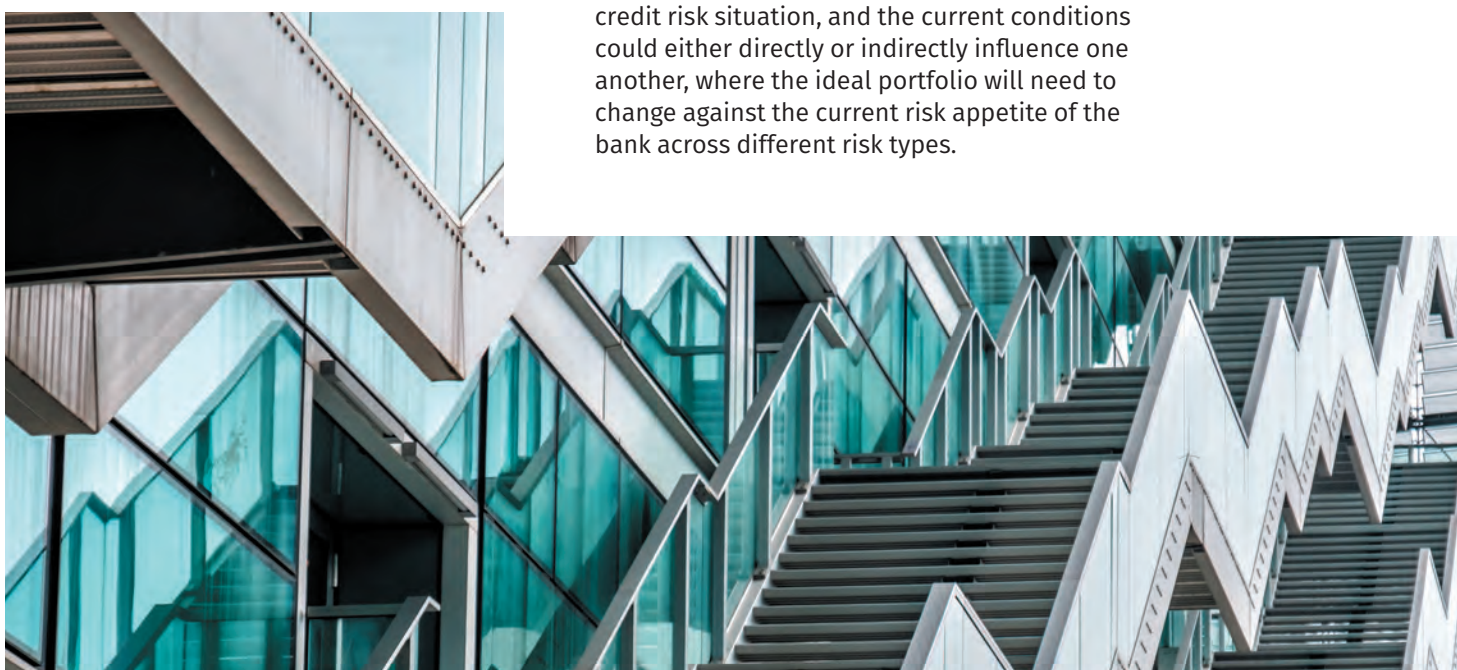
Systemic shocks like Covid-19 may increase the threat to a financial institution's solvency. Institutions, therefore, must measure the strength of their assets, liabilities on and off the balance sheet, and all credit and investment portfolios, under stress scenarios considering such a shock. The results should be used to forecast the impact on profit and loss over multiple periods. The P&L analysis must factor in the strategies that an institution has applied. The best strategies encompass rollovers of current positions and maximize their evolution to assume a constant balance-sheet composition, while including new market conditions.

Financial instruments may be rolled over in a portfolio after they mature and, together with new positions, reflect the growth of the existing portfolios and the introduction of new accounts and portfolios in a new balance-sheet composition. One has to define the volume, type and pricing assumptions of these contracts, and consider the evolution of the underlying risk factors under expected and stress conditions.

