



The impact of systemic and illiquidity risk on financing with risky collateral



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ABSTRACT

Repurchase agreements (repos) are one of the most important sources of funding liquidity for many financial investors and intermediaries. In a repo, some assets are given by a borrower as collateral in exchange of funding. The capital given to the borrower is the market value of the collateral, reduced by an amount termed as haircut (or margin). The haircut protects the capital lender from loss of value of the collateral contingent on the borrower's default. For this reason, the haircut is typically calculated with a simple Value at Risk estimation of the collateral for the purpose of preventing the risk associated to volatility. However, other risk factors should be included in the haircut and a severe undervaluation of them could result in a significant loss of value of the collateral if the borrower defaults. In this paper we present a stylized model of the financial system, which allows us to compute the haircut incorporating the liquidity risk of the collateral and, most important, possible systemic effects. These are mainly due to the similarity of bank portfolios, excessive leverage of financial institutions, and illiquidity of assets. The model is analytically solvable under some simplifying assumptions and robust to the relaxation of these assumptions, as shown through Monte Carlo simulations. We also show which are the most critical model parameters for the determination of haircuts.

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1. Introduction

Funding is one of the most critical activities for the functioning of financial institutions. When an institution needs funding, it might use a large variety of contracts with other counterparties, including other financial institutions or central banks. Such contracts are mainly defined by their duration and by the presence of a collateral. In the last case, which is the object of this paper, the contract is termed as repo. Specifically, repurchase agreements (repo, plural repos) are deals stipulated by two parties: a borrower (the seller of the repo) and a lender or financier (the buyer of the repo). At the beginning of the contract the borrower lends a security (usually a bond or an equity) to the financier against cash collateral. On the other side, the financier lends cash against the security as collateral. At the maturity of the repo the borrower returns the capital lent (plus some interests) to the financier and receives back the security. Nevertheless, as a consequence of the uncertainty of the collateral, the capital lent by the financier is always strictly smaller than the market value of the security

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at the beginning of the contract. This extra quantity required from the financier is usually termed as margin or haircut and, as defined in [Gorton and Metrick \(2012\)](#), it [...] reflects the perceived underlying risk of the collateral and protects the lender against a change in its value.

Repo agreements are the main source of funds for securitized-banking activities, both for investment and commercial banks. Further, they are a very important segment of security finance because, quoting [Fabozzi and Mann \(2005\)](#), they [...] enable market makers to take long and short positions in a flexible manner, buying and selling according to customer demand on a relatively small capital base. In addition, repos are used extensively to facilitate hedging and speculation. Repo is also a flexible and relatively safe investment opportunity for short-term investors. The ability to execute repo is particularly important to firms in less-developed countries that might not have access to a deposit base.

There are three possible ways in which a financial institution can get funding through repos. In the first one, the repo is stipulated on a bilateral basis between the lender and the borrower over the counter. In the second way, which is becoming increasingly popular in recent years, the two counter-parties are met by a clearing house, i.e. a financial institution that is in charge of setting the proper margins and bears the burden of counter-party risk. Consider, for example, the case of Eurex Clearing: the informative note *Risk Based Margining*¹ reports that the margin is set in order to cover 99% of all possible price variations, given the current forecast of volatility. Translated in formula this means that, if $\hat{\sigma}$ is a forecast of the daily volatility, the margin m_{clearing} (in unit of the current value of the collateral) set by the clearing house is²

$$m_{\text{clearing}} = \sqrt{2T}\hat{\sigma} \operatorname{erfc}^{-1}(2p), \quad p = 0.01, \quad (1)$$

where T is the maturity in days. Eq. (1) implicitly assumes that the value of the collateral follows a standard Brownian motion. The third way of collateralized financing, when available, is to open a repo with a central bank. For example, those banks with at least an agency in the Euro Zone can currently sell a repo to the European Central Bank (ECB) that provides low haircuts (see, for example, the table in the publicly available document [ECB, 2013](#)). Nevertheless, with the gradual reduction of the recent economic crisis, this preferential channel is likely to be closed, and the volume of the repos traded with ECB reduced accordingly.

It is important to understand the effect of the expected decline of the availability of ECB repo funding and the increasing activity in competitive markets. Let us focus on the case of government bonds. For repo bonds the European Central Bank (see [ECB, 2013](#)) applies haircuts based on the bond rating, the residual maturity and the type of the coupon (zero/fixed). Most important, the margin required is applied to the market value of the bond, hence a drastic reduction of the bond's value is translated in a reduction of the margin. On the contrary, clearing houses, such as Eurex Clearing, set margins according to a volatility forecast and apply them to the nominal value of the bond. In periods of distress, highly illiquid bonds are likely to rapidly lose value and thus the margining procedure applied by the clearing house can severely reduce their potential as collaterals.

The relevant role of margins in affecting financial equilibria is analyzed, from a theoretical point of view, by [Brunnermeier and Pedersen \(2009\)](#). This paper presents a three periods equilibrium model where margins can potentially increase with illiquidity and create liquidity spirals. The impact on haircuts of balance sheet constraints and, more generally, on the capacity of bearing risk by lenders is analyzed in a continuous-time model in [Oehmke \(2013\)](#). The key-point of the paper by [Oehmke \(2013\)](#) is that, if lenders face a maximum level of risk (volatility) on their position, their optimal strategies are deeply affected by this threshold and, moreover, rather than relying on purely statistical models, repo lenders should take into account creditor structure, strategic interaction, and their own balance sheet constraints when setting margins [haircuts] to manage counter-party risk [...].

The future transformation of the practice of repo funding calls for a better understanding of the risks associated with this type of contracts. As we have discussed above, the current practice of setting margins considers only the volatility risk, and in this case the volatility measure does not take into account the fact that it should be computed conditionally on the default of the borrower. Moreover other sources of risk should be considered. The first is the liquidity risk, i.e. the fact that the price obtained by the financier when liquidating the collateral in the case of borrower's default might be lower than the mark to market price at the time of liquidation. This is due to market impact and to the finite liquidity of markets. More important, this paper focuses on the impact of systemic risk on collateral financing. In fact, in case of default, the borrower will liquidate its position, depressing the price of other assets and thus triggering a subset of the rest of the financial system to rebalance their positions. This in turn will modify the price of a certain number of assets: the larger the degree of portfolio overlap between the borrower and the rest of the financial world, the larger the number of assets affected. In particular, the asset used as collateral in the repo may be hit by this sort of avalanche effect. The resulting depreciation is clearly not captured by the standard practice adopted in setting haircuts (which is summarized by Eq. (1)). Here, we develop a model and provide a closed form expression for the haircut, which takes explicitly into account all the aforementioned sources of risk. Specifically, we take the point of view of a financier that has to decide the proper margin that must be applied at the beginning of the contract. Our model shows that the value of the haircut, taking into account liquidity and portfolio overlap, depends critically on the linear combination of an illiquidity weighted scalar product between the portfolio of the borrower and those of other financial institutions. The coefficients of the linear combination are the leverage of each financial

¹ Downloadable at: <http://www.cftc.gov/ucm/groups/public/@otherif/documents/ifdocs/eurexmcorkbasedmargin.pdf>

² The derivation of formula (1) is reported in [Appendix A](#).

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