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CREDIT RISK MITIGATION IN CENTRAL BANK OPERATIONS AND ITS EFFECTS ON FINANCIAL MARKETS: THE CASE OF THE EUROSYSTEM

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by Ulrich Bindseil and Francesco Papadia[1]

In 2006 all ECB publications will feature a motif taken from the €5 banknote.

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ABSTRACT

This paper reviews the role and effects of the collateral framework which central banks, and in particular the Eurosystem, use in conducting temporary monetary policy operations. First, the paper explains the design of such a framework from the perspective of risk mitigation, which is the purpose of collateralisation. The paper argues that, by means of appropriate risk mitigation measures, the residual risk on any potentially eligible asset can be equalised and brought down to the level consistent with the risk tolerance of the central bank. Once this result has been achieved, eligibility decisions should be based on an economic cost-benefit analysis. Second, the paper looks at the effects of the collateral framework on financial markets, and in particular on spreads between eligible and ineligible assets.

I INTRODUCTION

Central banks implement monetary policy by steering short-term market interest rates around a target level. They do this essentially by controlling the supply of liquidity, i.e. the deposits held by banks with the central bank, mostly by means of open market operations. Specifically, major central banks carry out open market operations in which liquidity is provided on a temporary basis. In the case of the Eurosystem, an amount of around €400 billion was provided in the last quarter of 2005, mostly through operations with a one-week maturity.

In theory, these temporary operations could take the form of short-term loans to banks, offered via a tender procedure. It is, however, one of the oldest and least disputed principles that a central bank should not, under any circumstances, provide *unsecured* credit to banks. This principle is enshrined, in the case of the Eurosystem, in Article 18.1 of the Statute of the European System of Central Banks and of the European Central Bank (hereafter referred to as the ESCB/ECB Statute), which prescribes that any Eurosystem credit operation needs to be "based on adequate collateral". There are various reasons why central banks should not provide uncollateralised lending, namely:

– Their function, and area of expertise, is to implement monetary policy to achieve price stability, not to be credit risk managers.

– Access to central bank credit should be based on the principles of transparency and equal treatment. Unsecured lending is a risky art, requiring discretion, which is neither compatible with these principles nor with the accountability of the central bank.

– Central banks need to act quickly in monetary policy operations and, exceptionally, also in operations aiming at maintaining financial stability. Unsecured lending would require careful and time-consuming analysis and limit setting.

– They need to deal with a high number of banks, which can include banks with a rather low credit rating.[1]

– They cannot establish credit lines reflecting the creditworthiness of different banks. A central bank can hardly stop transacting with a counterparty because its limit has been exhausted. Such an action may be interpreted as a sign of deterioration of that counterparty's credit quality, resulting in its inability to get liquidity from the market, with potential financial stability consequences.

– To reflect the different degrees of counterparty risk in unsecured lending, banks charge different interest rates. By contrast, central banks have to apply uniform policy rates and thus cannot compensate the different degrees of risk.

The principle that all temporary operations supplying liquidity need to be secured with collateral implies that they have two legs: one in central bank deposits and one in collateral.

While the cash leg obviously has a decisive influence on the market for deposits, it is less recognised that the collateral leg also has an influence on the market for the underlying asset. This effect is less strong, but it is surprising how little it has been researched, also considering that central banks face some important choices in the specification of their collateral framework. In addition to the description of their collateral framework in some technical documentation (see ECB (2005) for the case of the Eurosystem), there is to our knowledge only one comprehensive and analytical central bank study on collateral, namely the one by the Federal Reserve System (2002). Our paper aims to partially fill this gap, following the useful analyses of Fels (2005),

1 Some central banks, including the US Federal Reserve System, conduct their open market operations only with a limited number of counterparties. However, all central banks, including the Fed, offer a borrowing facility under which they lend at a preset rate to a very wide range of banks.

Buiter and Sibert (2005) and Allen (2005). After discussing the Eurosystem collateral framework from the perspective of risk mitigation, the paper considers its effects on financial asset prices. The paper also clarifies some misunderstandings that emerged about the Eurosystem collateral framework. A systematic comparison of the Eurosystem collateral framework to equivalent such frameworks in other countries, including their effects on financial market spreads, goes beyond the scope of the present paper. Obviously, such a comparative analysis would be a very useful future research project.

The design of a central bank's collateral framework may be summarised in five phases, which are also reflected in the organisation of this paper:

- First, a list of all asset types which could be eligible as collateral in central bank credit operations has to be established. These assets will have different risk characteristics, which implies that different risk mitigation measures are needed to deal with them.

- The specific aim of risk mitigation measures is to bring the risks that are associated with the different types of assets to the same level, namely the level that the central bank is ready to accept. Risk mitigation measures are costly and since they will have to be differentiated across asset types, the costs of these measures will also differ.[2] The same applies to handling costs for different asset types: some types of collateral will be more costly to handle than others.

- The potential collateral types should be ranked in increasing order of cost.

- The central bank has to choose a cut-off line in the ranking on the basis of a comprehensive cost-benefit analysis, matching the demand for collateral with its increasing marginal costs.

- Finally, the central bank has to monitor how the counterparties make use of the opportunities provided by the framework, in particular which collateral they use, and how much concentration risk occurs. The actual use by counterparties drives the residual credit risks taken by the central bank in a decisive way, while being very difficult to anticipate. If actual risks deviate much from base assumptions, there may be a need to revise the framework accordingly.

The first two and the last step are discussed in Section 2. Steps three and four are presented in Section 3. Section 3 also discusses, in the framework of a simple model, the effect of eligibility decisions on spreads between fixed income securities. Section 4 concludes. An annex looks at one important specific issue in the design of the collateral framework, namely whether to segregate central bank policy operations across asset classes, or whether to allow for the pooling of different types of collateral in one collateralized operation.

2 THE COLLATERAL FRAMEWORK AND EFFICIENT RISK MITIGATION

This section discusses how the collateral framework can ensure the desired level of credit risk protection for the central bank. Any central bank, like any commercial bank operating in the secured interbank market, has to specify its collateral and risk mitigation framework. Central banks have somewhat more room to

2 The fact that adequate risk mitigation measures can reduce risks of losses to a very low level is illustrated by the experience of the Deutsche Reichsbank between 1873 and 1900 with bills of exchange, which were by far the predominant asset type accepted by it. Although bills of exchange are relatively risky assets, losses relating to non-performing bills were insignificant. Around 0.01% of the value of bills was not paid immediately at maturity by the liable parties, and only 0.003% was actually never paid (Reichsbank (1910), pp. 152-64). The finding that risk mitigation measures can reduce residual risks for bills of exchange to a very low level is, of course, not sufficient to conclude that such bills should be made eligible. This would require the risk mitigation measures and the general handling of such a type of collateral to be cost-effective, as demonstrated in a comprehensive cost-benefit analysis, as discussed in Section 3.

impose their preferred specifications, while commercial banks have to follow market conventions to a larger extent. Sub-section 2.1 discusses the desirable characteristics of eligible collateral, Sub-section 2.2 looks at risk mitigation techniques, the specification of which needs to be different from asset type to asset type, while Sub-section 2.3 stresses that the actual functioning of the collateral framework has to be checked against expectations.

