TopQuants Newsletter

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Editorial

Dear reader,

The TopQuants team presents the second issue of our 2015 newsletter series. This is the first newsletter of hopefully many that will be produced by our new editor, Marcin Rybacki (Cardano). Therefore we would like to welcome him into the TopQuants team, and also at the same time express our deep gratitude towards the previous editor, Aneesh Venkatraman (RBS), for his hard work in the past years. We wish you all the best in the United Kingdom, Aneesh, and hope to welcome you at one of our future events so we can thank you for your efforts in person!

As always we cordially invite all readers to contact us with your ideas and submissions. Anything that is relevant to our quant audience, is more than welcome!

The current issue will kick off with a summary of the Spring Event that was held at EY earlier this year. This event focused on the transition from bilateral derivative agreements to central clearing, and had speakers presenting three different perspectives on clearing - Philip Whitehurst (LCH.Clearnet, a clearing house), Raoul Pietersz (ABN Amro, a clearing member) and Svetlana Borovkova (Free University of Amsterdam and DNB, the Dutch regulator). The event summary is followed by an in-depth article from one of the speakers, Svetlana Borovkova, about the effect of central clearing of OTC derivatives on the financial system stability by means of network simulation approach. This work builds on the presentation she gave at the Spring Event, and is co-authored with Hicham Lalaoui El Mouttalibi (PwC Netherlands).

The third article is a submission from Guusje Delsing, Nathan Meibergen (coincidentally also the winner of the TopQuants Best Quant Finance Thesis Award 2015) and Jan Willem Timmer (all working at EY). Their article deals with one of the more recent paradigm shifts in the world of derivative pricing – that of valuation adjustments. The authors focus on CVA and DVA, both of which are valuation adjustments to take into account the default of either of the two involved parties within a bilateral derivative contract.

The final article is an interview with the host of our next Autumn Event, DNB. Hugo Everts (DNB, Senior Risk Manager Financial Markets) interviewed Paul Wessels (DNB, Head of Risk Management) and Pieter Moore (DNB, Risk Manager Financial Markets) on the topic of interest rate risk management at the central bank. As a result of the quantitative easing within the Eurozone, the balance sheet of DNB contains more risks than ever before, making this a very important topic.

Before we let you all enjoy the great articles within the current newsletter, we glance forward to the next newsletter. This will certainly contain more information on the recently held Quant Careers 2015 event, at which three former students Nathan Meibergen (TU Delft), Marcin Rybacki (Tilburg University) and Sina Zolnoor (Free University of Amsterdam)) battled it out against each other in order to decide who is the winner of the Best Quant Finance Thesis Award 2015. Moreover, the first newsletter of 2016 will also contain coverage of the upcoming Autumn Event, kindly hosted by DNB.

Since 2016 marks the fifth anniversary of TopQuants, keep a look out in your mailbox, on Twitter (@topquants), and on our webpage, for new events. We are working very hard to make 2016 bigger, better, and quantier than ever!

On behalf of the TopQuants team,

Marcin Rybacki

TopQuants Spring Event—2015

Beyond bilateral – Three perspectives on Central Clearing of OTC derivatives by Tim Mexner (ABN AMRO)

At least since the credit crunch of 2008, Central Clearing Counterparties (CCPs) have stirred a lot of interest within the financial sector. Opinions often differ between practitioners, researchers, and regulators. Central clearing is nowadays prescribed by several regulators and law-makers as a remedy against counterparty risk, and to promote transparency in derivatives markets. Some critics are concerned that CCPs themselves pose a new systemic risk, others are worried that margin account rules will discourage smaller non-financial companies from executing hedge strategies involving derivatives. No matter whether perceived as a blessing or a burden, central clearing is applicable to a steadily growing number of derivatives transactions. Consequently, quantitative finance professionals need to take it into account in the models they build, and reflect it in the tools they provide to traders and risk managers.

Of course, all this makes central clearing of OTC derivatives a perfect topic for an afternoon seminar. About a hundred financial professionals thought likewise and attended the TopQuants Spring event, held at the EY headquarters in Amsterdam on 26 May 2015.

Martin van Buren (Rabobank), the TopQuants facilitator of the event, started with a warm word of welcome. After that, Diederik Fokkema (EY) welcomed the audience on behalf of the host and sponsor of the Spring event. Diederik also announced that TopQuants had been formally registered as an association with the Chamber of Commerce and presented the association's board of directors.

The main part of the programme combined three presentations and a panel discussion. Philip Whitehurst (LCH.Clearnet), the first speaker, introduced the topic from the perspective of LCH.Clearnet, an important clearing house for derivatives. He explained which problems CCPs solve and how they do this, namely by "unbundling market risk from credit risk". He then discussed the concept of the CCP's resource waterfalls, and how this works to protect the trading parties in a concrete example of an interest rate swap. In his presentation, Philip argued that the much discussed "skin in the game" ought to provide the proper incentives for the CCP, but does not need to provide itself a lot of risk absorption.

The second presentation was given by Svetlana Borovkova (VU Amsterdam, DNB), who talked about Central Clearing and Systemic Risk – A network approach . She argued that the advantages of central clearing were novation and netting as well as increased transparency of OTC markets, but that the transformation of counterparty into liquidity risk was a downside. Svetlana explained how these conclusions could be drawn from network models of financial markets. In such models, she has studied the effects of large yield curve movements as external shocks on the system, investigating in particular the phenomenon of contagion defaults. In some of such network structures resembling real financial markets, Svetlana found that central clearing may reduce total capital losses for the model economy as a whole. However, she warned that this is achieved at the expense of an increased number of contagion defaults in the periphery of the structure, i.e. among relatively smaller and less connected market participants.

In the third talk, Raoul Pietersz (ABN AMRO) explained the contribution of his team of front-office quants to the Default Management Process. Participation in this process, often also referred to as a "fire drill", is typically compulsory for banks who have interest rate swaps cleared via a CCP. The bank has to bid on the swap portfolio of a hypothetical party gone into default. While this "fire drill" is intended by the CCP to test and improve the reliability of the auction process, anonymized information on value ranges is communicated back to the participants. Raoul Pietersz argued that this feedback loop helps banks by providing a benchmark to test the quality of their internally developed pricing models.

After the three presentations, all speakers participated in the panel discussion. Event attendees could ask questions via text messages, Twitter (@topquants), or verbally. Topics covered in the discussion included derivatives pricing under CCP collateralization versus the "old" bilateral collateralization, the possibility of clearing house defaults, and whether governments should step in in such cases.

After the lively panel discussion, all event participants were challenged to play the game "Down-and-Out", an exciting and entertaining knock-out quiz. Finally, everybody had ample opportunity for informal discussions and networking during a complimentary buffet dinner and drinks session.

TopQuants would like to thank

– all speakers for their contributions,

– EY for hosting and sponsoring the event,

– all participants for attending.

See you at our next event!

