OLIVER WYMAN

Financial Services

HOW TO IMPROVE RISK MANAGEMENT FOR FINANCIAL INNOVATION

AN OLIVER WYMAN PERSPECTIVE

AUTHORS

Peter Carroll, Partner

Dominik Weh, Manager

MARSH GUY CARPENTER MERCER OLIVER WYMAN

MARSH & McLENNAN COMPANIES

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1. EXECUTIVE SUMMARY

Governance mechanisms in financial services include extensive risk management processes that have been developed over the past decades including new product development and approval processes employing various safeguards against unwise financial innovations. And of course they consist of an extensive regulatory infrastructure that has been in place since before the crisis and is already being amended and extended as a result of it.

Although financial innovation has a long history of success, delivering benefits widely felt in the industry and across the broader economy, recently, some financial innovations have not been viewed so favourably supporting the need for improved governance tools to make financial innovations safer.

So the question that arises is how the existing governance mechanisms could fail in the sense that financial innovations developed unfavourable outcomes as observed in the recent past.

A key characteristic of financial innovation is the introduction of "Knightian uncertainty," making its impact in some ways unmeasurable. This is easiest to demonstrate in the context of a new product being introduced to the marketplace.

Any attempt to anticipate its future performance runs into various difficulties. If the product is unequivocally original, there will be no empirical evidence to support estimates of its performance or its effect in the marketplace. If the product is innovative but seems similar to a pre-existing one, or could be considered a variant of another, it will be tempting to use available empirical data to frame some estimates of the likely performance of the new one. And this may be even more risky, for the assessment will seem to be "in sample" when it is really "out-of-sample", promoting a false sense of confidence. While it may be relatively easy to recognise an innovation as it emerges from an established new-product development process, it may be significantly harder to correctly identify innovative adaptations – which are a feature of the financial world.

Another way innovation introduces Knightian uncertainty is through the unpredictability of customers' responses to the innovation and, in a broader sense, of unforeseeable ripple effects through the wider economy. And again, where one may be tempted to seek analogies from prior responses to similar or similar-seeming products, an innovation always calls into question the relevance of the analogy.

Thus, it can be summarised that:

- Innovation is a broadly positive force within financial services
- Innovation, by definition, introduces Knightian uncertainty to financial services
- This uncertainty occasionally manifests itself in negative outcomes
- The financial services sector's relationship to the rest of the economy makes it vital to reduce the likelihood of negative outcomes
- The best way to do this is by adapting existing risk management mechanisms to be more sensitive to the specific contribution of innovation to uncertainty and risk

The following recommendations are made to improve risk management for financial innovation:

A. Ensure appropriate oversight of financial innovation using adequate tools such as a "Knightian uncertainty map"

B. Improve the identification and handling of adaptations and "mutations" of financial innovations to assess incremental innovations arising from changes to existing products

C. Allow for a trial phase for new products (especially consumer products) to enable collection of data for testing the use of the product and its associated risks

D. Use flexible limits to encourage innovation and allow in-market testing of new ideas while managing total exposures until sufficient real-world observations permit further expansion

E. Address the lack of historical data through forward-looking adjustments to model parameters and through adequate stress testing and scenario analyses

F. Review the usefulness of flexible methodological approaches, such as real options and fuzzy logic, to address the out-of-sample properties of financial innovations

G. Improve Management Information Systems (MIS) to better monitor financial innovation

2. FINANCIAL INNOVATION

INTRODUCTION

BACKGROUND AND MOTIVATION

Oliver Wyman and the World Economic Forum recently collaborated on a project whose objective was to ensure the continued flow of benefits from financial innovation – including product innovation, process innovation, marketing innovation and organisational innovation[1]. Financial innovation has a long history of success, delivering benefits that are widely felt in the industry and across the broader economy, just think of ATMs, credit cards, online payment services, weather derivatives, credit scoring and others.

Recently, however, some financial innovations have not been viewed so favourably, especially innovations in capital markets, e.g. CDOs, SIVs, MBS etc. A degree of hostility to financial innovation arose from the role played by the financial services sector in the recent financial crisis and deep recession. Our project did not set out to determine whether the grounds for this hostility were valid; we left that exercise to others, who generally concluded that the financial services sector – along with its regulators – deserved at least some of the blame[2].