2.1 DESIRABLE CHARACTERISTICS OF ELIGIBLE COLLATERAL

There are a number of properties that assets should have to be suitable as central bank collateral. Some, but not all, relate to the risks associated with the asset.

(i) *Legal certainty*
There should be legal certainty about the transfer of the collateral to the central bank and the central bank's ability to liquidate the assets in case of a counterparty default. Any legal doubts should be removed before an asset is accepted as eligible.

(ii) *Credit quality and easy availability of credit assessment*
To minimise potential losses, the probability of a *joint* default of the counterparty and the collateral issuer should be extremely limited. For this, both a very small probability of default of the collateral issuer and a limited correlation of default between the collateral issuer and the counterparty are important. Ensuring a limited probability of default requires a credit assessment. For most marketable assets, a credit assessment is publicly available from rating agencies. For others (e.g. bank loans to corporations), the central bank may have to undertake its own credit assessment, or require the counterparty to obtain such an assessment from a third party, which is costly. To limit the correlation of default between the counterparty and the collateral issuer, central banks (and banks in the interbank market) normally forbid "close links" between the counterparty and the collateral issuer. The ECB assumes "close links" exist when the counterparty (issuer) owns at least 20% of the capital of the issuer (counterparty), or when a third party owns the majority of the capital of both the issuer and the counterparty (see ECB (2005), p. 42, footnote 14).
With regard to credit quality, central banks typically set a minimum credit quality threshold. In the case of the ECB, this has been set to an A- rating by at least one of the three international rating agencies for rated issuers, and a corresponding 10 basis point probability of default for other issuers. The setting of a minimum rating is also standard in the interbank use of collateral, and in particular in triparty repo arrangements, in which systematic eligibility criteria need to be defined. The need to define a rating threshold is particularly acute in the case of the ECB, which accepts bonds from a plurality of governments and also a wide variety of private paper. Obviously, a trade-off exists between the credit quality threshold and the amount of collateral available.

(iii) *Easy pricing and liquidity*
Preferably, the asset should be easy to price and liquid so that, in case of counterparty default, it can be sold off quickly at prevailing prices.

(iv) *Handling costs*
Handling costs should be limited: while some collateral, such as standard bonds, can be easily transferred through an efficient securities settlement system, other types of collateral may require manual handling or the setting-up of specific IT applications.[3]

3 According to the Federal Reserve System (2002, pp. 3-80): "Securities (now most commonly in book-entry form) are very cost effective to manage as collateral; loans are more costly to manage because they are non-marketable."

(v) *Available amounts and prospective use*
The amounts available of an asset type and the asset's actual (or prospective) use as collateral are important to determine whether it is worth investing the resources required for its inclusion in the list of collateral (in terms of acquiring the needed expertise, financial and legal analysis, data collection, setting up/adapting IT systems, maintenance, etc.).

The asset class which ranks highest on the basis of these criteria is normally central government debt: it has a credit rating and generally a relatively high credit quality and is highly liquid, easily handled and massively available. Also rather attractive are rated, marketable, private debt instruments, in particular if they have a standard structure and are abundantly available. In the euro area, Pfandbriefe and other bullet bonds of banks, as well as local government debt and corporate bonds, have these characteristics. Asset-backed securities (ABSs) or collateralised debt obligations (CDOs) also normally have ratings, but tend to have special characteristics and are often less liquid. Non-marketable assets, such as bills of exchange or bank loans, rarely have credit ratings and may have higher handling costs. Finally, commodities or real estate could also be considered as eligible collateral, as they were in the past (see e.g. Reichsbank (1910)). However, the handling costs of such assets tend to be very high and there is, to the authors' knowledge, no industrial country's central bank that currently accepts them.

2.2 RISK MITIGATION TECHNIQUES

Different potential collateral types imply, before the application of risk mitigation measures, differing degrees of risk for the central bank. For instance, a credit operation is, everything else equal, riskier if the counterparty submits as collateral an illiquid ABS, relative to the case of a government security. In case of counterparty default, it will be more likely that the central bank will realise a loss when liquidating the ABS, relative to the government paper.

The central bank cannot protect itself 100% from risks: some extremely unlikely events may lead to a loss (e.g. in case of sudden simultaneous defaults of both the counterparty and the issuer). While it is not easy to derive, in the framework of a stochastic general equilibrium model, the optimal risk tolerance of the central bank, this should in practice be clearly defined, and then be reached through adequate risk mitigation measures. Since the risk associated with collateralised operations before the application of credit risk mitigation measures depends on the type of collateral used, the risk mitigation measures will need to be differentiated according to the collateral type to ensure compliance with the defined risk tolerance of the central bank.

The following risk mitigation measures are typically used by central banks.

– *Valuation and margin calls:* collateral needs to be *valued* accurately to ensure that the value of the liquidity provided to the counterparty does not exceed the collateral value. As asset prices fluctuate over time, collateral needs to be revalued regularly, and new collateral needs to be called in whenever a certain trigger level is reached. In a world without monitoring and handling costs, collateral valuation could be done on a real-time basis, and the trigger level for margin calls would be zero. In practice, these costs create a trade-off. The Eurosystem, in line with market practice, values collateral daily and has set a trigger level of 0.5%, i.e. when the collateral value, after haircuts (see below), falls below 99.5% of the cash leg, a margin call is triggered.

– *Haircuts:* in case of counterparty default, the collateral needs to be sold. This takes some time and, for less liquid markets, a sale in the shortest possible time may have a negative impact on prices. To ensure that there are no losses at liquidation, a certain percentage of the collateral value needs to be deducted when accepting the collateral. This percentage depends on the price volatility of the relevant asset class and on

Table 1 Eurosystem haircuts for marketable tier one assets

(percentages)

Maturity	Liquidity categories			
	Category I (central government debt, central bank debt)	Category II (local and regional government debt, Jumbo Pfandbriefe, etc.)	Category III (traditional Pfandbriefe, bank debt, corporate debt)	Category IV (ABSs)
0-1 year	0.5	1	1.5	2
1-3 years	1.5	2.5	3	3.5
3-5 years	2.5	3.5	4.5	5.5
5-7 years	3	4.5	5.5	6.5
7-10 years	4	5.5	6.5	8
>10 years	5.5	7.5	9	12

Source: ECB (2005, pp. 46-7).

the prospective liquidation time. The higher the haircuts, the better the protection, but the higher also the collateral needed for a given amount of liquidity. This trade-off needs to be addressed by setting a certain confidence level against losses. The Eurosystem, for instance, sets haircuts to cover 99% of price changes within the assumed orderly liquidation time of the respective asset class. Table 1 summarises the Eurosystem haircuts for marketable tier one assets. Haircuts increase with maturity, because so does the volatility of asset prices. In addition, haircuts increase as liquidity decreases, when moving from category I to category IV, because the estimated time needed for orderly liquidation increases.

– *Limits:* to avoid concentration, a central bank can impose limits on the use of collateral from certain issuers or on the use of certain types of collateral. As the setting-up of a limit framework for collateral and the monitoring of compliance are normally rather costly, it is often preferable to set the other parameters of the framework to avoid the need for limits. This is what the Eurosystem has done.