Systemic Risk and Centralized Clearing of OTC derivatives: A Network Approach

by Svetlana Borovkova (VU Amsterdam)
and Hicham Lalaoui El Mouttalibi (PwC Nederland)

Abstract

In September 2009, G20 paved the way for the mandatory central clearing of over-the-counter (OTC) derivatives, which currently is being implemented. This new regulation involves a central clearing counterparty (CCP): a financial institution acting as an intermediary between buyers and sellers of OTC derivatives. The rationale behind this regulation is that, by removing bilateral agreements, CCPs will absorb the risks facing individual firms and act as a cushion in the event of market stress. However, this increases the systemic importance of CCPs within the financial system.

We analyse the effect of central clearing of OTC derivatives on the financial system stability by means of network simulation approach. We build tractable but realistic networks of financial firms, connected by bilateral links and via a single CCP. We simulate balance sheets of firms and introduce shocks to the system to simulate defaults. The default mechanism and shock absorption in presence of the CCP is modelled in the way that maximally reflects the reality. We run Monte Carlo simulations of the networks' evolution and obtain their default and contagion characteristics. We analyse the likelihood of the CCP's default and compare the stability of the financial network with and without the CCP for various network configurations and market scenarios.

We find that, for a homogeneous financial system, the presence of the CCP increases the network's stability; moreover, in this case the probability of the CCP's failure is virtually zero. However, for non-homogeneous financial networks (e.g., for so-called "core-periphery networks"), we find quite the opposite effects: the presence of the CCP leads to a disproportionately large probability of contagion defaults, especially for smaller financial firms, which are sacrificed in order to keep systemically important financial firms afloat. Furthermore, we find that the probability of the CCP failure is substantial in this case, regardless of the capitalization requirements. In all, we find that non-homogeneous networks exhibit greater instability and contagion in the presence of the CCP: a worrying fact, given that any real financial system is highly inhomogeneous in terms of size and concentration.

Introduction

Systemic risk and the contagion of losses (especially those resulting from OTC derivatives) became prominent discussion topics during the latest financial crisis. The opaque nature of the OTC derivatives markets, combined with mismanagement of risk, provided an environment for excessive risk taking by a few institutions, leading to major bailouts. Various measures have been taken so far: the regulation has been put in place to absorb disruptive shocks resulting from a possible default of a Systemically Important Financial Institution (SIFI). To counter the opaque nature of the OTC derivatives market, reporting and central clearing mechanisms have been introduced, in the form of EMIR in Europe and Dodd-Frank act in the USA. Central clearing counterparties (CCPs) are entrusted with the task of mitigating counterparty credit risk (perceived as the main risk in the financial system) and of enforcing prudential risk management practices of their clearing members. One of the main advantages of central clearing is netting of positions, which decreases the total amount outstanding in the system. However, netting only works well when a small number of CCPs clear a limited variety of derivatives.

New clearing requirements may be a challenge for many financial institutions such as pension funds and insurance companies: the main buyers of OTC derivatives (mainly interest rate swaps). Risk sharing mechanisms and short-term margin requirements, meant to mitigate counterparty risk, are experienced by these parties as an extra source of risk – in particular, liquidity risk - and costs. Moreover, these parties will have difficulties integrating these requirements with their long-term-focused business models. Many financial players believe that the introduction of centralized clearing of OTC derivatives does not simply eliminate credit risk, but replaces it with liquidity risk of a comparable magnitude.

The aim of this paper is to understand the contagion risk faced by financial institutions after the introduction of centralized clearing. To achieve this goal, we make use of the network approach. We are interested in the comparison of stability and contagion characteristics of a system where OTC derivatives are centrally cleared and the one where trades are bilateral. We study, for different network topologies, whether the centrally cleared system is more resilient to cascading failures. We make a distinction between a random (possibly tiered) network and a tiered core-periphery structure. Furthermore, we study how the size distribution of the market participants affects stability. We also address the question whether a higher capital buffer positively affects risk of contagion defaults and losses.

Network models of a financial system

The financial system is represented by a network, i.e., a graph consisting of the set of nodes (financial institutions) and the set of possible edges, i.e., links between financial institutions – these can be loans/deposits, but also can be derivatives transactions. The graph is directed, so that each edge has a direction of the exposure associated with it (i.e., loan/deposit, long/short position, fixed/floating leg of a swap contract). We characterize the network by weighted links, the weights indicating the sizes of the exposures.

We consider several types of networks. The first class are random graphs, also called Erdos-Renyi graphs. In such a graph, each edge is present independently of other edges with probability p. So this is a typical example of a homogeneous system (in terms of connectivity). The second class of networks is a more realistic model, which introduces a "tiered structure"'. Banks are divided in "small" and "large", where large banks have a higher probability of being connected than small ones. Some recent studies have found that the financial system has the so-called core-periphery structure, which is not captured by random Erdos-Renyi graphs, even when allowing for tiering. Such a network is represented by two classes of nodes: highly connected core nodes (linked to one another) and periphery nodes, which are connected only to core but not to each other.

Recall that here we are mainly concerned with modelling the financial system from the point of view of the OTC derivatives markets. From this viewpoint, financial systems, particularly in developed markets, are typical examples of core-periphery networks. There are only a few big "core" financial institutions, highly connected to each other (large investment banks such as JPMorgan, Morgan Stanley and Goldman Sachs in the US, Barclays and HSBC in the UK, Deutsche Bank in Germany), which are net sellers of OTC derivatives, while a very large group of (typically smaller) financial institutions, such as pension and mutual funds, insurance companies, are buyers of such derivatives, in particular, interest rate swaps. So our main focus is on core-periphery networks, as we believe these represent a typical financial system in the most realistic way. We compare them to random graphs and their variation with a tiered structure. The parameters such as the number of institutions, the proportion of large (well-connected) institutions and the overall connectivity probability are kept fixed to make all networks comparable.

Figure 1 shows examples of a random homogeneous network, a network with a tiered structure and a core-periphery network. All networks consist of 100 nodes and the overall connectivity probability is fixed at 0.2. The size of each node is determined on the basis of the number of edges.

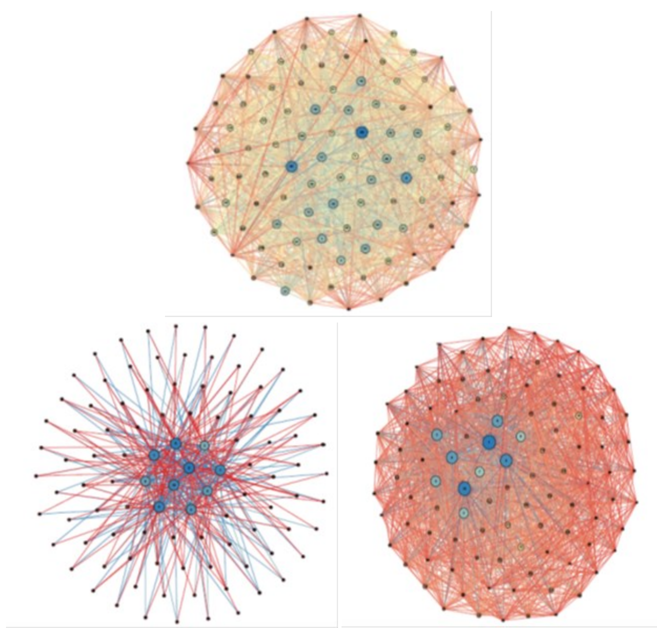

Figure 1: *Random , tiered and core-periphery networks.*

Note that the core-periphery network seems less dense than random (also tiered) networks, and the linkages between the nodes is much orderly: peripheral institutions are connected only to core nodes and do not have any connections mutually.