Under stress conditions, institutions must consider two prominent cases:

- **Roll-down or runoff scenarios:** Underlying risk factors as defined at the date of analysis are not only deterministically shocked but evolve along one or more specified market scenarios. The paths can be defined by the bank – dynamically – and could describe the condition in which the portfolio will change when a certain event happens.
- **Going-concern scenarios:** These encompass all risk factors related to market conditions and behavior change for existing accounts and the generation of new business. They can change in an interdependent way, as new business evolution depends on prevailing risk conditions. In other words, the assumption is that the company is keeping a similar investment alive, but against newer risk factor conditions.

The liquidity, value and income of existing and new financial contracts under stress scenarios must be analyzed dynamically, taking into account the interdependencies of multiple risk factors, to optimize future portfolios. The ideal liquidity situation may not give rise to the ideal credit risk situation, and the current conditions could either directly or indirectly influence one another, where the ideal portfolio will need to change against the current risk appetite of the bank across different risk types.

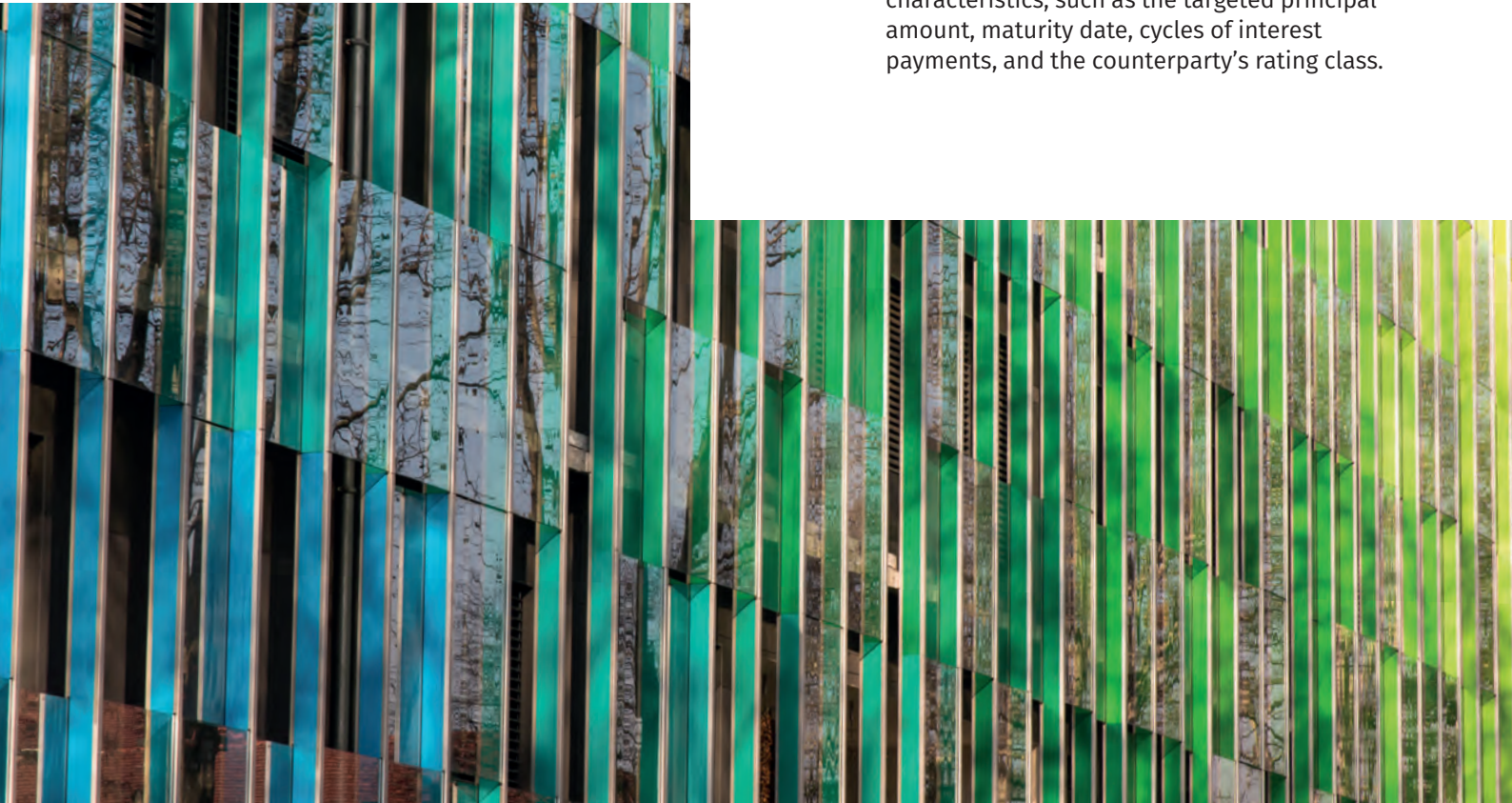


## Dynamic simulation

Static analysis aims to evaluate the past and adjust present actions accordingly. Apart from cash, a portfolio's present value depends on income to be derived in the future. This brings us to dynamic analysis.

In dynamic analysis, everything – market and credit conditions, counterparty characteristics, behavior assumptions, new business – is seen to be in flux because the future remains undetermined and forever changing. Thus, in dynamic simulation:

- Market conditions, for example the risk factor of yield curves, are no longer derived from prices observed at  $t_0$ ; instead they are forecast using a simulation process.
- The counterparties' status, for example default probability and credit rating, may change as time passes. The rating transition can follow probabilities driven by the evolution of market conditions, their correlations with one another, and the counterparties' idiosyncratic characteristics.
- The generation of new business depends on current and future market and credit conditions. Portfolios of assets and liabilities are being rolled over, but, given the plans for new business, assets and liabilities are also being generated, leading to a growing balance sheet. Growth can follow predefined strategies and is included in the over-time analysis of the portfolios. These strategies depend very much on an institution's type, and the underlying risk factors to which current and future portfolios are exposed. Given the stress scenarios on risk factors, the bank identifies its risk appetite for the portfolios. A retail bank's strategy may focus on how loans or savings accounts are added to the balance sheet, while an investment or private bank may be most concerned with developing investment accounts and portfolios.
- The simulated contracts are generated by defining the characteristics of planned future financial instruments. This is most efficiently done with a well defined set of financial contract types. For instance, new bonds generated by using a principal of maturity contract type and then defining the contract characteristics, such as the targeted principal amount, maturity date, cycles of interest payments, and the counterparty's rating class.