One issue that has been discussed is whether haircuts should also be set to address different degrees of credit risk, inter alia to avoid that the Eurosystem's collateral framework biases downwards spreads between euro area government issuers of different credit quality. The first author to argue so was Joachim Fels of Morgan Stanley in a Financial Times article dated 1 April 2005:

"In its weekly refinancing operations, the system of European central banks treats the bonds of all member countries as equal when accepting them as collateral. Banks therefore have no incentive to discriminate between the bonds of issuers with different credit ratings, because banks can always ship bonds of lesser credit quality to the ECB to obtain liquidity. Thus, through its own actions, the ECB contributes to fiscal profligacy by preventing markets from fulfilling surveillance and signalling functions. [...] The ECB should consider discriminating between issuers based on countries' credit ratings when accepting collateral at the weekly refinancing operations. For issuers with a lesser credit quality, it could apply a haircut when accepting these bonds as collateral. Thus, banks participating in the refinancing operations would have a new incentive to price relative credit risks more adequately, and it would send a powerful signal to both markets and governments. Together, the markets and the ECB could become powerful allies in the surveillance of eurozone fiscal policies."

Fels' criticism was made before a clarification by the ECB that it has a rating threshold for accepting collateral in its operations[4] and thus may have been based on a lack of information.

4 Such a rating threshold could however be derived from the public list of eligible collateral.

In any case, the practical proposal he puts forward, namely to apply credit-based haircuts, has a basic weakness, i.e. that such haircuts would be rather low, especially for government securities, if derived from risk management calculus, as shown below, and would, instead, be purely discretionary ad hoc measures, if set at higher levels. The latter course of action would inappropriately mix central bank risk management with fiscal policy and would also be inconsistent with a collateral framework based on objective grounds and reasoning. Furthermore, the empirical relevance of Fels' criticism is not so clear, given the indications about the size of the eligibility premium reported in section 3.2. Given that the eligibility premium may be estimated at a few basis points and that additional haircuts would have proportional effects on spreads, even a 10% credit risk haircut (which is well beyond what can be justified from a risk perspective) would imply less than a one basis point effect on spreads, which is, from every point of view, insignificant. While arguing along similar lines, Buiter and Sibert (2005) and Allen (2005) extend the argumentation of Fels with some more modeling and further-reaching proposals. We discuss these arguments in more detail at the end of this section.

On the basis of its methodology for deriving haircuts, the Eurosystem, like a number of other central banks, has opted not to apply haircuts to protect against credit risk while addressing it by setting a minimum credit quality threshold. This choice is supported by the following simple credit Value-at-Risk (VaR) calculus. To ensure consistency, a credit risk haircut would have to be derived in the same manner as liquidity risk haircuts, namely, in the case of the Eurosystem, it would have to be set at the 99% confidence level for the losses arising at the relevant liquidation horizon. For euro area government bonds, this liquidation horizon has, conservatively, been assumed to be one week. It is therefore necessary to look for the 99% confidence level credit loss to be expected at a one-week horizon.

Credit VaR can be calculated in two modes: default mode and transition (or migration) mode.[5] In default mode, only the default of the issuer is considered. Much more frequent, however, are credit losses that result from rating downgrades. Since rating changes are issuer-specific, the associated bond price changes are classified as credit risk (and not as spread risk, which is the risk associated with a general change of spreads, e.g. of A rated corporate bonds relative to AAA rated ones). If risks resulting from rating migrations are included in the calculation of potential credit losses, one speaks of credit risk under migration mode.[6]

5 For a general introduction to these methods, see Basle Committee on Banking Supervision (1999).
6 See S. Ramaswamy (2004).

Table 2 One-year transition probabilities of investment-grade bonds and five-year credit spreads [1)]

(percentages)

	Probability of transition from AAA	Probability of transition from AA	Probability of transition from A	Probability of transition from BBB	5-year spreads
AAA	90.81	0.70	0.09	0.02	-0.07
AA	8.33	90.65	2.27	0.33	0.26
A	0.68	7.79	91.05	5.95	0.80
BBB	0.06	0.64	5.52	86.93	1.13
BB	0.12	0.06	0.74	5.30	3.64
B	0.00	0.14	0.26	1.17	5.04
CCC	0.00	0.02	0.01	0.12	8.89
Default	0.00	0.00	0.06	0.18	

Note: The credit spreads are calculated with respect to the swap curve.
1) The transition matrix (from Standard & Poor's) and the term structure of swap spreads, are provided by CreditMetrics (1997, p. 25).

Credit loss distributions resulting from possible downgrades and default are typically obtained from historical transition matrices and some measure of credit spreads. Such data are contained in Table 2.

Still, two issues arise when calculating a one-week 99% credit VaR. First, we smoothen the credit loss distribution by calculating the variance of the loss distribution and then imposing the normality assumption. Second, migration matrices refer to a one-year horizon, while we have to deal with a one-week liquidation horizon. In line with the CreditMetrics model, we simply divide the one-year transition and default probabilities by 52.[7] It should however be noted that this reflects a conservative approach. To see why, assume a basic structural credit risk model in which the changes of the value of the firm's net assets, x, follow a Brownian motion, and in which default occurs when this net value is zero. Assume that x is $N(x_0,1)$ over the one-year horizon. Assume that the one year PD (or downwards migration probability) would be α. This allows us to determine x_0 from the other assumptions:

$$P(x<0)=\Phi(-x_0)=\alpha \Leftrightarrow x_0=-\Phi^{-1}(\alpha)$$

We are looking for the one week PD φ, knowing that over a one week horizon, the net asset value is $N(x_0,1/52)$, since the asset value follows a Brownian motion. We thus have:

$$\Phi(-x_0\sqrt{52})=\varphi$$

By substituting x_0 from above, we obtain:[8]

$$\varphi=\Phi(\Phi^{-1}(\alpha)\sqrt{52})$$

This is an extremely small number, much smaller than α/52. By simply dividing the one year probability of default by 52, we actually overestimate the one week probability of default, according to the simple model above, by e.g. an incredible factor of 10^{152} for a one basis point one year PD, and still by a factor of 10^{59} for a one percent one year probability of default. There may, of course, be good reasons to argue why this simplistic structural approach is not adequate to scale down probabilities of default at shorter horizons (fat tails in the innovations to asset price, jump-diffusion processes, bundled revelation of new information, etc.), but the argument above in any case highlights the large uncertainties in establishing short-term PDs, and that, with our approach to subdivide simply the one year PD by 52, we clearly are on the conservative side.

