

## TOWARDS A RUSSIAN DOLL MODEL OF FINANCIAL FRAGILITY AND CORPORATE GOVERNANCE

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### Abstract

We show that the phenomenology of sources of financial instabilities can be traced back to the iteration of a single and conceptually simple step: the pooling of cash-flows priced at different levels of resolution of price-relevant information. We illustrate this with examples from bond rating, bond pricing, deposit insurance pricing, various kinds of regulatory arbitrage, risk-adjusted capital allocation, persistent mispricing of risk, the impact of accounting for Level-3 assets, the design problem for a special resolution regime and financial implications of the process of financial reform itself. We find that conflicts between the financial interests of various stakeholders can be viewed as examples of tranche wars from the point of view of abstract synthetic re-securitizations of pools of cash-flows.

**Keywords:** Risk intermediation, capital allocation, financial market stability, capital structure, asymmetric information, re-intermediation, dynamic control

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### Introduction

In spite of much agreement on the lessons to be learned from the 2007-2009 financial crisis, there is still no consensus on the extent to which it may have been endogenous to the process of financial intermediation with its increasing complexity. This question is of equal importance to practitioners, policy makers and researchers, since it may well affect the entire edifice underpinning the success story of the free enterprise system with its strong dependence on functioning capital markets.

Taking it from the modern theoretical foundations as provided by mechanism design theory, it is clear that there is no question about the capacity of security markets to solve the capital allocation problem optimally, given certain background assumptions about market concentration, external effects and asymmetric information. At the same time, we are undeniably living in an economy where the strict versions of these background assumptions do not hold. Hence we are left with having to discuss second-best alternatives. This necessity complicates the process of financial market reform considerably. It is hence vital to clarify the extent to which the various deviations from ideal market environments can be tamed and how they interact in out-of-equilibrium (or: less than desirable) contexts.

It has long been known that the principal agent problems that arise from asymmetric information are at the heart of this problem, and there is a body of theory applying this to financial intermediation. For our present purposes, the most relevant are the study of financial fragility by Bernanke-Gertler, the Grossman-Stiglitz observation that informationally efficient markets are an idealization that is self-contradictory under practical

assumptions about the cost of information gathering, and the Dewatripont-Tirole framework of optimal allocation of control rights mitigating the incentive compatibility problem in the managerial firm.

Our main idea is to seek the natural level of generality in which to express these insights, and we find that we should be looking at the iteration of the simple logical step of introducing limited liability in the funding of a portfolio of uncertain and possibly dependent cash-flows. We point out that from the point of view of contingent claim pricing, the realm of objects in which this can be carried out freely is tranches of synthetic pools of credit risky bonds. We then proceed to turn around the common process of demonization of these instruments in order to reveal that the problem of finding valid pricing methodology for them is merely an explicit version of the task of understanding the second-best alternatives we found to be the inevitable object of our interest above. While this redescription does not by itself solve any problems, it serves to clarify the discussion and we hope that it enhances the economy of thought on these issues.

The contribution of this paper is purely conceptual. We do not add anything to the existing modeling approaches, nor to empirical findings. But we demonstrate in a list of examples that many seemingly unrelated problems turn out to have a common conceptual backbone. In particular we relate the problem of divergent financial interests of stakeholders in a managerial firm to the pricing problem for tranches of debt, thereby rediscovering the root of the task of finding adequate executive compensation structures in asset pricing methodology.

## **Pooling of cash-flows and changing levels of granularity of information as drivers of uncertainty in a toy model of financing relations**

### **The risk balance sheet: tranching of debt, capital structures and iterated self-applications**

On the asset side of a financial intermediary we find a pool of financial instruments that are themselves obtained from claims in a capital structure of other firms. Often these claims are simpler in the sense that they refer to the capital structure of non-banks, but they may also themselves be tranches of debt written against a pool of assets. It is important to note that this process of iteration of tranching of debt - which can lead to re-securitization - is not eliminable from the process of finance itself. It arises naturally from the iteration of the elementary simple step of introducing limited liability in a funding structure together with pooling of assets. When the full risk implications of this view on assets are spelled out we refer to its representation as a risk balance sheet, borrowing the term from Andrew Lo (2009).

As in the classical Merton structural model, we view bank equity as a call-option on assets. It must be kept in mind that (losses on) assets follow a Vasicek loan loss distribution, not a geometric Brownian motion with lognormal returns - we will discuss the implications of this later.