The balance sheets of the financial institutions in the network are modelled in a standard way, i.e., consisting of assets and liabilities, where the assets are divided into the fixed assets, liquid assets (used for the required clearing margins) and the interbank assets, and the liabilities include the capital, deposits and interbank liabilities. For all network participants, the balance sheets are simulated in such a way that it reflects their size and connectivity, satisfies the borrowing/lending conditions and keeps the total size of the system fixed. For more detail on balance sheet simulation, as well as on the algorithm for wiring the network of a particular type, we refer the reader to our full paper.

The next step in setting up our network model is to determine the links representing OTC derivatives transactions. Here we consider interest rate swaps, as these represent the largest OTC derivatives class. We assume that there is just one interest rate curve in this system (evolving according to some factor model, in our case 1-factor Hull & White model) and 5 tenors for these swaps. Each party has an equal chance to hold the fixed or the floating leg of a swap. We distribute the contracts randomly through the system, again, paying attention to the size and connectivity of the participants – the larger is the participant, the bigger (in terms of notional) is its IRS portfolio.

Central Clearing and default mechanisms

Clearing houses apply a number of layers of protection in a default scenario to meet the obligations of the defaulter. A so-called Default Waterfall, as shown in Figure 2, is set up to cover losses and to ensure the performance of cleared derivatives. CCPs will request margin (collateral) to cover changes in the market value of contracts (variation margin) or potential losses if a member would default (initial margin). The default fund contribution is the next protection layer meant to cover any losses not covered by the margin calls. The CCP's own capital (which is relatively small) is utilized if needed as a final measure to cover any residual losses. Currently there are additional measures of protection suggested, such as top-up of the default fund by the non-defaulting members.

In our study, we set initial margins to 10% of the IRS notional (which comes quite close to actual initial margins, usually computed by sophisticated risk measurement techniques) and the default fund contribution – to the 10% of the initial margins – again, a relatively realistic number.
Our simulation experiments are constructed to investigate how shocks affect the financial system. Our starting point is thus a first default, which we call a fundamental default, that acts as a cause of all possible contagion losses and contagion defaults. Recall that we stochastically

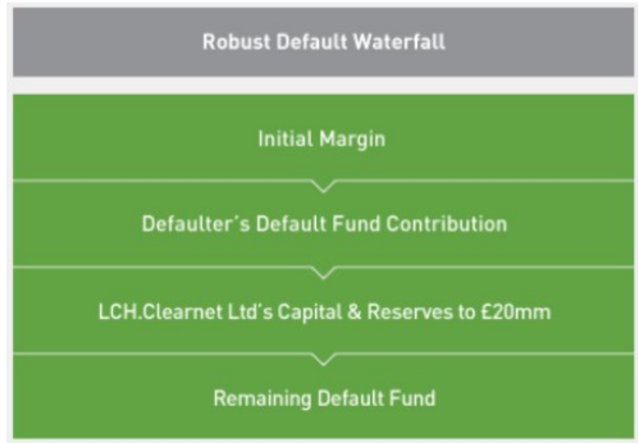

Figure 2: *Default waterfall of a CCP*

simulate the interest rate curve, increasing the volatility until the first fundamental default (there may be more than one) occurs. It happens when a loss (on derivatives contracts) big enough leads to at least one default. In centrally cleared system, a fundamental default occurs when the required margins (variation, initial and default fund contribution) are greater than a clearing member's available capital. The losses in two systems that we study - a system with central clearing and one without – are compared by taking the same default event as the starting point for all contagion losses and defaults in both systems.

IRS contracts of the defaulted parties are set off against each other if possible. The CCP always maintains a zero net exposure, which it achieves by transferring the contracts of the defaulted clearing member to financially healthy ones, by means of a closed auction. This may result in other members acquiring the defaulted member's contracts at a discount. As it is impossible to determine such a discount beforehand, we assume that the outstanding contracts change owner at their market value, which gives us an upper bound on all the default characteristics. Moreover, it is not unrealistic: following the default of Lehman Brothers, the auction value of their IRS contracts was very close to the market value, according to reliable sources.

After the CCP has transferred all the IRSs of the defaulted parties, we compute the extra collateral each member has to post in the second round. This can either be an extra contribution to the default fund if this is eroded in the previous round or a simple margin call (variation and intial) for all the new contracts held by a specific member. If any member is unable to perform on its obligations, it defaults, and the process is repeated. We stop the recursion when no contagion defaults are found.

Losses in a bilateral market are more straightforward to compute and simulate, compared to a system with central clearing, so we do not explain it here – interested readers are referred to our full paper.

If the default fund is exhausted (and we assume that no top-ups are allowed), CCP defaults. In this case, we carry out a transition to a bilateral OTC market. As we keep track of the actual counterparties of derivatives transactions (also in centrally cleared situation), members become each other counterparties instead of the CCP. All collateral of the members held by the CCP is lost in this case and all further computations are handled in line with the bilateral approach.

Results of the simulation study

The first step in the simulation experiments is to generate a network, i.e., a random graph. Here we will compare random Erdos-Renyi, random tiered and core-periphery networks. The second step is to construct all the balance sheets and IRS portfolios of the participants and of a CCP. Portfolio values are simulated after that, until we obtain a fundamental default. Next, the spread of the shock through the system and contagion characteristics are calculated, from which we obtain the overall number of defaults and the total losses to the system. For each network, it is done in CCP-cleared and bilateral situation. This Monte Carlo simulation experiment is repeated 10.000 times. The analysis is subsequently based on the averages obtained from these simulations.

The probability of a fundamental default is, understandably, very low. So to get meaningful numbers from our simulations, all our results are conditioned on the first fundamental default.

Random network

The following three plots in Figure 3 show the default and contagion characteristics of a random network vs the system size. The number of contagion defaults (top graph) grows, as expected, in a bilateral system, together with the system size, but declines in a CCP cleared situation, indicating the netting benefits of a CCP. The total capital lost (central graph) declines for both situations, but is smaller for CCP-cleared system than for a bilateral system. Finally, the probability of CCP defaulting is very small, and is declining together with increasing number of participants. In all, this shows that for a random network, CCP clearing shows clear benefits over a bilateral system.