Instead, the project took as its premise the view of Joseph Schumpeter and others that innovation is a foundational source of economic benefits[3], in the financial services sector as well as in the wider economy. The objective of the project was therefore to allow financial innovation to continue to deliver these benefits by finding ways to reduce the likelihood of bad outcomes as observed in the past. Examples of bad outcomes include systemic risk as introduced by capital markets innovations such as CDOs, exploited consumers as in the mortgage crisis, loss of market integrity as observed after the collapse of Lehman Brothers due to the lack of understanding the risks and uncertainties introduced by a number of novel products.

In practice, much of this objective is accomplished by improving our understanding of how innovation increases risk and uncertainty, and by upgrading risk management processes accordingly.

1 "Rethinking Financial Innovation, Reducing Negative Outcomes While Retaining The Benefits" published in 2012, a World Economic Forum report in collaboration with Oliver Wyman

2 For example: "Financial Crisis Inquiry Report: Final Report of the National Commission on the Causes of the Financial and Economic Crisis in the United States" published in January 2011 by The Financial Crisis Inquiry Commission

3 Schumpeter, J. A. (1942). Capitalism, socialism and democracy. London: Routledge

RISK AND UNCERTAINTY – DEFINING TERMS

Human endeavour is always vulnerable to risk. However, as first clearly set out by the economist Frank Knight in 1921, this "risk" comes in two different flavours: risk and uncertainty. It is central to the issues of "innovation risk" to make this distinction. Knight differentiates risk and uncertainty in his book by the degree of measurability: risk is considered a measurable uncertainty and thus far different from an unmeasurable uncertainty.

The distinction between risk and uncertainty is important to the discussion of financial innovation for a number of reasons. One is straightforward: by their nature, innovations tend to generate a high degree of Knightian uncertainty beyond any way they may change measurable risk.

A second reason is that some negative outcomes in financial services seem to be caused by ignoring a key uncertainty simply because it is unmeasurable – with the fact that is ignored often lying hidden among the key assumptions that surround an innovation.

Alternatively, it is possible to wrongly classify a Knightian uncertainty as a measurable, quantifiable risk.

Determining whether an innovation is subject largely to measurable risk or unmeasurable uncertainty is not, in itself, an easy task. In the case of incremental innovations, there is often a temptation among innovators to look to the performance of similar, earlier products in terms of both their performance track record and the fundamental data that inform their design (e.g. default rates). However, such analogies can be dangerous if the incremental innovation is a small change to a financial product that actually significantly affects its risk and return profile as well as it may introduce Knightian uncertainty.

This Oliver Wyman Perspective will present selected findings and recommendations from the project.

3. FINANCIAL INNOVATION

FINDINGS

THREE MAJOR FINDINGS

1. **Bad outcomes are essentially unpredictable**

   Negative outcomes cannot reliably be predicted for individual innovations based on their characteristics. Examining actual innovations and focusing upon those frequently cited for their contribution to the crisis proves to be inconclusive. While certain factors appear to recur, there is no obvious combination of defining characteristics for an innovation that reliably predicts negative outcomes. Among the factors that recur, one can cite complexity, leverage or embedded leverage, and the alignment of incentives. Yet, while these may be associated with some cases of negative outcomes, they are not always. At best, these factors may, in some combination, signal the need for a higher level of attention to possible future concerns.

2. **Innovation increases uncertainty**

   It is perhaps the defining feature of innovation that it increases (Knightian) uncertainty. This is almost definitional: an innovation takes us beyond the empirically known. It is vital to recognize that innovation leads to situations for which there is no relevant history. It introduces "Knightian uncertainty", making its impact in some ways unmeasurable. Additionally, Knightian uncertainty is introduced through the unpredictability of customers' responses to the innovation and, in a broader sense, of unforeseeable ripple effects through the wider economy. Where one may be tempted to seek analogies from prior responses to similar or similar-seeming products, an innovation always calls into question the relevance of the analogy. Indeed, one can argue that the highest actual risk arises from an innovation that is not recognised as such, because here we are likely to attach an unwarranted degree of confidence to our assessment of risk, but based on inappropriate empirical data associated with similar-seeming, yet different, products.