Setting up a risk balance sheet will necessarily raise compatibility questions between market standard models and the Basel-II standard for credit risk. To the extent that the risk balance sheet cannot be built or obtained, this indicates that the institution in question is not only potentially too big to fail but possibly too big to be monitored, too big to be accounted for and hence too big to wind down. As such, the risk balance sheet is the main input for the special resolution regime, and should ideally be fully disclosed. It can then also form the basis for a strong reliance on subordinated debt in the capital structure. This introduces a heightened market discipline so that risk premia of those tranches of debt would lead to a control on the regions far out in the loss distribution of the assets of the bank whose capital structure is under consideration. Versions of this have been proposed in numerous recent works, for example Raviv (2005), Kashyap et al (2008), Caballero (2009), Flannery (2009) Hart and Zingales (2009) and Wenger (2010).

Scaleability of the business presupposes agility and hence control. Without solving the problems of aggregation and minimizing the creation of pseudo-facts in the calibration of risk models - which are essential steps in the construction of the risk balance sheet - scaleability of the business cannot be achieved. Hence the risk balance sheet is also the key to business success. In particular the cost of its implementation cannot be taken as an argument against regulation based on it. Even the full disclosure of the tail risks (which is a particular consequence of the risk balance sheet) of an institution's stock performance may not lead to the evasion of those risks, since equity holders may actively seek those risks. Here, again the introduction of a thick tranche of

subordinated debt helps control the perverse incentives by means of market risk premia reflecting those tail risks.

From the necessity of setting up a sound risk balance sheet there result serious restrictions as to which activities can be accommodated jointly in a single financial institution. There is a slippery slope towards front-running if advisory functions and transactions of prop desks co-exist within one institution operating with a single balance sheet.

The risk balance sheet will allow investors and creditors to perform a style analysis with respect to the drivers of the asset value process of the pool of collateral against which the firm seeks funding, and hence is a crucial step in the process of arriving at adequate risk premia for the funding instruments.

### **The Bernanke-Gertler general equilibrium model, the Grossman-Stiglitz paradox and the Dewatripont - Tirole theory of allocation of control rights**

The Bernanke-Gertler (1990) general equilibrium model originally applies to an economy of firms seeking funding for risky projects from households under conditions of asymmetric information. One of its main conclusions is that there is a critical threshold of firms' original endowment to be used as equity funding for the projects. Below this threshold, firms will prefer a riskless investment, the reason being that the costs of the screening of the option to carry out the risky investment become prohibitive. The loss distribution for investors is highly skewed and fat tailed by construction in this model: it is a Bernoulli distribution with only two possible outcomes. While this feature of the model certainly does not interfere with its applicability in the context for which it was originally intended, it also has an unintended side effect: it represents precisely the problem arising within a market segment where investors seek extra returns by writing credit protection - or various other options with pay-outs that lead to fat tailed return profiles. Indeed, one can apply the model to the case of re-intermediation of risk, by replacing the firms by banks and the households by possibly highly sophisticated capital market participants or re-intermediaries who would still suffer from insufficient information about the underlyings - which represent single tranche synthetic CDOs to be formed out of assets of the banks that replace the firms in the original Bernanke-Gertler model. The critical threshold of endowment then indicates a possible source of collapse of the funding of securitization markets, which will be triggered as soon as banks seeking an off-load of credit risk exhibit excessive levels of leverage leading investors to demand high risk premia. In this view, the model would predict a rational collapse of the market for re-intermediation of credit risk if originator banks (try to) operate with too little capital.

In the set-up of Grossman and Stiglitz (1980), agents interact in a market where a risky asset is traded at a price and offering a return  $u$  following a decomposition  $u = \theta + \varepsilon$  with  $\theta$  observable at a cost  $c$  and  $\varepsilon$  unobservable, representing the difference between informed and uninformed traders. Only the informed ones will observe  $\theta$  after having invested  $c$  (assumed fixed and positive in

the model). The uninformed ones observe only the price of the risky asset. This can be refined with a sum

$$\theta = \sum_{i=1}^N \theta_i$$

with terms  $\theta_i$  requiring different costs of measurement  $c_i$  and probing increasingly refined regions of the return distribution, such as in modified VaR or according to any expansion of the loss distribution sensitive to its higher moments.

In our toy example, the interesting case is where some contributors to the sum are sensitive to the 'unpriced' option and some others are not. The model then makes explicit that the option is priced to various process of capital adequacy determination<sup>18</sup> or in proper pricing methodology would be detected by a suitable application of importance sampling techniques.<sup>19</sup> The point of this example is precisely that asymmetric information and the change of resolution in price-relevant information are basically two sides of the same coin.