The calculation of a credit VaR in default mode requires the probability of default of the issuer and the recovery rate of the asset. The standard deviation to be used in the calculation of the credit VaR under the normality assumption is calculated as the standard deviation of a binomial distribution.[9]

In transition mode, the required inputs are the transition probabilities of the issuer for the different ratings, as shown in Table 2, the price and the modified duration of the bond, a term structure of credit spreads and lastly the recovery rate. The percentage loss or gain PL_{ij} from transition from the initial credit rating $_i$ to the credit rating j can be approximated by the following formula: PL_{ij} = *modified duration* * *(spread$_i$ – spread$_j$)*, *spread$_i$* being the credit spread of the initial rating and *spread$_j$* the credit spread of the new rating. For transition to the default state, the loss corresponds to (1 – R), R being the recovery rate. In this case also, first the standard deviation of the loss distribution is calculated and is then used to calculate a credit VaR under the "normal" assumption.[10]

7 See e.g. CreditMetrics (1997).

8 This is actually a slight simplification as it ignores the possibility that the net asset value gets negative, and triggers default, before the end of the respective horizon, while no linger being negative at the end of the horizon. This can be taken into account rather easily by applying the reflection principle for Brownian Motion (see e.g. Doob, 1953).

9 Let PD be the issuer default probability and R the recovery rate. A credit VaR at 99% confidence level could be calculated as follow: $CreditVaR_{99\%}=2.33\times(1-R)\sqrt{PD(1-PD)}$. See also Ramaswamy (2004).

10 The expected loss is calculated as follows: $Eloss_i=\sum_j PL_{ij}P_{ij}$, P_{ij} being the probability of transition from the initial credit rating ***i*** to the credit rating ***j***. The credit VaR at 99% confidence level corresponds to a scaling of the unexpected loss by a factor of 2.33: $CreditVaR_{99\%}=2.33\sqrt{\sum_j P_{ij}(PL_{ij}-Eloss_i)^2}$

Table 3 One-week 99% credit VaR for different rating levels, for liquidity category I

(percentages)

Rating	Transition-mode credit VaR	Default-mode credit VaR
AAA	0.29	0.00
AA	0.46	0.00
A	0.70	0.40
BBB	1.42	0.69

Using the transition probabilities and the five-year credit spreads from Table 2, and the assumption of a 50% recovery rate in case of default, we obtain the credit VaR figures in Table 3.

Both transition and default mode CreditVaRs increase as the rating deteriorates and, as expected, the transition-mode VaR is consistently larger. Still, even the transition-mode VaR seems to remain, at least down to the single A rating level, so low that the added precision obtained from including credit risk-related haircuts in the framework would not really justify the increased complexity, which would result in the haircut matrix, reported in Table 1, needing a third dimension for ratings. The credit VaR would obviously be larger if the liquidation horizon was longer than one week, the latter being the ECB liquidation horizon assumed for the most liquid assets, such as government bonds. The conclusion reached above therefore needs to be qualified for assets with lower liquidity. The following table displays transition mode CreditVaR figures for five-year bonds for each of the four liquidity categories of the Eurosystem framework (i.e. assuming a one, two, three, and four weeks liquidation time, and correspondingly scaling up linearly the one year probabilities of migration and default). Scaling probabilities of default linearly over time, means (approximately) scaling CreditVaR according to the square root of time.

The last row of Table 4, containing the liquidity risk related haircuts of a 5-7 year maturity fixed coupon bond, is repeated from Table 2 and presented again for comparison purposes.[11] Since both the CreditVaR and the liquidity risk related haircut are scaled up using (approximately) the square root of time, the ratio of the two theoretical haircuts is independent of the liquidity category, and, as it can be seen from the table, the liquidity risk related haircut is more than four times higher than the credit risk related one – for a "single-A" rated instrument. Thus, the conclusion reached above, that it is probably not worthwhile to add one dimension to the haircut matrix, is confirmed for all four liquidity categories.

A final issue worth studying further is the correlation of liquidity and credit risk, and the effect this would have on appropriate haircuts. It is clear that in crisis situations, both interest rate volatility and the likelihood of credit risk materializing will be exceptionally high, and thus there will be more correlation in the tails than under usual circumstances (i.e. a Gaussian copula will not be adequate). As the challenges to model the correlation of credit and interest

11 It should be recalled that for the calculation of CreditVaR, we used a five years modified duration, while the liquidity risk related haircuts reflect a 5-7 year residual maturity, which fits well.

Table 4 99% credit VaR for different rating levels and liquidity classes, for five year fixed coupon bond

(percentages)

Rating	Liquidity category I (1 week liquid. period)	Liquidity category II (2 week liquid. period)	Liquidity category III (3 week liquid. period)	Liquidity category IV (4 week liquid. period)
AAA	0.29	0.41	0.50	0.57
AA	0.46	0.65	0.80	0.92
A	0.70	0.99	1.21	1.39
BBB	1.42	2.01	2.46	2.84
Liquidity haircut	3	4.5	5.5	6.5

rate risk in the tails of distributions are however substantial both in theoretical and empirical terms (the latter due to a scarcity of data), it is concluded that such an analysis would go beyond the present paper.[12]

After this brief analysis, we can discuss in the following in slightly more detail some criticisms of Buiter and Sibert (2005), following Fels (2005), of the Eurosystem collateral policy.

The first, general problem with the line of argumentation of Buiter and Sibert is that they do not derive haircuts from solid risk management calculus. The ECB has explained its approach to risk mitigation in e.g. ECB (2004), namely that haircuts on marketable debt instruments are derived on the basis of a 99% VaR for price changes within the assumed period in which orderly liquidation can take place after a counterparty default.[13] Haircuts should thus depend on the assumed liquidation time and on the volatility of the asset prices. It is obvious that asset price volatility increases with the maturity of the assets. This is why the ECB, like the Fed and the Bank of Japan, has established haircuts that increase with the maturity of the assets. By contrast, Buiter and Sibert's desire to make haircuts dependent on credit risk is not really supported by the analysis above: credit risk haircuts derived on the basis of risk management calculus would be relatively low for the relevant range of eligible assets, in particular for liquid government securities, which are the focus of attention of the two authors.

Unlike the practices of the Eurosystem and other central banks, haircuts in market operations do not systematically depend on maturity. The difference between the central banks' approach and market conventions can be justified on the basis of two specific features of central banks. First, central banks apply the same policy rates to all counterparties. Therefore, a higher residual risk in a repo operation, due to imperfect haircuts, cannot be compensated, as in the case of commercial banks, by a higher interest rate. Second, central banks nearly always deal with a wide range of counterparties, without any possibility to impose credit caps, so there is more of a need to be very precise and systematic in haircut methodology. By contrast, banks have discretion when deciding with whom and for what amounts to deal and can thus manage the higher risks resulting from a simple haircut formula.