3. **Improved risk management procedures are the proper response**

Most of the existing governance framework for risk management within financial services was developed to measure and manage the quantifiable risks associated with established products. The main developments of the last 10–15 years have focused on risk quantification through the use of statistical models that translate empirically observed outcomes in a structural way to set probabilistic expectations about future outcomes. At a high level, it has been argued that an over-reliance upon these methods led to a misplaced confidence in the industry's sense of control; during the crisis, these methods were challenged through the use of scenario planning and stress testing which have become a far more central feature of risk management – and are likely to remain so. A corollary is that most of the recommendations associated with innovation and its potential for generating negative outcomes are suggestions for adapting and improving existing governance mechanisms. Another way to state this finding is that concerns over innovation outcomes do not require an entirely new innovation governance framework, so much as enhancements to existing ones.

CHARACTERISTICS OF INNOVATION IN THE FINANCIAL SECTOR

A review of multiple industries shows that they all innovate and all experience occasional problems with innovation. Over time, each industry has developed its own mechanisms for the management of uncertainties and risks associated with innovation. Financial services is no exception. The financial services sector, however, exhibits a unique combination of characteristics that makes innovation and the management of outcomes difficult:

- **Connectedness:** Within financial services there is a higher degree of connectedness between participants than in most sectors, and at a macro level, there is a higher degree of connectedness between the financial sector as a whole and the rest of the economy than is true for most other sectors
- **Non-physical product:** Most financial products are essentially contracts or agreements between two (or more) parties. Traditionally, these contracts were recorded in paper documents but today they are often just electronic book-keeping entries. Once conceived, a financial product can proliferate and grow extremely rapidly, amassing a total market in the billions or even trillions of dollars far faster than can happen in markets for most "physical products"

- **Dynamism:** As an extension of the first two characteristics, the financial services sector exhibits a high degree of dynamism that may include interactions between innovations, behavioural change on the part of participants and interactions with economic and market changes
- **Innovation spiral:** Any one financial innovation can spawn a series of further incremental innovations. Merton (1992) introduced the term "financial innovation spiral effect" to describe this process. He pointed out that the development of a market in standardized products often leads on to more tailored, bilateral products. These tailored products are then hedged on the standardized market, leading to yet more volume, lower trading costs, and encouragement to launch similar contracts and markets, "spiralling toward the theoretically limiting case of zero marginal transaction costs and dynamically complete markets"[4]
- **Long-term nature:** Many financial contracts, in both banking and insurance, involve long-term commitments between parties such as life insurance, mortgages and many others
- **Embedded features:** Some contracts contain embedded optionalities, such as a fixed-to-floating interest rate structure, that are hard to value over time
- **Leverage:** This is a distinctive feature of the financial sector that can magnify the effects of unintended outcomes. In May 2007, Ben Bernanke said: "The leverage that can be embedded in new financial instruments and trading strategies compounds the difficulties of risk management. Embedded leverage can be difficult to measure; at the same time, like conventional leverage, it may increase investor vulnerability to market shocks. Some credit derivatives do make it easier for investors to take leveraged exposures to credit risk"[5]
- **Information asymmetries:** Again, financial services is a sector in which information asymmetries are common, and particularly marked whenever a financial innovation is involved

4 Merton, R. (1992) Financial innovation and economic performance. Journal of Applied Corporate Finance, 4, pp. 12–22

5 Bernanke, B. S. (2007) Speech to Federal Reserve Bank of Atlanta's 2007 Financial Markets Conference. May 15. Available at: http://www.federalreserve.gov/newsevents/speech/bernanke20070515a.htm

4. FINANCIAL INNOVATION

RECOMMENDATIONS

In order to improve its management of financial innovation the primary industry focus should be on upgrades to existing risk management frameworks, not the creation of a separate innovation-governance framework. Our recommendations strike a balance between a general, high-level summary of "issues to be addressed" and a comprehensive, detailed and prescriptive set of recommendations. What follows is a set of ideas and examples for how to better address the specific uncertainties and risks of financial innovation, in particular Knightian uncertainty.

The recommendations build upon four pillars. First, they address known weaknesses in the governance of financial services and take advantage of on-going efforts to address them. Second, they take a different perspective on New Product Approval Processes from an incremental innovation perspective. Third, they try to apply lessons from other industries, especially in the modelling field, such as the use of real options and fuzzy logic. Fourth, they reference and leverage existing risk management tools such as stress testing, scenario analysis and sensitivity testing to address the uncertainties linked to financial innovation.