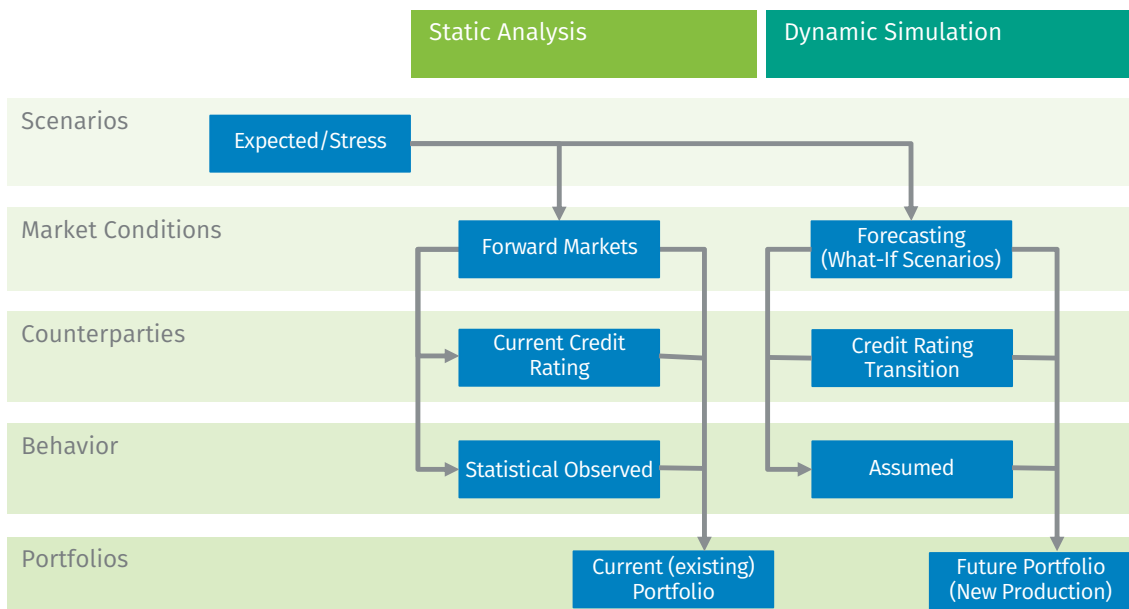


- As new positions are generated, given the evolution of the markets and new counterparties assigned to these positions, assumptions about their behavior also must be considered. If the bank's strategy is to structure a new portfolio to provide facilities, say, the credit lines' possible exercising should be defined. Given the evolution of market conditions, scenarios of expected and stress behavior on exercising the facilities also should be applied.
- Given that parameters may change in a discrete or interdependent way, new business generation depends on those changes and how they develop. Stress on those parameters also can be applied. Liquidity, value and various risk measures can be analyzed dynamically, along with income and funds transfer pricing. Within this category fall earnings at risk, dynamic stress and value at risk (VaR), as well as dynamic liquidity and liquidity at risk (LaR). During the dynamic analysis, the potential impact – positive and negative – on a bank's income from applying stress scenarios to existing and

*The pandemic continues to affect the economy, so banks must define and execute stress testing scenarios for current and future portfolios that take the potential effects of the pandemic into account.*

future portfolios shows how robust the bank is to risk factors. *Figure 5* below illustrates the elements considered in the flow of static analysis and dynamic simulation.

**Figure 5: Elements in static analysis and dynamic simulation**



*Looking at the world economy, lockdowns in response to the pandemic created unprecedented recessionary conditions.*

#### **Stress testing under Covid-19**

We have seen the impact of the pandemic, with variations across cities and regions. The impact on credit risk and on counterparties is significant and plays into the recognition of expected and incurred credit losses. In addition, alongside the EU, the national government has taken steps to limit the spread of Covid-19 and put a series of measures in place to support local businesses and people who are temporarily unemployed.

This could have a positive and a negative effect. The positive effect is to give counterparties that would have become insolvent due to the pandemic, but were sound businesses under normal operating conditions, a break until the pandemic is over, and so limit the amount of credit loss. The negative effect is to keep on life support businesses that otherwise were headed into default, which is not necessarily money well spent.

Looking at the world economy, lockdowns in response to the pandemic created unprecedented recessionary conditions. But governments' provision of liquidity limited the damage and helped maintain financial stability, so after the record deterioration of economic output, a record recovery is underway.

The pandemic continues to affect the economy, so banks must define and execute stress testing scenarios for current and future portfolios that take the potential effects of the pandemic into account.

Below are the GDP annual growth rates for the euro zone, which demonstrate the sharp economic contraction and the sharp rebound.

#### **Euro Area GDP Annual Growth Rate**



Source: TradingEconomics.com

### Examining different stress testing strategies under Covid-19

In the following exercise, we will consider stress testing and strategies for new business applied to typical banking portfolios containing loans, bonds, stocks and deposits to gauge how institutions are likely to – or should – alter their models to take into account the long-term impact of the pandemic and optimize the performance of their businesses. The table below presents exposures to three broad types of risk: market, credit and behavioral. Market risk can have an impact through changes to yield curves (YC), foreign-exchange rates (FX) and credit spreads (CS). Credit risk can



be reflected in changes in credit ratings and probability of default (PD). The contributors to behavioral risk are the exercise of prepayments or withdrawals.