The Dewatripont and Tirole (1994) theory of allocation of control rights provides another manifestation of this phenomenon, in this case representing the informational asymmetry between stakeholders and management.

### **A qualitative PCA of the phenomenology of financial instabilities - the emergence of a hierarchy of factors**

The phenomenology of crisis-enhancing factors, of destabilizing influences, of self-reinforcing processes in the course of the financial crisis (or meltdown) can be put into a preliminary taxonomy<sup>20</sup> or classification by means of simple recombination of the following building blocks or factors:

- the modeling of the stochastic underlyings or risk drivers (interest rates, default intensities etc.)
- balance sheet structure of firms whose capital structure is traded (or synthetically replicated in terms of traded ones)
  - agents, agency problems, moral hazards, iterated or nested moral hazards
  - new product process, enlargening the range of traded contingent claims.
  - the competitive environment, supply and demand, profit margins – including backward bending curves and the absence of equilibrium as well as various forms of ruinous competition

<sup>18</sup> The phenomenon strongly calls for the introduction of coherent risk measures, as defined in Artzner et al (1999). A discretized version of the coherent risk measure expected shortfall is proposed in Wenger (2010).

<sup>19</sup> Intuitively, one can view the application of the method of importance sampling to the problem of pricing senior tranches of CDOs, see e.g. Anderson and Sidenius (2003), as a computationally effective version of the decomposition of  $\theta$  that we suggest.

<sup>20</sup> in the spirit of a qualitative principal component analysis.

degrees by different market participants. A simple example to bear in mind for our purposes is to form the sum (at the level of loss variables) of a diversified pool of risky debt, described by a Vasicek (2002) distribution in aggregate, and an extra exposure interfering with the granularity of the pool, for example a CDS adding a low probability but high loss credit exposure. The point of this example is that it is plausible to assume that different agents will arrive at different valuations of the low probability and high loss impact of such an exposure - since by construction it is reasonable to assume that basically no historical evidence exists for the loss potential in question. Of course the construction strongly resembles the so-called side bets in re-insurance and is taken care of by a proper application of the Pillar 2

- (term structure or dynamics of) the market price of risk
- the regulatory environment, the rule of law and the tax regime

Any of these has destabilizing and risk-increasing effects on its own, and any two or several interact in typically self-reinforcing ways unless counteracted suitably. This is the consensus view on the lessons from the crisis, for which we refer to BIS (2009), Haldane (2009), HM Treasury (2009) and IIF (2009).

To build financial market models that are realistic to the extent that they face these phenomena, one must also face the question of their decoupling - which can plausibly be assumed to hold at best under normal 'unstressed' market conditions. A major task of regulatory reform is to enhance financial stability without reliance on such ultimate modeling challenges. This has also been pointed out in Caballero (2009).

Our russian doll view of balance sheets is found in the hierarchy between these factors: starting from cash-flows and instruments depending on cash-flows alone, we integrate more and more of the complexities that result from the iterated self-application of the process of tranching of debt under circumstances of asymmetric information.

### **Locating stylized facts from the post-crisis analysis in the qualitative PCA**

#### **Bond rating, bond pricing and deposit insurance pricing**

Most of the post-crisis analysis has focused on strengthening capital requirements as a response to the over-leverage of the financial intermediaries and the resulting instability. While regulatory reform certainly deserves to be stressed, it should not be over-emphasized either: the problematic nature of hard-to-quantify tails of loss distributions of pools of credit risky instruments or cash-flows applies directly to the problem of bond pricing, with the paradigm case being the pricing of debt issued by banks themselves. Similarly, the methodology of rating agencies has to deal with this challenge whether it is applied in the determination of ratings for securitized debt or in the rating of the debt issued by financial intermediaries directly. The same applies to the pricing of

deposit insurance, which opens the difficult question of which pricing methodology should be applicable to the generalizations of deposit insurance that are envisaged for a broader base of financial intermediaries.

In all of these cases, a pricing methodology which is simultaneously robust and applicable to the true complexity as found in the emerging consensus on the stylized facts on the return distribution of underlying assets is largely still to be found. For example, there is no sensitivity to the possibility of multi-modal loss distributions as brought about by contagion effects<sup>21</sup> in the current methodologies of setting deposit insurance premia or in regulatory capital requirements.