Although current market practices show a wide range of sophistication, we believe that for a significant part of the industry, addressing these weaknesses is an important agenda item now and in the immediate future.

1. ENSURE APPROPRIATE OVERSIGHT OF FINANCIAL INNOVATION USING ADEQUATE TOOLS SUCH AS A "KNIGHTIAN UNCERTAINTY MAP"

Very few financial services companies have roles embedded in their organisation that are dedicated to financial innovation – especially from a risk management perspective. Few firms have a "new product risk role" and this should be addressed given the importance of new products for financial services and the fact that associated Knightian uncertainty may not be covered well by standard risk management governance.

To improve the organizational governance of innovation in financial firms we suggest two specific changes:

- Introduce a dedicated senior role to focus on and manage the idiosyncrasies of financial innovation risk
- Ensure appropriate Board oversight, for example by broadening the role of the Board Risk Committee

While this may seem to state the obvious, the financial crisis has highlighted various governance shortcomings. Readers should view this as a "call to action" rather than an original idea. However, a major focus when acting upon this suggestion should be "to increase awareness of Knightian uncertainty".

SENIOR ROLE

Having a senior role within the risk department that is dedicated to new products and financial innovations seems like the most straightforward way to upgrade the risk organisation; after all, risk organisations have created specialist roles for other specific components of risk. The role of Knightian uncertainty and the need to increase awareness of it and then to address and manage it, is a key finding of our work.

A key tool for this senior role could be a "Knightian Uncertainty map" to classify innovations along measurable versus unmeasurable risks. This would allow a deepened understanding of where the "high unmeasurable risk" factors lie within the organisation and sensitize for potential agglomerated uncertainties in portfolios, business units, geographies or similar dimensions.

The risks and uncertainties of financial innovation affect many internal processes and policies (such as Enterprise Risk Management, MIS, New Product Approval, Stress Testing and others) and we believe it requires a central role to manage especially the Knightian uncertainty component in that respect and emphasise its importance.

This specific role could thus be responsible for the following recommendations where we outline how Knightian uncertainty and the idiosyncrasies of financial innovation can be managed and mitigated by modifying the existing risk management infrastructure.

BOARD OVERSIGHT

The Basel Committee's Principles for enhancing corporate governance (published in October 2011) cite the failure of Corporate Boards to:

1. Understand or control risks taken by the executive
2. Limit exposure to complex or leveraged lending
3. Allow their banks to operate with a material liquidity shortfall, as the basis for a recommendation that banks should establish a Board-level risk committee

Thus, dedicated oversight of financial innovation should be made an explicit task for the Board Risk Committee including dedicated reporting on this subject embedded in the existing Board reporting. The Board should be able to understand the risks associated with innovation and the likelihood of negative externalities associated with the innovations. The risks for the institution if an innovation fails or develops a set of negative externalities can be severe, ranging from reputational impacts to bankruptcy in the worst case.

2. IMPROVE THE IDENTIFICATION AND HANDLING OF ADAPTATIONS AND "MUTATIONS" OF FINANCIAL INNOVATIONS TO ASSESS INCREMENTAL INNOVATIONS ARISING FROM CHANGES TO EXISTING PRODUCTS

Improvements to and variations of existing products are frequently de facto innovations. These adaptation-innovations can exhibit the same increase in Knightian uncertainty that is more visible with "new-new" products. In fact, an adaptation-innovation may be even riskier. It may be easier to recognize the absence of relevant empirical data when evaluating a "new-new" innovation. In the case of an adaptation, it is possible to make the mistake of thinking that empirical data from an earlier version of the same product can provide a statistically reliable guide to the future behaviour of the adaptation.

This may cause distress in financial markets precisely because the necessary sense of increased Knightian uncertainty is replaced by a false sense of high certainty. This may hold true especially in cases where the original innovation is not a problem at all, but where a downstream mutation changes the underlying characteristics of the original, and thus leads to trouble. Prominent examples in this area can be found in the recent crisis, when CDO structures were enhanced to CDO2 or CDO3, thereby altering the risk profile and characteristics of the original even though it was just "another packaging and tranching" rather than an entirely new product.