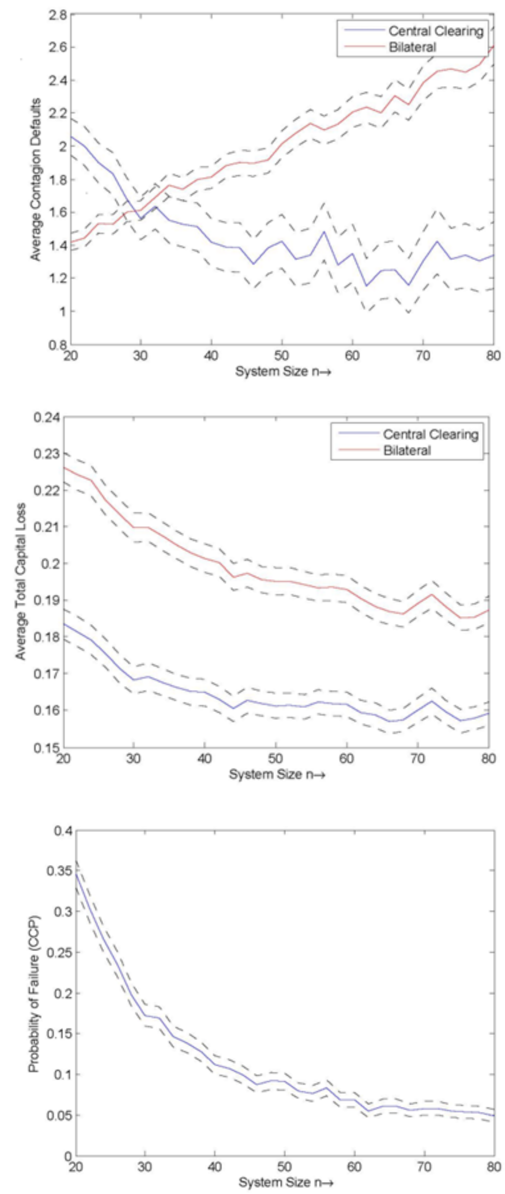

Figure 3: *Contagion characteristics of a random network: number of defaults, lost capital and probability of CCP default..*

Random tiered network

Random graph is, however, not a realistic representation of a financial system. So now we move to random tiered networks, which is a step towards a more realistic situation. We assume that big institutions form 10% of the network, the rest of institutions are "small". Figure 4 shows the default and contagion characteristics for such a network.

Similar patterns to a random network are observed in

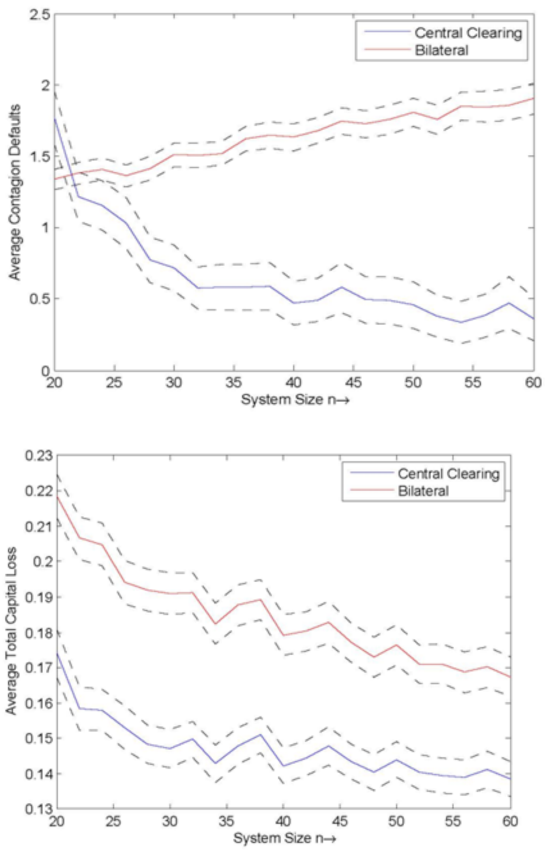

Figure 4: *Contagion characteristics of a random tiered network: number of defaults, lost capital*

Figure 4 and the benefits of central clearing are visible. However, recall that 90% of members in our model are "small" players while only 10% are large financial institutions. Cascades from failure of a small institution are highly unlikely, while it is instructive to analyze the contagion in the system following a default of a large institution, which will have graver consequences than a default by a smaller one. So now we condition everything on a fundamental default of a large institutions and the corresponding default and contagion characteristics are presented in Figure 5.

The number of defaults shows that there is a much higher contagion risk in a CCP-cleared situation when a large player defaults, while the number of defaults in bilateral system hardly changes. This is because in a bilateral system the losses spread to the counterparties of the defaulter, while in a system with a CCP defaults and their residual losses are covered by all market participants. This leads on the one hand to a better management of the total losses suffered in the system (the lower plot on Figure 5, which shows that in terms of total loss, centrally cleared system performs still better than bilateral one), but puts smaller players into financial distress much faster. The capital lost when these players default is relatively small, so although there are more contagion defaults, the total contagion losses are lower.

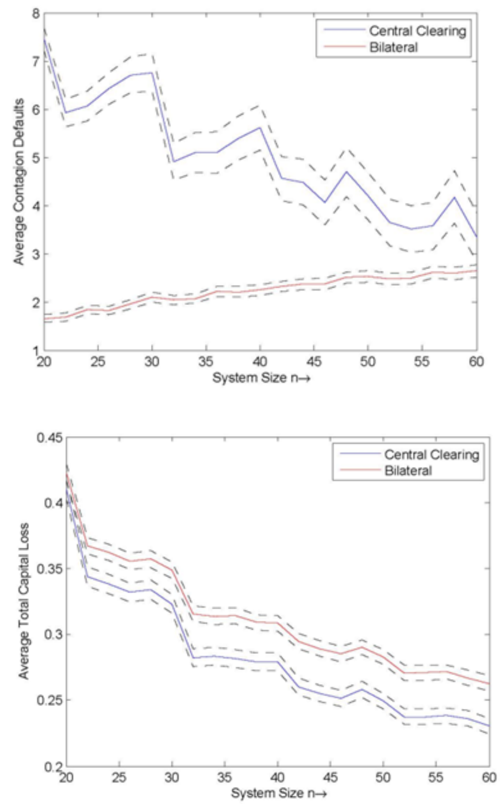

Figure 5: *Contagion characteristics of a random tiered network: number of defaults, lost capital conditioned on a fundamental default of a large financial institution.*

Figure 6 shows the probability of CCP failure, upper graph corresponds to the situation where all defaults are considered as the start of the contagion cascade and the lower one - where the cascades are the result of the failure of a large institution. The CCP benefits from a larger number of participating members, but the default of CCP following a default of a large member is significantly higher.

So already for a random but tiered network it is clear that the benefits of central clearing are not that obvious, in particular in the situation when a large clearing member defaults. The contagion of defaults is, in that case, higher than in a bilateral system, as small players are affected faster and more severely, however, in terms of the total capital lost the centrally cleared system still seems to perform better than a bilateral one.