### Portfolios and accounts considered in bank stress testing referring to our case on EU credit institutions

Portfolio Account	Risk Factors		
	Market	Credit	Behavior
Stocks & indexes	Prices Increases by 80% Decreases by 20%		
Corporate loans denominated in developing country currencies	YC Increases 2.5% p.a. Decreases 0% p.a.	Ratings  Downgrading three notches	
	FX 50% drop		
	CS Based on rating changes		
Government bonds & Corporate bonds denominated in euros	YC Increases 1.5% p.a. Decreases 0.1% p.a.	Ratings (unchanged)	
	CS (unchanged)		
Retail loans (mortgage and long-term loans)	YC Increases 2% p.a. Decreases 0.1% p.a.	Ratings PDs (unchanged)	Prepayments Reduced by 50%
	CS (unchanged)		
	CS		
Current & Saving Accounts			Withdrawals (stable)

*The devaluation of developing countries' currencies may continue, albeit to a lesser extent for countries with vigorous export activity, and to an even lesser extent for countries that produce minerals, metals, energy or other commodities*

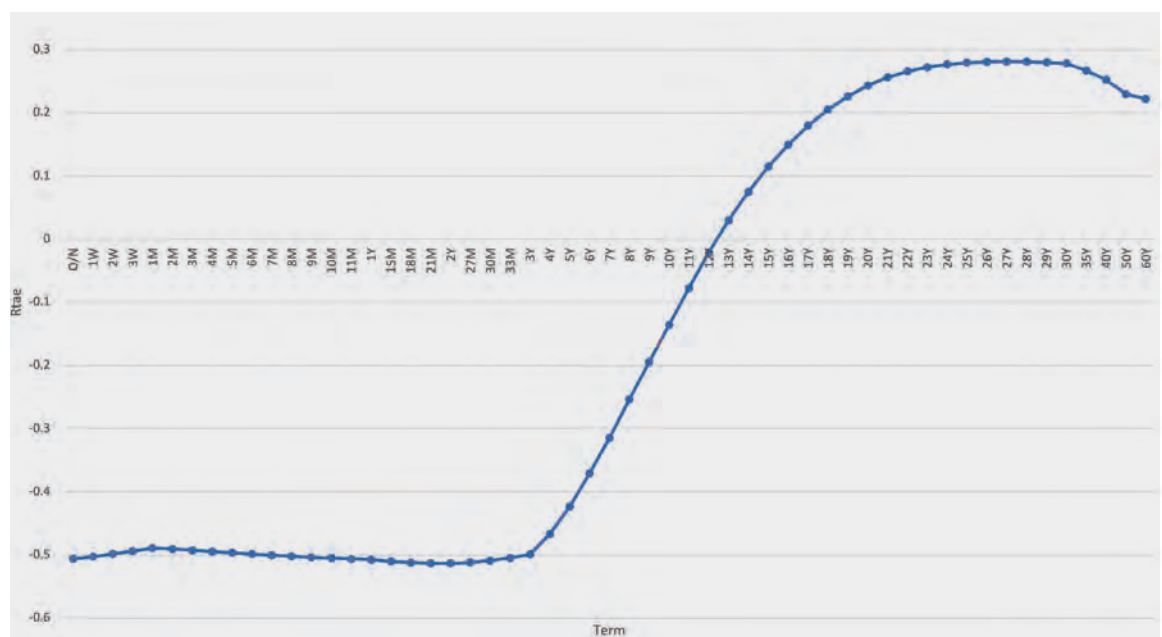
#### Scenarios based on interest rates and counterparty default probabilities

Policymakers worldwide have used massive fiscal and monetary stimulus programs to manage the pandemic's impact. As a result, public debt has soared in developed countries. To manage the debt and reduce it in the long run, governments will need to keep interest rates lower than inflation and economic growth rates by maintaining their policies of financial repression. Very low or negative rates on all major interest rate curves and developed countries' government bonds are almost certain to continue in the long run (see *Figure 6*),

despite the unprecedented amounts of fiscal stimulus. But if rapid growth should send rates higher in developed markets, shock on yield curves should be applied to evaluate the credit portfolios' impact on value and liquidity. Moreover, under ordinary market conditions, the probability of defaults is not expected to be high. Any stress applied for steepening yield curves will directly impact default probabilities and credit ratings.