Alternatively, the adaptation of an innovation for a different purpose than originally intended may lead to a set of externalities previously not considered and therefore not anticipated in the risk management processes governing this innovation.

A firm's internal risk management framework and its New Product Approval process must account for changes to existing products. To repeat the guidance given by the EBA, with added emphasis: companies "... shall have in place a well-documented new product approval policy ... which addresses the development of new markets, products and services and significant changes to existing ones". In other words, once characteristics are changed (not the appropriate interest rate for a mortgage but a change to the characteristics of the mortgage), the nature and size of risks will need to be reassessed.

Innovation is not only characterized by new markets and new technologies but also includes changes, improvements, extensions and variations.

There are two major possibilities for these variations:

- Use of innovations beyond their original core purpose (for example, risk mitigation, capital relief, hedging, revenue enhancement, client need, etc.), especially with increasing opacity, complexity and heterogeneity of financial innovations, the intended or unintended new use could lead to adverse outcomes
- Use of innovations beyond the original target market or client (for example, retail, institutions, particular industry or sector, infrastructure, etc.) exposing customers to risk which was not planned for

Thus, similar scrutiny should be applied as for "full" innovations that are not in the grey area of variations and modifications. This includes any combination of products for

new strategies (e.g. investment or hedging) that may result in a new risk profile, not simply the addition of the products involved.

There is a limit to the extent to which the original innovator can be held responsible for modifications and adaptations of financial innovations in the market. Taking the example of CDSs, we would argue that JP Morgan as the original innovator should not be held responsible for any abuse of this innovation in conjunction with CDOs; rather, the "incremental innovator" introducing these new structures should have re-assessed the risks and likelihood for negative outcomes.

Consequently, a key question to be answered by the individual institution but also by the industry as a whole is where the threshold between innovations and mere updates should be set. This will ultimately determine where the full application of governance mechanisms is required.

3. ALLOW FOR A TRIAL PHASE FOR NEW PRODUCTS (ESPECIALLY CONSUMER PRODUCTS) TO ENABLE COLLECTION OF DATA FOR TESTING THE USE OF THE PRODUCT AND ITS ASSOCIATED RISKS

In the retail world, where time horizons can be long (home mortgages and variable annuities, for example), a trial phase for new products may prove useful to observe the product in the market. Contrary to the previously suggested limits, as part of the New Product Approval Process (NPA) an institution may also want to consider setting a certain timeline to conduct dedicated market trials with focus groups of a new product, in a manner similar to clinical trials in pharma. Market trials would not only produce real data on usage but these data could be supplemented through ethnographic research to observe how consumers actually use the product, compared to assumptions made during the NPA process.

This would help address the potential for mis-selling or customer disservice in the industry. In line with the FSA's efforts towards "Treating Customers Fairly", it is important that the innovating company understands " [... and] can identify and put in place appropriate controls to ensure customers are not exposed to inappropriate risk"[6].

This test phase would not only allow for some assessment of risks inherent in the product but also risks arising from misuse. The innovator can evaluate the product design but also the associated disclosure, suitability and comprehensibility of the product and improve these dimensions where required.

4. USE FLEXIBLE LIMITS TO ENCOURAGE INNOVATION AND ALLOW IN-MARKET TESTING OF NEW IDEAS WHILE MANAGING TOTAL EXPOSURES UNTIL SUFFICIENT REAL-WORLD OBSERVATIONS PERMIT FURTHER EXPANSION

Flexible internal limits can be used for new products if they are considered risky relative to other financial innovations. Financial innovation needs to be tested in the market in order to assess the true externalities, behavioural changes and potential risks. Rather than denying the introduction or launch of innovations, a trial period which allows the innovator

6 The UK Financial Services Authority. (2012) Product Design: Considerations for Treating Customers Fairly. Available at: http://www.fsa.gov.uk/pages/doing/regulated/tcf/pdf/product_design.pdf

and other stakeholders, such as customers and the regulators, to observe and evaluate an innovation should be considered.

An internal set of limits for new products that evolves and is responsive to observations could help in evaluating financial innovations. This is standard practice in insurance and reinsurance but other financial services might also benefit from applying this approach.