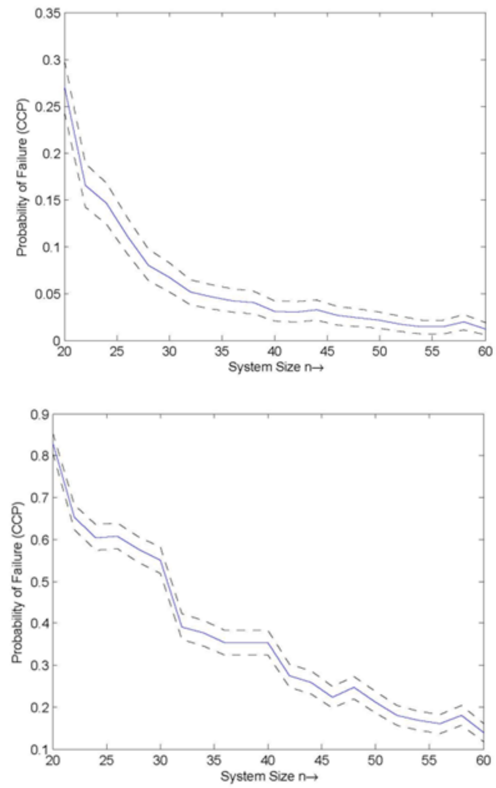

Figure 6: *Probability of CCP default: conditioned on any fundamental default (left) and on a default by a large clearing member (right)*

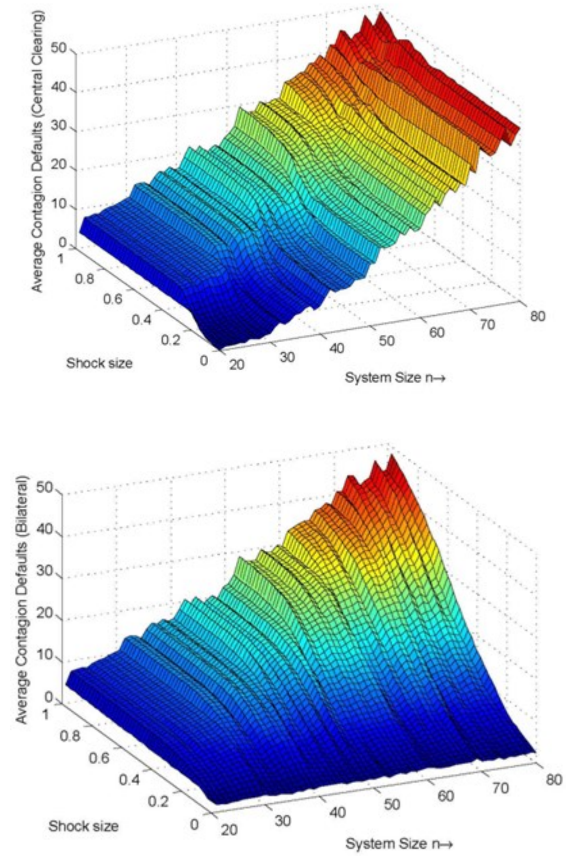

Figure 7: *Number of defaults in centrally cleared and bilateral core-periphery network.*

Core-periphery network

As we argued before, a core-periphery network reflects the topology of a financial system more realistically, so we consider it in more detail in our experiments: everywhere we also consider various shock sizes as an extra dimension. As with tiered networks, we assume that 10% of the institutions are at the core of the network and the rest – on the periphery.

Figure 7 shows the average number of defaults in a centrally cleared and bilateral systems. Central clearing, for this network configuration, has less benefit in terms of contagion defaults, and even has adverse effect for small system size.

The capital losses are given in Figure 8, for a system with CCP and one without, respectively. Central clearing of OTC derivative appears to have some benefit when the losses are considered instead of the number of defaults, apart from large shocks, when losses in both systems are similar.

The number of defaults and contagion losses resulting from the failure of a large clearing member are shown in Figures 9 and 10. Central clearing does not lead to lower number of defaults (in fact, it exacerbates it, especially for smaller shocks), but it does lead to limited contagion losses (especially for larger systems), as it does for tiered networks.

The probability of CCP failure, conditioned on a default of a core institution, is given in Figure 11. The most notable observation is that, if the shock is big enough, the CCP will most surely get into trouble, and the positive effect of a larger system (observed for random networks) is not observed for core-periphery network anymore.

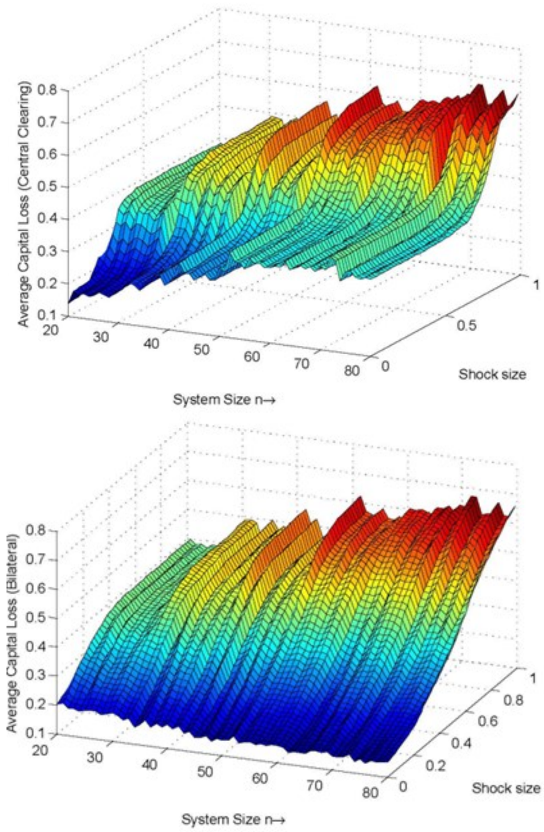

Figure 8: Total capital lost in centrally cleared and bilateral core-periphery network.

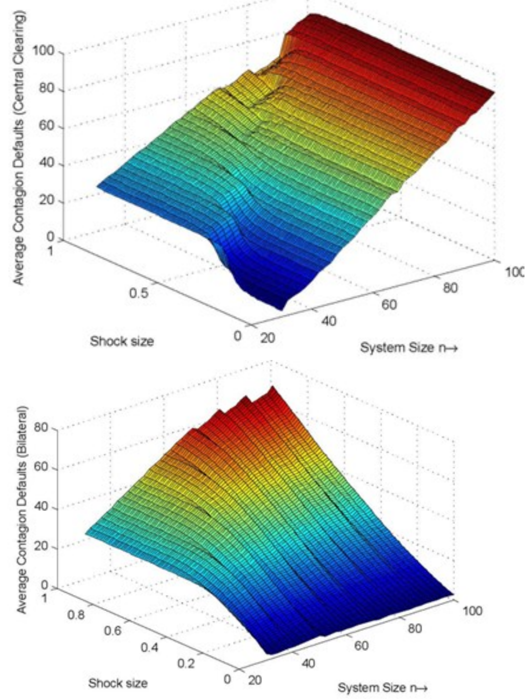

Figure 9: *Number of defaults in centrally cleared and bilateral core-periphery network, conditioned on a large institution's default.*

Conclusions

This paper examines how central clearing of OTC derivatives impacts systemic risk and contagion in financial systems. We consider a set of network topologies, which are typically used to analyze financial systems: random, tiered and core-periphery networks. Our aim was to keep the models as simple, but also as close to reality as possible. For this purpose, we applied simplified versions of many clearing mechanisms available to CCPs.