A strategy is to roll over the mortgage and long-term loan portfolios aligned with the scenarios mentioned above.

*Figure 6: Long-term projection of EONIA*

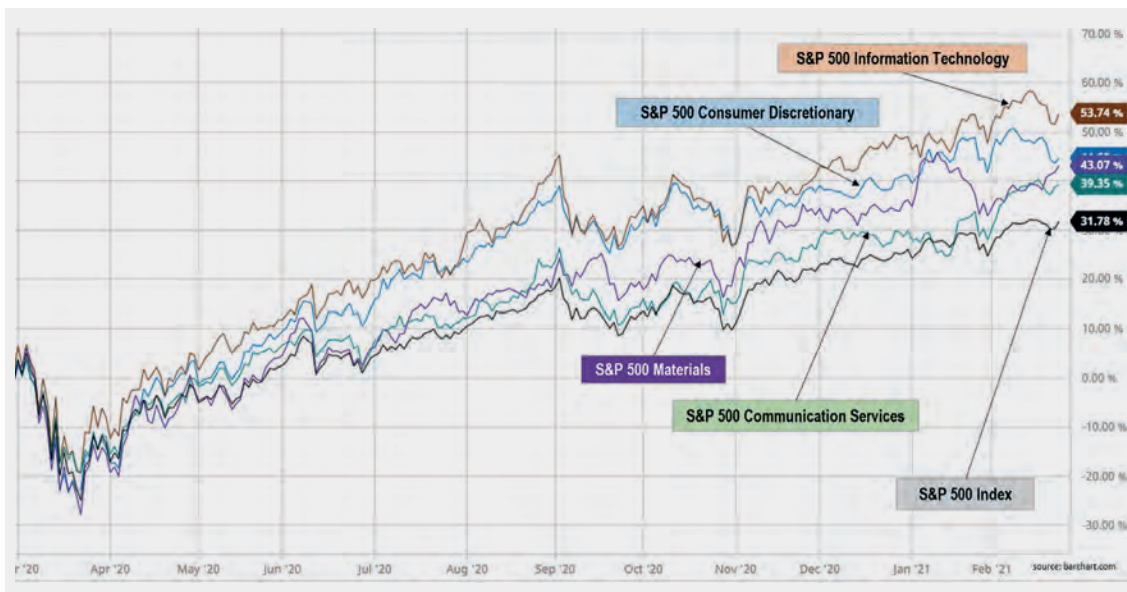


### Scenarios based on stocks

Stock prices plunged in March 2020 as the severity of the pandemic became apparent, then quickly recovered to varying degrees. Growth sectors like technology outperformed, while economically sensitive sectors such as

energy and basic materials lagged. *Figure 7* below displays how the Covid-19 crisis has impacted S&P 500 performance over the last year.

*Figure 7: Performance of the S&P 500 during the Covid-19 crisis*



### Scenarios based on FX rates and counterparty ratings

With short-term interest rates in mature economies expected to remain clustered around zero percent for the foreseeable future, the main factor driving foreign-exchange movements is likely to be differences in economic growth and inflation. No significant revaluations among the main currencies are expected, therefore, as developed countries' economic recovery policies have many common features. Thus, FX rates need not feature in stress scenarios used by institutions in these economies.

Emerging economies often try to devalue their currencies against those of large, developed countries to remain competitive. The public debt of developing countries is not large, but private and corporate debt has increased significantly, mainly debt denominated in foreign currencies. A devaluation of the local currency makes debt repayment more challenging, therefore, especially for companies that depend on domestic sales.

The devaluation of developing countries' currencies may continue, albeit to a lesser extent for countries with vigorous export activity, and to an even lesser extent for countries that produce minerals, metals, energy or other commodities. Thus, stress on FX rates must be considered in the scenarios applied in portfolios exposed to these economies.