### **Regulatory arbitrage**

If we assume for a moment that regulatory capital is set in full accordance with the Pillar 1 Vasicek asymptotic single risk factor model, then even under the assumption that the requirements of the model to be applicable are satisfied, we still arrive at various intrinsic sources for potentials to carry out regulatory arbitrage:

- the underlying Merton structural model has a built-in sensitivity with respect to the riskless interest rate which is plausible and empirically valid under normal circumstances but which may provide the wrong signal in the event of a crisis driven by asset value declines (as the current one)
- the distributional implications of the ASRF model are not self-applicable in the following sense: the assumption of gaussianity of the driving factor corresponds to the common modeling assumption for the underlying in a Black-Scholes option pricing model. But even if we assume that the gaussianity holds, the model itself produces a return distribution for bank equity - in the special case of a bank with only credit exposure and no further sources of risk or economic capital needs - that is inconsistent with the Black-Scholes world

### **Persistent mispricing of risk and uncertainty in the determination of net risk exposures**

In the process of pooling and aggregation of exposures and risks, we encounter the question of netting of risks. This depends very strongly on the hedges in place and on the extent to which they are reliable after consideration of counterparty risks. While this source of instability is always present to some extent, it becomes excessive in markets where risk is persistently mispriced, since in that case, the process of calibrating the market price of risk carried out by agents is systematically distorted by the possible presence of arbitrage opportunities that are too risky for any individual agent to seek. The result is that the mispricing of risk gets even worse with time, and a near-universal illusion of safety builds up.

### **Risk-adjusted capital allocation and perverse incentives in compensation schemes**

Based on risk-adjusted capital allocation, compensation becomes a problem of adequate pricing of equity and layers of debt within the firm – viewing compensation as itself a form of return on a risky investment. While this view helps to clarify and justify compensation (even when it turns out to be high), it also puts into evidence the complexity of the task at hand: finding adequate levels of compensation at the senior level (where much of firm value is determined) cannot be any easier or simpler than pricing the instruments in the funding structure of the firm - simply because from an abstract synthetic point of view of internal transfer pricing the task is of precisely the same structure.

In particular, the perverse risk taking incentives of firms resulting from risk measures that are insensitive to the tails of the risks taken apply verbatim to the case of compensation. This has also been stressed in Bebchuk and Spamann (2009) and Stiglitz (2010).

### **Held-to-maturity versus mark-to-market accounting**

For financial intermediaries that exhibit a mixture of loans in the banking book at held-to-maturity values and tranches of securitized credit exposure in the trading book there is a very strong question of compatibility to be asked about how the various claims in the liabilities of the firm holding these assets are affected by the accounting regime applied to the credit risky assets. While there may well exist a single valid answer to this question in each case, it is to be assumed that various players in the capital markets will arrive at divergent views simply due to differences in interpretation of model implied parameters affecting the Level-3 assets. There is hence a source of transactions and trading of assets motivated directly by asymmetry of information. It is important to note that since these transactions arise by construction in a situation of asymmetric information, there is little guidance from classical micro-economics as to whether such trading will eventually lead to an allocation representing the most 'informed' view of the assets. From general principles it cannot even be ruled out that such transactions keep perpetuating themselves and creating ever new price impacts with no origin in information about the layer of underlying cash-flows at all.

### **Special resolution regime and living wills**

To avoid the external effects brought about by insolvency<sup>22</sup>, it is essential that firms with a highly dispersed base of creditors are forced to price their liabilities - including the most senior ones, such as deposits - on an ongoing basis. In a sense, the 'living will' simply means that there is a permanent requirement to price liabilities without the going concern assumption, or in other words, in a stress scenario. The effect of this

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<sup>21</sup> Which had already been studied extensively before the advent of the crisis, see chapter 9 in Lando (2004)

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<sup>22</sup> as described in Brunnermaier et al (2009)

requirement depends on the business model of the intermediary in question, but it is always an illustration of the russian doll view of balance sheets, as can be seen from the two extreme cases:

- for a bank following the classical deposit taking and loan business, it means that the moral hazard induced by deposit insurance is mitigated and the costs for pricing it are left with the bank, as they should. This requires an assessment of the originator banks' view on the value of the option to renegotiate bad loans or resp. of liquidating them.
- for an investment bank with wholesale funding it implies that the price of the option to asset substitution - which makes the pricing of its debt notoriously hard, far beyond the means of any standard structural model - is calculated by the bank itself, hence providing disclosed insights on the evolution of the asset side across all time-scales relevant for the application of a nested application of structural models to the banks' capital structure.