We have shown that the effect of the central clearing on the financial system is complex and highly non-linear. The first part of the analysis focused on random networks, where all parties are similarly connected and are of a similar size. The CCP successfully mitigates system risk in such a setting, in terms of both number of contagion defaults and capital losses. This setting, however, does not represent financial networks in a realistic way: financial institutions are generally of different sizes and have different degree of connectedness.

A more realistic model is a tiered network, i.e., containing a few large and highly connected financial institutions. At first glance, it seems that also in this setting, the CCP is capable of reducing contagion. However, when a fundamental default affects a large financial institution, we find that, in presence of CCP, the number of contagion defaults is significantly higher than for a bilateral market. On the other hand, total capital losses are still lower in presence of CCP: this follows from the fact that higher number of defaults are caused by smaller members, which are disproportionately sacrificed in the event of market stress.

Finally, a core-periphery network is implemented, representing the most realistic setting. In this case, the size and connectedness of financial institutions differ even more, so we find that the CCP has more trouble reducing counterparty risk. Small counterparties in a bilateral OTC market are not directly affected by contagion, as they are shielded away from the rest of the market: that these parties are generally only connected to one counterparty in the core and none in the periphery. In contrast, central clearing translates to a much wider spread of contagion to small institutions in the periphery, which subsequently instigates a high default rate when losses from a large clearing member are high.

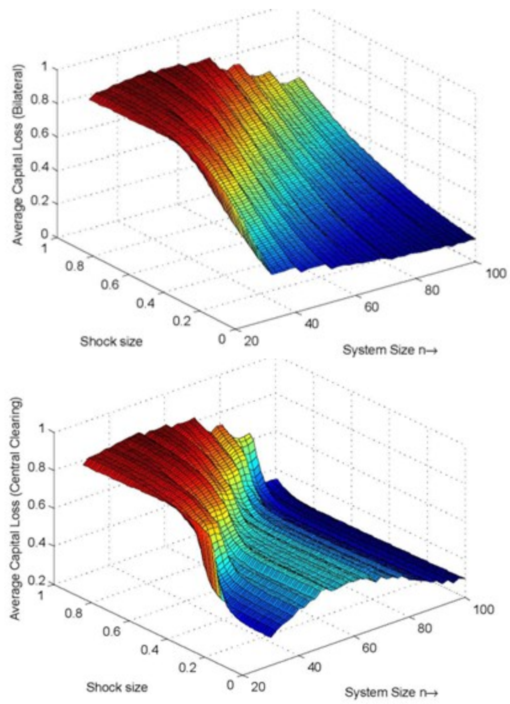

Figure 10: *Total capital lost in centrally cleared and bilateral core-periphery network, conditioned on a large institution's default.*

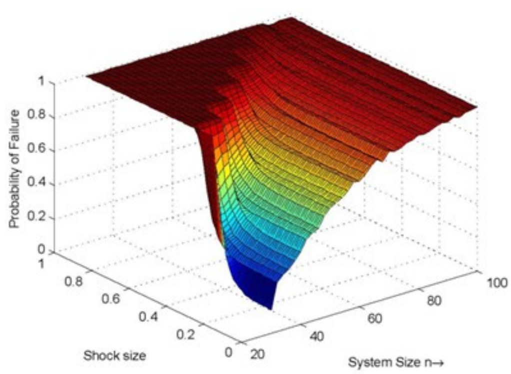

Figure 11: *The probability of CCP failure, conditioned on a default of a core institution.*

Capital losses still appear to be limited by the CCP. To mitigate this effect, a "social cost" of default should be introduced into a financial system, because the peripheral institutions, such as pension funds, are more essential to the well-being of an average taxpayer, than large investment banks.

The impact of central clearing on systemic risk is complex and a network structure heavily affects how defaults propagate through the system. In how far the CCP successfully mitigates system risk depends on which financial institutions first experience fundamental defaults. If a large financial institution defaults due to some fundamental reason, such as an adverse shock to the interest rates, small financial institution suffer more from contagion – and this effect is further exacerbated by the central clearing. So it appears that for the sake of financial system stability it is more useful to concentrate regulatory efforts on core/large financial institutions.

References:

Borovkova, S. and H. Lalaoui (2013). *Systemic Risk and Centralized Clearing of OTC Derivatives: A Network Approach.* Available on SSRN: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2334251

A paradigm shift in pricing: the era of the credit valuation adjustments

— G. Delsing, N. Meibergen, J.W. Timmer (EY Financial Services Risk)

The concept of default and its painful financial repercussions have been well established in history. Examples include Sovereign entities such as Russia (1998) and Argentina (2001), and entities such as WorldCom.Inc (2002) and Lehman Brothers (2008). Despite this, the recent financial crisis has shown that the risks associated with counterparty default were severely underestimated.

Counterparty credit risk is the risk that arises when a counterparty in an over-the-counter (OTC) derivative transaction will default prior to expiry and fails to fulfil its contractual obligations. While relatively large business entities are often viewed as too-big-to-fail, the financial crisis has shown us otherwise. Major bank defaults during the financial crisis highlight the need to incorporate counterparty credit risk into the valuation process of derivatives. As a result, many market participants adjust the reported value of their derivatives transaction by credit and debit valuation adjustments (CVA/DVA). Credit valuation adjustments hinge on three key components: the exposure of the contract at time of default, the probability of default and the amount that can be recovered after default occurs, the recovery amount. The remainder of this article will focus on the correct calculation of credit valuation adjustment as well as known implementation challenges and possible solutions. This includes the model selection and calibration of the exposure problem, the modelling of wrong-way risk as well as retrieving an implied recovery from market quotes.

Regulator's views on credit valuation adjustments

Regulatory standards treat credit valuation adjustments differently. There are discrepancies between the definition of CVA as given by the accounting standards from IFRS and the regulatory requirements from Basel, [2].

IFRS 13 states that counterparty risk on the fair value of a derivative transaction should be included in its fair value for the purpose of accounting. This includes an adjustment for the investor's own credit risk, debit valuation adjustment (DVA). The DVA component under IFRS 13 accounting standards is perhaps the most common criticism: DVA requires banks to account for their own default in the value of transactions and therefore counteracts CVA losses. Many criticists believe this to be nothing more than an accounting trick as banks reported profits from DVA.
The CVA capital requirements as set forth by the Basel committee for regulatory purposes provide highly specific prescriptive methods and states that DVA must be removed from Tier 1 equity and is therefore not allowable in quantifying capital requirements under Basel. Furthermore, Basel does not consider market factors other than credit spreads. As a result fair value and regulatory methods result in different CDS hedges for the same position, making it difficult to simultaneously hedge CVA P&L and achieve full regulatory CVA charge relief.
In this paper we focus on the theoretical definition of CVA/DVA, which is more in line with the definition as in IFRS. In line with Brigo [1], we define the unilateral credit valuation adjustment (UCVA), assuming the investor is default free, at time t as:

$$UCVA_t = E_t[(1-R)D(t,\tau)NPV(\tau)^+]$$

where *D* the discount rate, *NPV* the net present value of the contract, *R* the recovery rate and τ the default time of the counterparty.