### Scenarios based on counterparty behavior

During the pandemic, deposits into savings accounts may be reduced. After the pandemic, current and savings accounts will continue to earn negligible or negative rates, but deposits are still expected to grow. Thus, no stress in withdrawals is applied.

Low interest rates are likely to result in declining loan prepayments, especially on mortgage portfolios, and an increase in new mortgages.

# Results and discussion

For this exercise, a corporate portfolio has been structured with domestic euro-denominated loans and foreign loans denominated in Turkish lira. The domestic portfolio component is still profitable, with steady cash flows and a low default probability for the corporate counterparties, including small and medium-sized enterprises. As a result, expected credit losses for the domestic portfolio are low. The foreign loans may incur significant losses, however, for reasons that soon will be made clear.

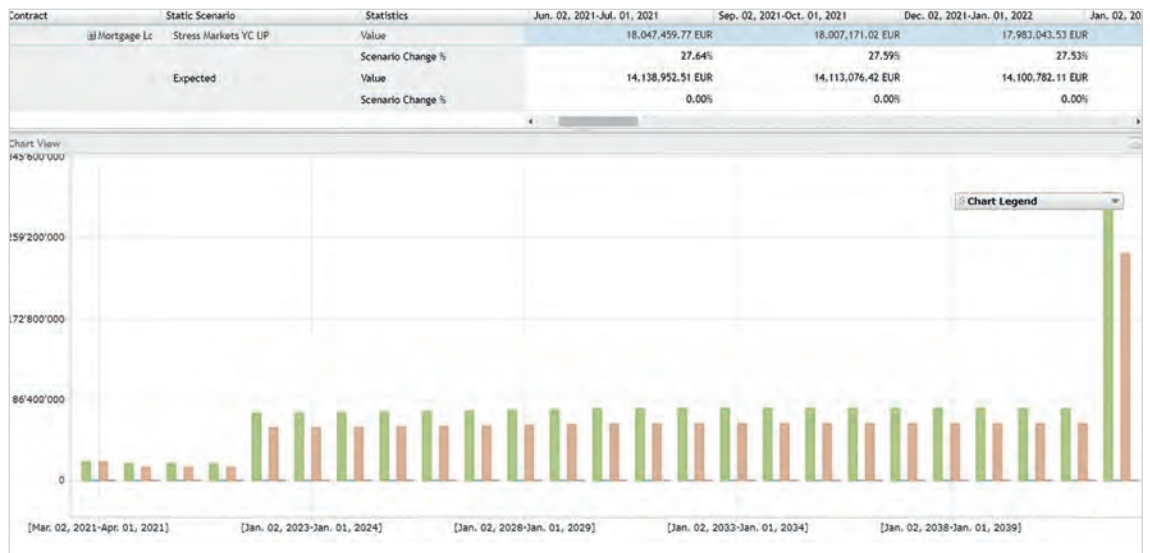
In designing stress tests to reflect the impact of Covid-19, we focused on portfolios containing the following asset classes: stocks and stock index funds, government bonds, mortgage loans, and corporate loans denominated in local and foreign currencies. The counterparties are in the euro zone. Ratings are BBB for Italian government bonds and AAA for German government bonds. The euro zone corporates are rated from A to BB, and foreign instruments are rated B. The retail corporates carry high credit ratings and a low probability of default. The market conditions (YCs) are following the standard euro zone term structures, for example the Euro Overnight Index Average (EONIA). The long-term (20 to 35 years) mortgages are floating-rate loans. The

corporate portfolio comprises floating-rate loans maturing in five to seven years. Stocks are concentrated in the technology sector.