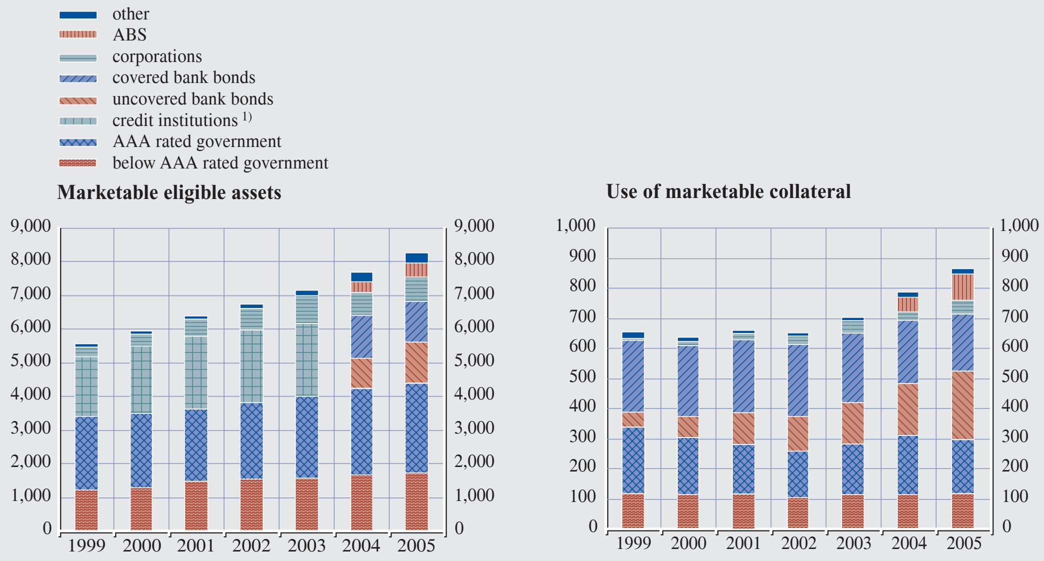
The second objection to Buiter and Siebert is that their criticism tends to disregard the methodology, explained e.g. in ECB (2004), for deriving risk mitigation methods.

The authors tend to focus exclusively on government bonds and ignore the most striking feature of the Eurosystem collateral framework, consisting in the high use of private debt instruments. Figures on the availability and use of collateral were first published by the ECB in its Monthly Bulletin in April 2001 (the article entitled "The collateral framework of the Eurosystem", pp. 49-62). Further information on this subject is provided in ECB (2006a), (2006b). As reported there, in 2005 the total outstanding amount of available collateral was approximately €8.2 trillion[14] (see Chart 1), of which 54% (or €4.4 trillion) was EU Member States' general government debt. Government debt of the four euro area countries which do not have an AAA rating from any of the three international rating agencies (Belgium, Greece, Italy and Portugal) accounted for 21% of total collateral, or 39% of the pool of government debt. Most of the remaining 46% of the total collateral pool consisted of the debt of private-sector issuers: covered and uncovered bank bonds (30%), corporate bonds (8%) and asset-backed securities (5%). Other issuers, such as

12 See Bindseil and Nyholm (2006) for a joint modelling of market and credit risk.
13 The total liquidation time is based on three components: a valuation period, a grace period and a realisation time. The valuation period, which is one day (reflecting daily valuation), and the grace period, which is assumed to be three to four days, are again common to all liquidity categories. By contrast, the realisation time required for an orderly sale of the assets is assumed to grow as liquidity decreases.
14 All figures for available and deposited collateral are annual averages. For 2005, the average is calculated over the first three quarters only.

Chart 1 Eligible and used marketable collateral by issuing sector (see also ECB 2006b)

(EUR billions)



1) Covered and uncovered bank bonds were not distinguished until 2004, and were called "credit institution".

supranational organisations, made up the remaining 4%.

The amount of collateral deposited for possible use in the Eurosystem's credit operations during 2005 was on average €853 billion, approximately 10% of the total amount of eligible collateral. Government bonds accounted for 34% of the collateral used (Chart 1). Using the percentage share of government bonds in the total pool of eligible collateral as a benchmark, government bonds are under-represented by 20 percentage points. The bonds of the four lower-rated governments, which represented 21% of the total pool of available collateral, account for only 13% of the total collateral used and are therefore also under-represented. In contrast, covered and non-covered bank bonds were used more than proportionally, relative to their share in the eligible assets. The more extensive use of bank bonds has nothing to do with lower credit quality, as the large majority of Pfandbriefe, which make up the largest share of bank bonds, are AAA rated.[15] Instead, this higher use is related to the fact that outstanding volumes and liquidity of bank bonds tend to be lower compared with government debt. The same kind of phenomenon appears, albeit in different size, for asset-backed securities. In any case, this underlines that the above-mentioned authors' focus on bonds issued by different governments is too narrow and that the more relevant phenomenon of over-proportional use is between government bonds on one side and bank bonds and asset-backed securities on the other side.

2.3 MONITORING THE COLLATERAL FRAMEWORK

However thorough the work underlying a collateral framework is, the actual use of collateral and the resulting concentration of risks[16] cannot be fully anticipated. The same framework may lead in one country to a much higher level of risk than in another, since the availability of collateral and its distribution may differ. The central bank, therefore, should

15 See e.g. Verband Deutscher Hypothekenbanken (2004, pp. 10-11).

16 E.g. do single counterparties tend to provide collateral with very correlated risks, in the extreme case only from one issuer? Is there a tendency of banks in general to make over-proportional use of certain types of collateral?

Table 5 Bid-ask spreads as an indicator of liquidity for selected assets

Rating	Issuer	Liquidity indicator 1)
AAA	Germany, France, the Netherlands and Spain	0.5 to 1 cent
	Austria, Finland, Ireland	1 cent
	Bavaria, Baden-Württemberg	3 to 5 cents
	Agencies/supranationals and Jumbo Pfandbriefe	3 to 5 cents
AA	Italy and Belgium	0.5 to 1 cent
	Portugal	1 cent
	Pfandbriefe	3 to 5 cents
	Other German Länder	3 to 5 cents
	Slovenia	20 cents
A	Greece	1 cent
	A rated new EU Member States	15 to 20 cents

1) Bid-offer spreads observed on 5-year euro-denominated bonds in Trade Web (when available) in basis points of prices (so-called cents or ticks). Indicative averages for relatively small tickets (less than €10 million). Bid-offer spreads very much depend on the size of the issue and how old it is. The difference in bid-offer spreads between the various issuers tends to increase rapidly with the traded size.

monitor the actual use of collateral, not only on aggregate, but also as much as possible on a bank-by-bank basis, to determine whether an adjustment of the framework may be needed. This remark is supported by the consideration that an appropriate point in the simplicity/precision trade-off must be chosen when building any actual framework. Indeed, to remain simple, transparent and efficient, a collateral framework has to accept a certain degree of approximation. For instance, the Eurosystem has defined, for the purpose of setting haircuts, four liquidity categories and has classified assets in these categories on the basis of institutional criteria, as shown in Table 1 (see ECB (2005), pp. 46-7). Obviously liquidity also differs within these categories as Table 5, which takes bid-ask spreads as an indicator of liquidity, shows.

For instance, while government bonds are normally very liquid, euro-denominated government bonds of new EU Member States are less so. The Eurosystem's classification of all government bonds under the most liquid category may thus be regarded as a considerable simplification. This is a case in which a central bank needs to monitor whether its simplifications lead to a significant deviation of actual risks from the agreed risk tolerance. What matters in this case is that: (i) the average liquidity of each class is correctly estimated; (ii) the heterogeneity within each asset class is not too high; and (iii) the prevailing heterogeneity does not lead to severe distortions and concentration risk.[17]

3 A COST-BENEFIT ANALYSIS OF THE COLLATERAL FRAMEWORK

A central bank should aim at economic efficiency and base its decisions on a comprehensive cost-benefit analysis. In the case of the Eurosystem, this principle is enshrined in Article 2 of the ESCB/ECB Statute, which states that "the ESCB shall act in accordance with the principle of an open market economy with free competition, favouring an efficient allocation of resources".