Depending on the nature of the innovation and innovating institution, these limits could take different forms, for example:

- **Internal capital limits:** Dedicated capital limits for innovative products to minimize extensive leverage in the beginning and restrict unanticipated losses.
- **Volume limits for new products:** Cap the exposure to innovations for individual institutions to provide some time to review and assess the innovation and its risks in the market until better understood.
- **Segment limits:** Limiting the "types" of customers to whom the new product would initially be sold would control risk exposure and avoid sales to unsophisticated consumers.

These self-imposed limits would likely discourage further regulatory limits and are tools for the Chief Risk Officer to encourage prudent launch of innovations. Also, this approach provides additional data points for a more accurate risk assessment of innovations after they have been launched.

5. ADDRESS THE LACK OF HISTORICAL DATA THROUGH FORWARD-LOOKING ADJUSTMENTS TO MODEL PARAMETERS AND THROUGH ADEQUATE STRESS TESTING AND SCENARIO ANALYSES

Stress tests (as well as scenario analyses) have become a well-established tool within the risk management framework of most institutions to test individual risk categories (such as credit risk and market risk) as well as the institution as a whole. This report will not elaborate on stress testing and its current use but rather will focus on what stress tests could do for managing the risk of financial innovation.

Two ways that stress testing could be employed to manage financial innovation should be considered. On one hand, financial innovations should be stress tested as a whole under different scenarios to assess the impact on the institution and how it may or may not shift the risk profile of the institution and other market participants. On the other, the underlying assumptions that influenced the innovation design should be stress tested to assess the impact of what happens if these assumptions do not hold true or adverse conditions unfold.

STRESS TESTING THE INNOVATION

One needs to acknowledge some underlying difficulties when trying to include innovations (e.g. new products) in a stress test. The Bank for International Settlement released a Working Paper in January 2012 on macro stress testing in which it calls out the difficulties associated with financial innovation[7].

7 Borio, C., Drehmann, M. & Tsatsaronis, K. (2012) Stress-testing macro stress testing: does it live up to expectations? Bank for International Settlements, Working Paper No. 369. Available at: http://www.bis.org/publ/work369.htm pp. 17, Box 2

"All stress tests – like all models – rely on historical data to estimate empirical relationships. Given typical econometric techniques, these models reflect average past relationships among the data series, rather than how the series interact under stress. Their reliance on past data also means that these models are not well suited to capturing innovations or changes in market structure. And yet, innovations – be they financial, such as structured credit products, or "real", such as the invention of railways – are often at the centre of the build-up of financial imbalances and the following distress [...] As always, assumptions are necessary to stress test new products. It is common practice to approximate the characteristics of new products by those of others for which historical information is available. This process involves potential pitfalls, which can result in a severe underestimation of risk."

These difficulties notwithstanding, stress testing a financial innovation should be seen as a key tool for identifying its risk profile. The limited historical data available must be augmented with forward-looking adjustments, acknowledging the specifics of an innovation, such as the unknown behaviours of customers and potential out-of-sample characteristics. The next recommendation will outline methodologies that could be used to improve traditional stochastic approaches.

Including tail risk in the stress testing is important. The financial crisis has taught that Value at Risk (VaR) calculations based on short time periods are poor at identifying tail risk. The use of extreme stress scenarios that include second and third order effects should become more standard.

STRESS TESTING THE UNDERLYING ASSUMPTIONS

Product innovations typically evolve based on a set of observed conditions, such as a low or high interest environment, abundant liquidity or inflation. These underlying assumptions need to be stress tested to assess the impact of adverse developments. This is less true of business model and process innovations but is still a consideration.

New products usually go hand-in-hand with a business plan that anticipates revenue development, operational costs and simulated risks (such as credit risk, etc.). These calculations should be revisited within a set of scenarios that explicitly stress these underlying assumptions, having the general question in mind: "How bad could it be?" or "How bad would it have to be?" Reverse stress testing is one way to identify the thresholds in parameters which will lead to a failure of the institution or the system.

A simple example from consumer banking can illustrate this. Negative amortization mortgages were popular in the pre-crisis era with low interest rates attracting customers. Even if the consumer is aware of the potential payment shock once the mortgage payments convert to amortizing payments which cover interest and principal, the financial impact on a household of these mortgages is strongly dependent on housing prices and can be especially painful for low to middle income families. If housing prices decline, the borrower would quickly owe more than the property is worth, increasing the credit risk for the bank.