### **The law of unintended consequences and the process of regulatory reform**

A prominent example of how the process of financial market reform affects stakeholders' interests is the discussion about cramdown legislation in the US with its immediate impacts on the discounted cash-flow value of the various tranches of securitizations with troubled mortgages as their underlyings. From what we have discussed so far, it would be surprising if this were the only such impact. And it is not, it is only a very obvious one, next to the distortion of funding costs due to too big to fail status. For example, changes in disclosure requirements will clearly improve overall resiliency but may have strong implications about transfer of wealth along various claims in existing capital structures funding banks. This is merely saying that any change in disclosure requirements may trigger a minuscule 'generalized' rational run on callable or renewable debt instruments in the funding structure of any institution affected by the requirements.

### **Relation to ideas from econophysics – dynamic equilibrium versus avalanches**

The russian doll metaphor makes an obvious reference to the notion of selfsimilarity. While it is indeed true that the phenomena described in this paper are closely related to many concepts and methods from econophysics, we do not claim to have provided any explanation for the observed ubiquity of power laws or regularly varying distributions in financial return series. The metaphor seemed fit by the very construction we look at: the iteration of pooling of cash-flows in the process of the formation of classical financial instruments (equity and debt), balance sheet formation, securitization or re-securitization, and finally passage to capital buffers or leverage at the systemic level.

That said, we have no reason to deny that we actually have some reason to expect a much closer relation between the self-similarity that we have brought up and the question of explaining the stylized facts for

financial time series. Such relations are not, however, the subject of the present paper. But the multimodality of loss distributions and possible phase transitions are.

### **Phase transitions, multimodal loss distributions and power law distributions of avalanche sizes**

Multimodal loss distributions can arise easily in the presence of optionalities with low probability that the option will be exercised. The options need not be explicit, they may also consist of mere lumps in credit exposures, spoiling the asymptotics of the credit portfolio loss distribution. More extreme cases arise from contagion or counterparty risk, as captured in the functional correlation model by Neu and Kuehn (2004), for example. They also arise from contributions of operational risk, which includes lawsuits filed against the firm due to fraud. With a view towards this financial crisis, the problem of accounting control fraud comes to mind, i.e. in particular of failure to write down risky exposures in timely fashion. The same functional correlation approach applies here, see Anand and Kuehn (2007)

### **Managing the risk of catastrophic meltdown: does adaptation require us to invite chaos?**

Complexity theorists have been fond of the hypothesis that the ability of complex systems to adapt thrives at the edge of chaos - and possibly only there. More recent approaches stress instead the need to map out an entire fitness landscape with the spectrum of all local extremal values instead of strictly seeking a global optimum. Clearly, if the prospects for success of financial market reform would depend on the solution of such controversies, we would be in major trouble. Hence we can be glad that no such dependence so far exists or can be established.

It may be a fact of financial life that we cannot manage risk at arbitrarily high confidence levels, and this may be because of limits of measurement or because of intrinsic effects in the aggregation of risks across the levels of resolution that we have been discussing. But that doesn't mean we can afford to invite disaster. Even if there were intrinsic reasons for the presence of phenomena like dynamic randomness or entropy production in financial returns, we would still have every reason to impose measures to at least keep at bay those factors that are known to produce them.

From the point of view of mechanism design we know a priori where to look for those factors and this paper is in a sense an illustration of this a priori knowledge: the characterization of the optimality of capital allocation in markets and the stability resulting from that optimality is known to depend on the hypotheses of limited bargaining power of individual agents, absence of external effects and absence of asymmetric information. We can find the failure of all three at work as we move through the scales of resolution in our hierarchy. While the limitation of external effects and of bargaining power is easy - via capital requirements and a resolution authority - it is much more subtle to keep asymmetric information at bay. What this paper strongly

suggests is that while we are clearly not able to eliminate it from the process of financial intermediation - since that process crucially depends on it – we can still point our fingers on the junctures where asymmetric information may become excessive and do harm as a result.

## Conclusion

It may seem trivial or unenlightening to try to reduce everything to different points of view on the probability that an uncertain cash-flow will impact an aggregate loss potential. But maybe what's even more surprising is the ease with which this triviality is commonly denied or brushed under the carpet - probably for the simple reason that dealing with it appropriately quickly leads to explosive levels of complexity.

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