In our stress scenario, we applied an increase of 200 basis points across the yield curve. The change in net present value (NPV) under those conditions was only 0.49%, whereas expected cash flow would rise. Under the same scenario, however, the increase in interest rates would cause losses in an investment portfolio holding rate-sensitive assets. Moreover, even though government bonds denominated in strong currencies, such as euros, dollars and yen, are highly rated, the negative yields that some of them carry could make the issues illiquid, as the prospect of earning a negative yield limits investor demand for such bonds. In the portfolio under study, fair value dropped by 18%. See Figure 8 below to observe the impact of negative interest rates on expected cash flows of mortgage loans.

Credit ratings for the foreign counterparties were between BB and B before the pandemic. The stress scenario called for each holding to be downgraded three notches. That resulted in a 20% decline in NPV for the annuity type of contracts and a 40% decline for the regular amortized loans. Given that the

Figure 8: The impact of negative interest rates on expected cash flows under current and stress scenarios on long-term mortgage loan portfolios



latter instruments are more common among corporate loans, the impact of the downgrades is significant. For corporate portfolios exposed to foreign counterparties, and denominated in foreign currency, two types of stress are applied, covering counterparty risk due to the three-notch downgrades, and foreign-exchange risk, in this case a 50% drop in the lira. The fair value of such portfolios was reduced by almost 60%, creating high market and credit losses.

Government bonds play a significant role in collateral management for banking portfolios, as shown in the stress testing scenario (see *Figure 9*). If more debt is issued with negative interest rates, the risk will grow that these assets will become illiquid.

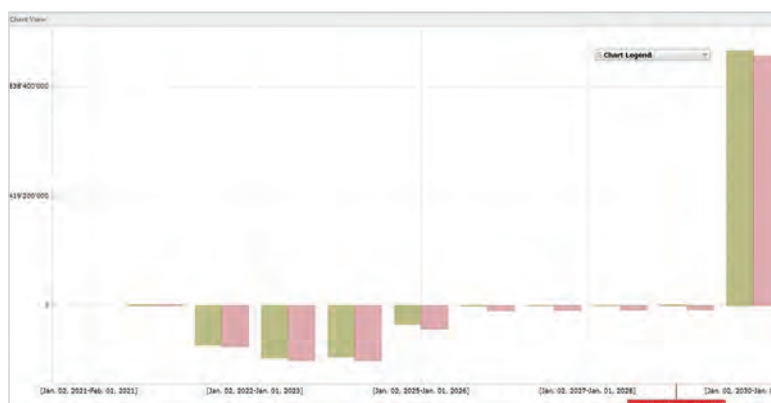
Finally, a reduction by 50% on prepayments should be applied to the mortgage and long-term retail loans. Still, in the last five years, the prepayment rate has been very low, so any stress does not impact the credit portfolios' expected cash flows.

### Conclusion

The pandemic continues, but there are signs that it will be brought under control before long. A return to normal social, business and economic conditions is coming. Under current and short- to medium-term market conditions, credit institutions must perform stress testing in portfolios affected by macroeconomic and financial risk factors exacerbated by the pandemic. Furthermore, after the pandemic abates, banks must ensure that rolling over existing portfolios and generating new ones will result in positive income. That requires banks to define strategies for the new portfolios on a going-concern basis by simulating the evolution of financial risk factors under expected and stress scenarios.

This paper discussed how banks might apply stress as a consequence of the Covid-19 crisis and, therefore, how observing both the input factors and results of the stressed portfolios on values and liquidity can guide future portfolios' strategies. For instance, as observed in the analysis and results, given the likelihood that interest rates will remain low, so will banks' finance costs. Thus, mortgage and corporate credit portfolios are expected to increase in volume and be profitable as long as the counterparties keep default probability low and steady. Notably, exposures to counterparties in emerging markets contain high credit risk,

*Figure 9: The impact of negative interest rates on expected cash flows on a bond portfolio under current and stress scenarios*



so banks may want to take extra care in rolling over portfolios with risky counterparties. Banks holding highly rated government bonds may face some challenges regarding negative interest income and liquidity. Stock portfolios may increase in volume, so price volatility must be included in the stress scenarios. Since crises seem to appear frequently in highly integrated and interconnected markets, banks must be diligent in applying stress scenarios to existing and future portfolios.

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