Model selection and calibration method for exposure modelling

Calculation of exposure requires simulation of the risk drivers on which the future portfolio value depends. The accuracy of simulation depends on the choice of model and calibration methods. These results can be highly dependent on both the shape of the yield curve and the implied swaption volatility surface, [7].

In the context of counterparty credit risk one is generally interested in the net positive exposure, which is defined as the positive future marked-to-market (MtM) value of a portfolio of contracts, potentially reduced by netting agreements and/or collateral posting. Reason hereof is that the exposure is the amount at stake at the moment of default of the counterparty. The expected exposure is defined as the expectation of the exposure at all future times until the greatest maturity in the portfolio. For CVA/DVA calculations, we are interested in the price of counterparty credit risk and hence this expectation is taken under the risk-neutral measure.
Exposure can be simulated directly, by assuming a certain distribution for the exposure, or by simulating the market risk factors that drive the value of the contracts and calculating the value of the exposure at future times. The latter method can become computationally infeasible for large time horizons, large portfolios or complex contracts.
The accuracy of the exposure simulation can be back- tested by comparing the observed exposure with the estimated exposure. In some cases an analytical formula is availa-

ble for the exposure which enables one to assess the accuracy of the simulated outcomes. One of these cases is that of a single interest rate swap, see [6], for which the exposure can be directly obtained from swaption prices. In Figure 1 the exposure profiles of an interest rate swap, calibrated using different models, is shown.

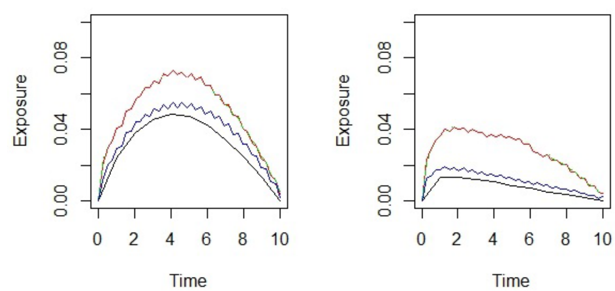

Figure 1: *Exposure profiles of a payer (left) and receiver (right) interest rate swap. The black line represents the theoretical profile obtained from swaption prices, the coloured lines are obtained by means of simulation with different models (G2++ in blue, Vasicek in red).*

Determining probability of default and dealing with wrong-way risk

The literature on extracting the probability of default in a risk-neutral pricing environment is vast. It has been shown that exposure and probability of default are correlated in most cases. This correlation can have a severe impact on CVA/DVA and underestimate the counterparty credit risk. The question is: How can we model this correlation in a risk-neutral environment?

Broadly, credit risk models can be classified as either structural (firm value) or intensity (reduced form) models. Structural models were the first to be applied to the modelling of default risk and are based on the behavior of the total value of the firm's assets. These models require strong assumptions on the dynamics of the firm's assets, it's debt and the way it's capital is structured. The main advantage of these models is that they provide an intuitive picture, as well as an endogenous explanation for default. They are however difficult to calibrate exactly to observed market prices, such as CDS or bond quotes.

In contrast to the structural default models, reduced form models describe default by an exogenous jump process and are not triggered by basic market observables. Market convention is to define default as the first jump time of a Poisson process. The default intensity process can be calibrated to market observable prices such as CDS spreads, to remain under the risk-neutral pricing measure. In [4], a CIR model as well as an exponential Vasicek model are used for the default intensity process.

The case where the probability of default is positively correlated with the exposure to the counterparty is called wrong-way risk. One common example of wrong-way risk is a put option where the underlying party and the counterparty of the trade are highly correlated. The put option value increases while the share price of the underlying party drops. A low share price is often accompanied by an increased probability of default. It is not until recently, when credit spread levels and volatilities inflated dramatically during the financial crisis, that wrong-way risk gained due attention of practitioners and researchers.

In Basel II/III the CVA capital charge including wrong-way risk is calculated by multiplying the CVA charge without wrong-way risk by a constant, usually between the values 1.2 and 1.4. The constant is often referred to as “alpha" and the approach the “alpha multiplier" approach. Where extreme WWR is involved, this approach can severely underestimate the counterparty credit risk.

A more detailed and complex approach to account for wrong-way risk consists of correlating the risk drivers of the exposure and default, as suggested in [1]. It is difficult to incorporate wrong-way risk into CVA, it is even more difficult to do this in the risk-neutral pricing measure. Even when using the approach specified by Brigo [1], the question remains as to what correlation parameter should be used. In [4], the correlation parameter between interest rates and default intensity is calibrated to CDS quotes, allowing for a risk-neutral valuation of counterparty credit risk for interest rate products. Fast numerical algorithms and analytical approximations have been developed and we refer to [4] for the specifics. The impact of the correlation can have a significant impact on the UCVA charge, see Figure 2.

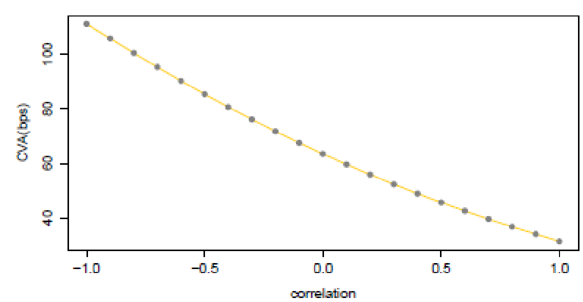

Figure 2: *CVA of a 10Y IRS using a CIR model for default intensity calibrated to JPMorgan (senior) CDS quotes as of June 10, 2012 for various correlations.*

The market’s expectation of recovery

Due to the difficulty of separately extracting the recovery and PD, the research on it is fairly scarce.

Market convention therefore simply fixes the recovery at its historical average. In the light of CVA, is that a fair assumption?

This question is investigated in [5] where a model was set up that dynamically linked the hazard rate to the recovery, in particular

$$\rho_t \equiv \Phi\left(\alpha_0 + \alpha_1\left(\frac{\lambda_t - \lambda_0}{\lambda_0}\right)\right) \qquad (1)$$

where ρ_t the recovery at t, λ_t the hazard rate at t, $\alpha_0 \in \mathbb{R}$ and $\alpha_1 \in \mathbb{R}_{\leq 0}$.

By means of modelling both legs of a CDS spread in terms of PDEs we are able to simultaneously extract the PD and the recovery within a finite difference scheme. We refer to this model as the PDE model.

From historical data it is known that PD and recovery are negatively correlated, in particular (1) is a fully negative correlated model when $\alpha_1 \neq 0$.

	PDE model	PC model
Banco do Brasil	1122.9	1460.8
Royal Dutch Shell	239.3	308.38
Air France - KLM	1208.5	1521.6
JPMorgan (senior)	216.1	310.3
JPMorgan (sub.)	318.4	485.6
ING (senior)	219.0	275.6
ING (sub.)	518.4	630.4

Table 1: *CVA of plain vanilla 5Y ATM call options sold by the same company. The value is presented in basis points with respect to the price of the call option*

It is market convention to model the recovery as a constant at its historical average and to use a piecewise constant intensity for the default probability, which will be referred to as the PC model. A comparison of the CVA between this market convention approach and the PDE model is shown in table 1 for a plain vanilla 5Y ATM call option sold by the companies on the left hand side of the table. One immediately observes that the PDE model provides lower CVA results. In [5] this result is discussed in more detail. It comes down to the fact that the negative correlation increases the recovery and decreases the overall PD, see figure 3 which highlights the results for Air France - KLM, reducing the resulting CVA. This might suggest that fixing the recovery at its historical average and then applying the PC model is always an overestimation. However, one should keep in mind that the PDE model presents a correlation which is fully negative, and not slightly negative as one would observe in practice.