Thus, before this new mortgage product was launched, an assessment of the underlying assumptions (for example, continuous increase in housing prices, stable macroeconomic situation, no adverse developments in the employment situation) could have highlighted that the bank would face unexpected risks if conditions deteriorated.

Thus, a stress test should simulate the target size of the portfolio and its credit risk in case the favourable conditions become adverse developments. Under a falling housing price scenario, estimates of the probability of default (PD), the loss given default (LGD) and delinquency payments would have revealed the significant credit risk for the institution.

Ultimately, this would influence the approval of the new product by either limiting the permissible exposure to stay within risk appetite limits in the scenarios or by delaying or prohibiting the launch of the new product due to further considerations, such as the reputational impact implied by the scenarios. The latter aspect should be a key consideration for the innovating institution. Trust has become a fundamental issue for financial services consumers. Once weaknesses of financial innovations are discovered, as in the case of the negative amortization mortgage, tailoring this product to a target group that understands the risks and wants to take them on rather than launching it for the general public could prove more sustainable for the innovating institution and the industry as a whole.

6. REVIEW THE USEFULNESS OF FLEXIBLE METHODOLOGICAL APPROACHES, SUCH AS REAL OPTIONS AND FUZZY LOGIC, TO ADDRESS THE OUT-OF-SAMPLE PROPERTIES OF FINANCIAL INNOVATIONS

Current practices could be improved by augmenting traditional stochastic approaches with more flexible methodologies to address the "out-of-sample" nature of financial innovation. Several tools are available for this task, though they currently have only limited application within the financial services industry, among more cutting-edge firms. Examples of such new methodological approaches include real options and fuzzy logic – though these are just two from a long list of available methods that could be considered.

REAL OPTIONS

Real options are a powerful alternative method to assess the value of Research and Development (R&D) projects and innovations. Originally introduced by Stewart Myers in 1977, "real options" refers to the application of option pricing theory to non-financial or "real" investments with learning and flexibility, such as multi-stage R&D.

The method has received increased attention since the late 90s and now has many applications. However, nowadays the term "real options" extends to the general discipline of decision-making under uncertainty and is thus an increasingly popular method for business strategy formulation.

Real options are an example of how decision-making under uncertainty can be improved by staging decisions: business conditions are volatile, outcomes are uncertain and there is a risk of negative outcomes.

Thus there is a high investment risk to any decision to proceed with innovations.

Real options address these risks and acknowledge that there is significant upside. They reflect the value of such possibilities as well as the option to abandon the project if circumstances prove worse than expected.

In fact, other industries explored in the course of this project, such as pharmaceuticals and the oil and gas industry, have been using real options for several years to evaluate risks and returns associated with R&D investments.

FUZZY LOGIC

As proposed by Zhou and Dong[8], fuzzy logic addresses situations where membership in a set is a matter of degree. In other words, it deals with problems in which a source of vagueness is involved, as well as interpretation that is approximate rather than fixed or exact. Fuzzy logic and probabilistic logic are mathematically similar (that is, both have values for a given "state" that range between 0 and 1.0) but conceptually distinct due to different interpretations. Fuzzy logic corresponds to "degrees of truth" where something may be "absolutely true," "absolutely false" or possess some intermediate degree of truth: one proposition may be more true than another proposition, whereas probabilistic logic corresponds more to "likelihood".

There are many examples of how fuzzy logic could improve decision-making under uncertainty in the field of innovation and new product approval processes. These examples are mainly drawn from the non-financial services world. An interesting application of fuzzy logic can for example be found in the article, "A fuzzy-logic-based decision-making approach for new product development"[9], where the authors outline three distinct applications of fuzzy logic to improve decision-making under uncertainty and address the idiosyncrasies of innovation:

- **Selection of innovative ideas:** Pseudo-order fuzzy preference model (Roy and Vincke, 1984)[10]
- **Selection of the best innovative idea:** Fuzzy weighted average method (Vanegas and Labib, 2001)[11]
- **Selection of the best development strategy:** Fuzzy AHP method (Triantaphyllou, 2000)[12]