The cost-benefit analysis can start from the condition, established in Section 2, that risk mitigation measures make the residual risk of each collateral type equal and consistent with the risk tolerance of the central bank. Based on this premise, the basic idea of an economic cost-benefit analysis is that all collateral types can be ranked in terms of the cost of their use.

17 In this context, another mistaken criticism of the Eurosystem by Buiter and Sibert (2005) may be mentioned, which results from the confusion between credit and liquidity risk. Buiter and Sibert question the fact that government paper with different ratings is put into the same, highest liquidity class in the Eurosystem collateral. Correspondingly, they propose putting all triple A government paper in the first liquidity class, double A in the second liquidity class and so on. To see that liquidity risk and credit risk are, conceptually, two different things does not require much explanation: the first refers to the risk that either time or price concessions would be needed to sell, or for that matter to buy, a given asset; the second refers to the possibility that one issuer may default or, less dramatically, that it would be downgraded. Table 5 above shows, in addition, that the two are also different empirically. In fact, there is one A rated issuer (Greece) which is more liquid than some AAA rated issuers (e.g. the state of Bavaria or supranationals), there are some triple A issuers (Austria, Finland and Ireland) that are less liquid than some other triple A issuers (Germany, France, the Netherlands and Spain) and so on, which also confirms that, empirically, credit risk and liquidity risk are different things.

This cost will in turn depend on the five characteristics listed in Sub-section 2.1.

Somewhere on the cost schedule between the least and the most costly collateral types, the costs associated with additional collateral types will be equal to the declining marginal value of one more unit of collateral. Of course, estimating the "supply" and "demand" curves is challenging, and will probably rarely be done in practice. Still, such an approach establishes a logical framework to examine the eligibility decisions. The next sub-section provides an example of such a framework in the context of a simple model.[18]

3.1 A SIMPLE MODEL

The following model simplifies drastically in one dimension, namely by assuming homogeneity of banks, both in terms of needs for central bank refinancing and in terms of holdings of the different asset types. Even with this simplification, the estimation of the model appears difficult. Still, it illustrates certain considerations that might be ignored if eligibility decisions were not dealt with in a comprehensive model. For instance, if a central bank underestimates the handling costs of a specific asset type, and thus overestimates ex ante the use of these assets by counterparties in central bank operations, then it may take a socially sub-optimal decision to make them eligible.

18 Consider briefly the potential implications of the collateral framework for monetary policy. After all, the purpose of collateralised operations is to implement monetary policy, so it is legitimate to ask whether the collateral framework does affect it. Actually, in the "real bills doctrine" and its numerous variants, it was argued that choosing the right type of assets is indeed essential for monetary stability. In its original sense, the real bills doctrine stated that banknotes, which are lent in exchange for "real bills", that is, titles to real value or value in process of creation, cannot be issued in excess (see, for example, Green (1987)). The origin of the real bills doctrine lies in 18th-century England and possibly relates to the fact that usury laws prevented the Bank of England's discount rate from being set above 5%. Therefore, when the appropriate Bank rate should have been higher, the Bank of England tried to limit the gold drain by restricting the set of eligible paper, for example to real bills, claiming that this type of paper had the specific property of representing real commerce. While already in 1802 Henry Thornton convincingly refuted the real bills doctrine, it was influential even until the 1990s. For instance, the Deutsche Bundesbank still required that "the trade bills purchased by the Bundesbank are those drawn between enterprises […] on the basis of deliveries of goods and services" (Deutsche Bundesbank (1995), p. 100). As it is obvious today that monetary policy implementation works via short-term interest rates, controlled through liquidity management, and thus does not depend on the type of collateral posted (or the type of assets purchased), this issue is not further investigated here.

A = {1…n}	Set of all asset types that may potentially be eligible as collateral.
$E \subset A$	Set of eligible assets, as decided by the central bank. Ineligible assets are ($A \backslash E$) (i.e. set A excluding set E).
W_j	Available amount of asset type j in the banking system which can be potentially used as collateral. This is, where relevant, after application of the relevant risk mitigation measures needed to achieve the desired low residual risk.
V_j	Amount of collateral of type j that is actually submitted to the central bank (again, after haircuts); obviously $j \in E$.
D	Refinancing needs of banking system vis-à-vis the central bank ("liquidity needs"). Exogenously given in our model.
K_j	Fixed cost component for central bank to include asset class j for one year in the list of eligible assets.
k_jV_j	Variable cost for central bank of handling collateral type j. The costs include the costs of risk mitigation measures.
c_jV_j	Variable cost for banks of handling collateral type j. Again, this includes all handling and assessment costs. If haircuts are high, obviously costs are increased proportionally. Moreover, this includes opportunity costs: for some collateral, there may be use in the interbank repo market, and the associated value is lost if the collateral is used for central bank refinancing.

When deciding which collateral to make eligible, the central bank has first to take note of the banking system's refinancing needs vis-à-vis the central bank (D) and it should in any case ensure that:

$$\sum_{j \in E} W_j \geq D \qquad (1)$$

Inequality (1) is a precondition for a smooth monetary policy implementation. A failure of monetary policy implementation due to collateral scarcity would generate very high social costs. For the sake of simplicity, we assume that D is exogenous and fixed; in a more general model, it could be a stochastic variable and the constraint above would be transformed into a confidence level constraint. In addition, collateral provides utility as a buffer against interbank intraday and end-of-day liquidity shocks. We assume that one has to "use" the collateral to protect against liquidity shocks, i.e. one has to bear the related fixed and variable costs (one can imagine that the collateral has to be pre-deposited with the central bank). For the sake of simplicity, we also assume that, as long as sufficient collateral is available, liquidity-absorbing shocks do not create costs. If however the bank runs out of collateral, costs arise.

We look at one representative bank, which is taken to represent the entire banking system, thus avoiding aggregation issues. Let $r = -D + \sum_{j \in E} V_j$ be the collateral reserves of the representative bank to address liquidity shocks. Let ε be the liquidity shock with expected value 0 and variance σ^2 and let F be a continuous cumulative density function and f be a symmetric density function. The costs of a liquidity shortage are p per euro. Assume that the bank orders collateral according to variable costs in an optimal way, such that *C(r)* is the continuous, monotonously increasing and convex cost function for pre-depositing collateral for liquidity purposes. The risk-neutral representative bank will chose $r \in [0, \sum_{i \in E} W_i]$ that minimises expected costs G of collateral holdings and liquidity shocks:

$$E(G(r)) = E(C(r) + p\max(-r + \varepsilon, 0)) =$$

$$\left(C(r) + p\int_{r}^{\infty} f_x(x - r)dx \right) \qquad (2)$$

The first-order condition of this problem is (see e.g. Freixas and Rochet (1997), p. 228):

$$\partial C / \partial r - pF(-r) = 0 \qquad (3)$$

The cost function $\partial C / \partial r$ increases in steps as r grows, since the collateral is ordered from the cheapest to the most expensive. The function $pF(-r)$ represents the gain from holding collateral, in terms of avoidance of costs deriving from insufficient liquidity, and is continuously decreasing in r, starting from p/2.