The modelling of recovery is an important aspect and should not be neglected. Hopefully future developments can provide us with more conclusive results.

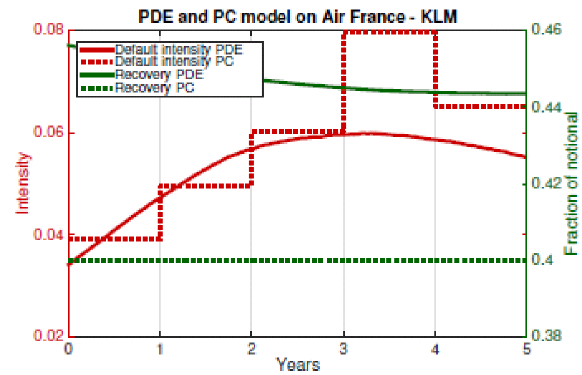

Figure 3: *Air France - KLM; PDE and PC model fits.*

XVA

Although complete consensus about CVA/DVA has not yet been reached between banks, regulators and accountants, a new range of possible valuation adjustments, also referred to as XVA, has been introduced in the past few years. These value adjustments should account for e.g. cost of funding (FVA), cost of capital (KVA), type of collateral (LVA), initial margins (MVA), etc.

In order to gain valuable insights in the market practice in regard to the variety of value adjustments, EY has conducted a survey among European banks on their application of the various value adjustments. For further details of this survey and references [4], [5] and [7]; contact Floris van de Loo.

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Interest rate risk management at the central bank: unchartered territory

by Hugo Everts (Senior Risk Manager Financial Markets DNB)

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EUROSYSTEEM

The quantitative easing programs that have been introduced by the ECB to support the Eurozone, have given rise to a form of interest rate risk that is new to central banks. We interviewed **Paul Wessels** and **Pieter Moore**, respectively head of risk management and risk manager at the Financial Markets division of the Nederlandsche Bank (DNB), and asked them how they manage this interest rate risk.

As a first question, how is risk management taken care of at the DNB?

Paul: "Within the Financial Markets division a team of around 12 is responsible for risk management of the own investment books of DNB, mainly fixed income, and for the monetary operations that are required as part of the Eurosystem. Where the own investment portfolio is basically stable at around EUR 30 billion, excluding the gold reserves, the monetary portfolio increased significantly over the last couple of years due to the quantitative easing program of the Eurosystem. As a result, the balance sheet of DNB contains more risks than ever before"

You talk about the Eurosystem, can you explain how this works in practice?

Pieter: "The Eurosystem of Central Banks concern the ECB and the national central banks, that jointly decide – via the Governing Council – on the monetary programs to guard the financial stability and to support the Eurosystems' policy inflation target of 'below, but close to 2%'. The main policy instruments concern key interest rate decisions, QE – quantitative easing – programs like EAPP (expanded asset purchase programs) and special facilities like the Targeted longer-term refinancing operations, or TLTROs, that support monetary transfers via commercial banks."

Can you explain the impact of the monetary support programs?

Paul: "As a result of the QE the balance sheet of central banks increased – and will further increase – significantly over the years."

Pieter: "The annual result of DNB is largely driven by the interest earned on the own investments and monetary operations that are mainly financed by interest free liabilities like banknotes, capital and reserves. Consequently, a strong decrease in interest rates has a negative impact on the net result and could lead to lower income for central banks. This is only partly compensated by the effect of the increased size of the balance sheet as a result of the purchase programs."

How can the interest rate risk materialize?

Paul: "The QE programs lock in low asset returns and expose central banks to rising funding costs if the interest rates pick up. This works as follows: In the course of the programs the amount of fixed rate assets will exceed the amount of banknotes and capital. This excess of fixed rate positions will need to be funded by deposits – placed by commercial banks at the central bank – which have a variable policy rate. Thus, as a result, if economic growth, inflation and policy rates increase – which is the aim of the QE programs – funding costs may rise above the fixed, low asset returns."

What type of risk measures do you use to quantify this increased interest rate risk?

Pieter: "Within the Risk Management team we quantify this interest rate risk with a 3-pillar method using the concept of an Asset & Liability mismatch and various interest rate scenarios. Where traditionally the ALM mismatch is negative and there is a money market shortage, in the coming years this will reverse. Within Risk Management, we have developed various increasing interest rate scenarios to estimate the potential extreme loss. This concerns market implied interest rate distributions, extrapolated from options and future markets data, random walks of interest rates and scenario analyses based on deterministic interest rate shocks."

Paul: "As an example of an extreme scenario, it is assumed that economic conditions improve swiftly and significantly during the execution of the QE programs and to such an extent that policy rates must be raised as well."

What is your view on the development of this interest rate risk – will it further increase?

Pieter: "In case the QE programs are not extended beyond September 2016 and the assets are held to maturity, the ALM mismatch will reverse again in a few years from now, reducing the interest rate risk.

Paul: "In case QE is extended, the ALM mismatch will continue to be present for more years. This prolonged ALM mismatch thereby extends the interest rate risk exposure on DNB's balance sheet."

Thank you very much for the interview. Is there anything you would like to add?

Pieter: "Sure. The type of analyses just discussed make working at DNB Risk Management quite unique. We deal of course with more common credit and market risk management topics that are relevant for risk managers at commercial banks as well."

Paul: "Especially the mix of using risk management techniques for both own investments and monetary operations, together with the international Eurosystem network and research opportunities, makes our work special indeed. I would like to add that DNB has the policy to rotate people on a regular basis and, as a result, we have opportunities for risk managers and quants quite frequently."

Upcoming TopQuants Events

1. The next event is the 2015 TopQuants Autumn Event on November 18th. The event will be hosted by DNB and will feature presentations from Kees de Graaf (UvA) and Sarunas Simaitis (Right Random Decisions), Cyriel de Jong (KYOS), Diederik Fokkema (EY), Veronica Malafaia (ING), Rob Sperna Weiland (UvA), Ryan van Lamoen (DNB), Gerben de Zwart (APG) and Johan Duyvesteyn (Robeco), Lech Grzelak (Rabobank), Bert-Jan Nauta (RBS), Steffen Pang (Zanders) and Mitchell Ponder (Zanders, VU), Philippos Papadopoulos (OpenRisk) and finally Pieter van Zwol (DNB). For more details on the event please see our TopQuants homepage.

2. As mentioned, 2016 will be quantier than ever... keep watching your inbox, our website and @topquants for information.

3. The next issue of our TopQuants newsletter will follow in March / April 2016. Contributions are already welcome. Please send any contributions to our editor Marcin Rybacki.