8 Dong, M. & Zhou, X-S. (2004) Can fuzzy logic make technical analysis 20/20? Financial Analyst Journal, 60(4), 54–75

9 Buyukozkan, G. & Feyzioglu, O. (2004). A fuzzy-logic-based decision-making approach for new product development. International Journal of Production Economics, 90(1), pp. 27–45

10 Roy, B. & Vincke, P.H. (1984) Relational systems of preference with one or more pseudo-criteria: Some new concepts and results. Management Science, 30, pp. 1323–1335

11 Vanegas, L.V. & Labib, A.W. (2001) Application of new fuzzy weighted average method to engineering design evaluation. International Journal of Production Research, 39(6), 1147–1162

12 Triantaphyllou, E. (2000) Multi-criteria decision-making methods: A comparative study. London: Kluwer Academic Publishers

A distinct feature of fuzzy logic is that its reasoning is similar to human reasoning. Being able to process incomplete data and involve expert judgement by applying the "degrees of truth" are key strength in this approach. Crucial here is obviously the selection of experts, i.e. the staff involved in the assessment.

A similar application in the space of financial innovation – tailored to the specific innovations and idiosyncrasies that characterize financial innovation – seems worth considering. It can prove to be a powerful tool for the industry to improve its decision-making under uncertainty.

A number of other approaches could be considered here to augment traditional stochastic methods currently predominantly in use in financial services. The examples given above are simply illustrations drawn from observations in other industries and disciplines to improve the ability to make decisions under uncertainty and decrease the likelihood of unfavourable outcomes in the field of innovations.

7. IMPROVE MANAGEMENT INFORMATION SYSTEMS (MIS) TO BETTER MONITOR FINANCIAL INNOVATION

The demands placed on MIS at financial institutions have increased significantly over the last four years. Increased regulatory requirements to provide tailored reports were certainly a driver but the appetite of internal stakeholders (such as the Board, Executive Management and Operational Management) for actionable and effective reports has also increased. As it is not within the scope of this report to outline best practices for MIS as a whole, the following will focus only on what MIS should ensure from a financial innovation perspective: how it can increase awareness of the risks and support decision-making. Reporting, however, is no panacea and robust feedback loops from monitoring to decision are mandatory to ensure that management information has "teeth". Even though MIS and monitoring may exist, the "call for action" is where failures can be observed in the past.

On an institutional and an industry level, periodic reports dedicated solely to financial innovations and their developments can be a useful source of information for the Board and the Executive Management, including the CRO, to take informed decisions in steering the institution.

Tracking revenues to see the percentage coming from products of different degrees of "newness" (e.g. a spectrum of "innovation vintages" across ranges such as "less than 6 months old", 7–24 months, 25–60 months, greater than 5 years) can provide insight into potential volatility of earnings and the inherent risks in those revenues.

Earnings at Risk is a well-established metric in a financial firm's MIS; it shows the impact of an interest rate change on net income. A similar metric could be constructed to show how a shift in the factors and assumptions associated with revenue-generating products, by "innovation vintage" could change total income.

All the previously outlined aspects that could be addressed from an ERM perspective should feed into the MIS and adjustments made to monitor each of these aspects adequately. Improved MIS will provide several benefits to individual institutions and the industry:

- Help management and Board members understand the effect of innovation on current income while reflecting the associated risks, and the sensitivity of revenues and income to innovation uncertainties
- Benchmark each institution against the industry, using metrics such as "revenue innovation vintage", to support decision-making for risk management and new product approvals
- Monitor and challenge the underlying assumptions for innovations and their planned or budgeted role in the portfolio of the institution. Stress testing will be effective only if it is adequately reported and leads to actionable decisions
- Track the utilization of internally imposed limits for innovations at the institutional level

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For more information please contact the marketing department by email at info-FS@oliverwyman.com or by phone at one of the following locations:

AMERICAS
+1 212 541 8100

EMEA
+44 20 7333 8333

ASIA PACIFIC
+65 6510 9700

ABOUT THE AUTHORS

Peter Carroll is a Partner in the Americas Retail & Business Banking practice.

Dominik Weh is a Manager in the Europe, Middle East and Africa Finance & Risk practice.

www.oliverwyman.com

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