While the first-order condition (3) reflects the optimum from the commercial bank's point of view, it obviously does not reflect the optimum from a social point of view, as it does not include the costs borne by the central bank. If social costs of collateral use are C(r) + K(r), then the first-order condition describing the social optimum is simply:

$$\partial C / \partial r + \partial K / \partial r - pF(-r) = 0 \qquad (4)$$

Consider now a simple numerical example that illustrates the decision-making problem of both the commercial and the central bank and its welfare effects. Note that we assume, in line with the actual central bank practice, that no fees are imposed on the banking system for the posting of collateral. Obviously, fees, like any price, play a key role in ensuring efficiency in the allocation of resources.

In the example, we assume that liquidity shocks are normally distributed and have a standard deviation of €1,000 billion and that the cost of running out of collateral in case of a liquidity shock is five basis points in annualised terms. We also assume that the banking system has either a zero, a €1,500 billion or a €3,000 billion structural refinancing need towards the central bank. The first-order condition for the

Table 6 Example of parameters underlying a cost-benefit analysis of collateral eligibility

Category (j)	Available amount (EUR millions) (W)	Fixed costs for central bank (EUR billions) (V)	Variable costs for central bank (b.p. per year) (k)	Variable costs for banks (b.p. per year) (c)
α (e.g. government securities)	1,000,000	0	0.5	0.5
β (e.g. Pfandbriefe)	1,000,000	5	0.5	0.5
γ	500,000	5	1	1
δ	500,000	5	1	1
ε (e.g. bank loans)	500,000	20	1	2
ζ (e.g. commodities)	500,000	50	10	5

representative bank (3) is illustrated in the following chart. The intersection between the bank's marginal costs and benefits will determine the amount of collateral posted, provided the respective collateral type is eligible.

It can be seen from the chart that if D=0; 1,500 or 3,000, the bank (the banking system) will post €1,280, 2,340 and 3,250 billion as collateral, respectively, moving from less to more costly collateral. In particular, where D=3,000, it will use collateral up to type ε – provided this collateral and all the cheaper ones are eligible.

How does the social optimality condition on eligibility (4) compare with that of the commercial bank (3)? First, the central bank should make assets eligible as collateral to respect constraint (1), e.g. when D=1,500 it needs to make eligible all category α and β assets. Beyond this, it should decide on eligibility on the basis of a social cost-benefit analysis. Considering (unlike the commercial bank that does not internalise the central bank costs) all costs and benefits, the following table provides, for the three cases, the total costs and benefits for society of various eligibility decisions.

Chart 2 Marginal costs and benefits for banks of posting collateral with the central bank

(assuming structural refinancing needs of zero, €1,500 billion and €3,000 billion)

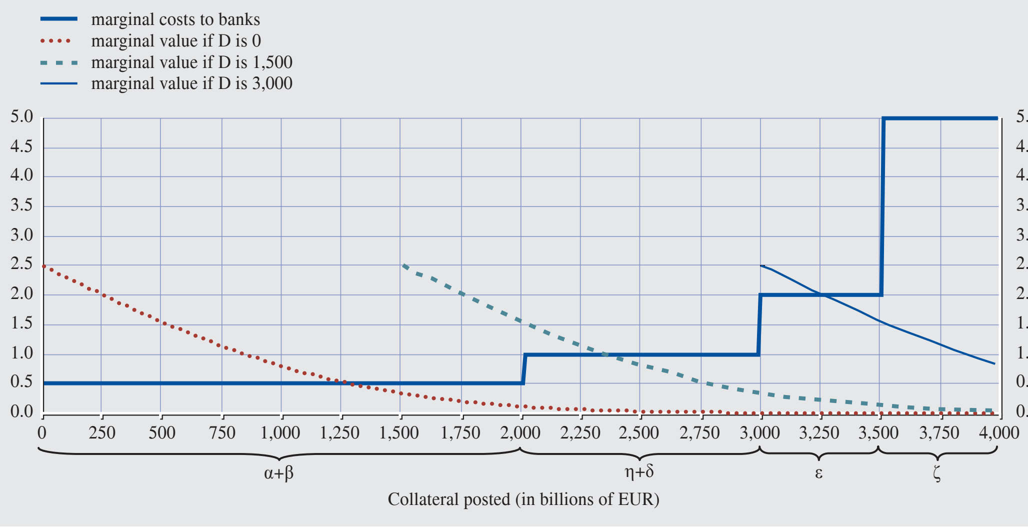


Table 7 Social welfare under different sets of eligible collateral and refinancing needs of the banking system, excluding costs and benefits of the provision of collateral for refinancing needs

(EUR billions)

Eligible assets	D=0	D=1,500	D=3,000
α	30.2	Mon. pol. failure	Mon. pol. failure
α+β	**42.8**	**45.0**	Mon. pol. failure
α+β+γ	37.8	15.2	Mon. pol. failure
α+β+γ+δ	32.8	10.2	**0**
α+β+γ+δ+ε	12.8	-9.8	-40.0
α+β+γ+δ+ε+ζ	-37.2	-59.8	-89.0

The highest figure in each column, highlighted in bold, indicates the socially optimal set of eligible collateral. It is interesting that while in the first scenario (D=0) the social optimum allows the representative bank to post as much collateral as it wishes, taking into account its private benefits and costs, this is not the case in the second and third scenarios (D=1,500 and 3,000 respectively). Here, the social optimum corresponds to a smaller set of collateral than the one that banks would prefer. The result is not surprising since the costs for the central bank enter into the social optimum but are ignored by the representative bank. Of course, the result also depends on the absence of fees, which could make social and private optima coincide.

When interpreting this model, it should be borne in mind that it is simplistic and ignores various effects relevant in practice. Most importantly, the heterogeneity of banks in terms of collateral holdings, refinancing needs and vulnerability to liquidity shocks makes a big difference, also for the welfare analysis. As the marginal utility of collateral should fall not only at the level of the aggregate banking system – but also clearly for individual banks, the heterogeneity of banks implies that the actual total social value of collateral eligibility will be higher than in the model.[19] Another notable simplification is the assumption that the value of the collateral's liquidity service is constant over time. This will actually vary, and peak in the case of a financial crisis. This should be taken into account by the central bank when doing its cost-benefit analysis.

Various effects could be illustrated with other examples. For instance, there could be cases in which the central bank would not order the collateral classes in the same way as banks, because the social costs ranking would not coincide with the private costs ranking.

It is interesting to consider, within the example provided, the effects of eligibility choices on the spreads between different assets. Let us concentrate on the case where refinancing needs are 1,500 and the central bank has chosen the socially optimal set of eligible collateral, which is α+β. The representative bank will use the full amount of available collateral (2,000) and there is a "rent", i.e. marginal value of owning collateral of type α or β of around 1 basis point, equal to the marginal value for this amount minus the marginal cost (the gross marginal value being $pF(r/\sigma) = 1.5$, for p = 5 basis points, r = 2,000 – D = 500 and σ = 1,000). Therefore, assuming that the ineligible asset γ would be equal in every other respect to α and β, it should trade at a yield of 1 basis point above these assets. Now assume that the central bank deviates from the social optimum and also makes γ eligible. The representative bank will increase its use of collateral to its private optimum of 2,340 and the marginal rent disappears, as marginal cost and marginal benefit are equalised for that amount. At the same time, the equilibrium spread between γ and α/β is now only 0.5 basis point, since this is the difference in the cost of using these assets as collateral. What now are the spreads of these three assets relative to asset δ? Before making γ eligible, these were -1, -1 and 0 for α, β and γ, respectively. After making γ eligible, these are -0.5, -0.5 and 0, respectively, i.e. the spread between γ and δ remains zero, and the spread between α/β and δ has narrowed down to the cost difference between the different assets.

19 This is because if the utility of having collateral is for all banks a falling and convex function, then the average utility of collateral across heterogeneous banks is always higher than the utility of the average collateral holdings of banks (a bit like Jensen's inequality for concave utility functions). One could aim at numerically getting some idea of the difference this makes, depending on assumptions that would somehow reflect anecdotal evidence, but this would go beyond the scope of this paper.

The increased "supply of eligibility" from the central bank reduces the "rent" given by the eligibility premium. This shows how careful one has to be when making general statements about a constant eligibility premium.

Within this example, further cases may be examined. If, for D=1,500, in addition to α, β and γ, δ is also made eligible, which represents a further deviation from the social optimum due to the implied fixed costs for society, nothing changes in terms of spreads, and the amount of collateral used does not change either. The same obviously holds when asset classes ε and ξ are added.

In the case D=3,000, the social optimum is, following Table 7, to make assets α, β, γ and δ eligible. Very similar effects to the previous case can be observed. The rent for banks of having collateral of types α and β is now two basis points, and the rent of owning collateral of types γ and δ is, due to the higher costs, 1.5 basis points. Therefore, the spread between the two groups of assets is again 0.5 basis point. The spread between assets of type α or β and the ineligible assets of types ε and ζ is 2 basis points. After making ε eligible, the spreads between ε and all other eligible asset classes do not change (because at the margin, having ε is still without special value). However, due to the increased availability of collateral, the spreads against asset category ζ shrink by 0.5 basis point.

Finally, an alternative interpretation of the model, in which the variable costs of using the assets as collateral also include opportunity cost, is of interest and could be elaborated upon further in future research. Indeed, it could be argued that financial assets can, to a varying extent, be used as collateral in interbank operations, as an alternative to the use in central bank operations. Using assets as central bank collateral thus creates opportunity costs, which are high for e.g. government bonds, and low for less liquid assets, such as ABSs and bank loans, as these are not used as collateral in interbank markets. Therefore, the order in which banks would rank eligible assets according to their overall costs could be different from a ranking based only on handling and credit assessment costs, as implied above. According to this different ranking, for instance, bank loans may be "cheaper" for banks to use than government bonds. While this underlines that the model above is a considerable simplification and should be considered only as a first conceptual step towards a comprehensive theoretical framework, it also shows that the model can be extended to encompass different assumptions.

3.2 EMPIRICAL ESTIMATES OF THE EFFECT OF ELIGIBILITY ON YIELDS

In the previous section, a simple model was described to provide a framework for the decision of the central bank to make different types of asset eligible and to look at the interest rate differential between eligible and ineligible assets, dubbed the "eligibility premium". In this section, we seek empirical indications of the possible size of this premium.

Before proceeding, we would like to highlight that we would not consider the eligibility premium as implying a "distortion" of financial markets, as some commentators have assumed. The central bank is a large and idiosyncratic player[20] in the money market. It is not surprising that a single, large and idiosyncratic player will have an impact on the economic equilibrium in a market, and a priori, this does not imply a distortion relative to some social optimum. The analysis in the previous section, on the contrary, was presenting a normative theory for a central bank's compilation of the list of eligible assets, which by definition aimed at a social optimum, without meaning that there would be no impact on spreads. In the model, a distortion was only occurring in so far as not all social costs of the use of collateral (namely the costs occurring to the central bank) were taken into account, such that banks would slightly overuse collateral.

20 The idiosyncracy arises for instance from the fact that the central bank, as not being threatened by illiquidity, can probably assign a different cost to a lack of liquidity of collateral, as compared to normal market players.

This is, however, an issue on its own, and can in any case be repaired, if really relevant in practice, by imposing a fee. In sum, we would conclude that it is not appropriate to generally identify the effect of eligibility decisions by the central bank as a "distortion".

As argued above, eligibility as central bank collateral should make, everything else being equal, the asset more attractive and thus increase its price and lower its yield.[21] The additional attractiveness results from the fact that the asset can provide a liquidity service, which has a positive value. While the value of liquidity can in principle be modelled easily in the style of the preceding section, it is very difficult to estimate the yield effect of declaring a specific security eligible for central bank operations. There are basically two reasons for this. First, with temporary operations, the price and credit risk of an asset remains with the bank putting it forward. This means that, in a portfolio model, the effect of temporary operations on the price of the involved assets is small. So, we know a priori that we are looking for a small variable, which presents a challenging test for any empirical approach, in particular if the variable in question correlates with other variables with a stronger impact, such as the credit rating. Second, the eligibility premium depends on conditions which change over time. As was seen in the model presented above, the first time-varying condition is the overall scarcity of collateral: if the banking system has a liquidity surplus and the need for collateral for payment system operations is limited, or if there is ample government debt outstanding, then declaring an additional asset eligible will have no measurable effect on prices, as it would anyway not be used to a significant extent. If, by contrast, the need for central bank collateral is high, and the amounts of eligible collateral are limited, then the price effects of declaring one asset type eligible will be substantial. Similarly, the relative amount of the collateral assets newly made eligible also matters, as it also changes the overall availability of collateral and therefore its value. Thus, the price of the eligible asset A should be affected more strongly by the decision to make asset B eligible, if asset B is in abundant supply. Moreover, the eligibility premium will change in case of financial tensions, shifting the demand curve for collateral to the right.

Of course, also the price elasticity of demand of those investors who are *not* interested in the collateral feature of the asset is also relevant. If this elasticity is high then, ceteris paribus, the price effect of eligibility decisions should be more limited and vice versa. Similarly, as argued below, the elasticity of supply of securities also matters.

In the following, three different approaches to quantifying the eligibility premium are presented.

(1) MEASURING THE EFFECT ON SPREADS OF A CHANGE IN ELIGIBILITY

For the reasons mentioned above, an ideal opportunity to measure the effects of eligibility on spreads arises when a small asset category is added to a large eligible set. Such a case occurred recently in the Eurosystem when, on 1 July 2005, selected euro-denominated securities from American, Canadian, Japanese issuers (non-European Economic Area, non-EEA, issuers) were added to the list of eligible assets (see the ECB press releases of 21 February 2005 and 30 May 2005). This change should have lowered the spreads of these instruments relative to comparable assets that were already eligible. Therefore, yields of the newly eligible assets issued by the non-EEA issuers mentioned above are here compared with yields of a sample of assets of EEA issuers which had been eligible for a long time.

The set of non-EEA bonds was taken from the ECB's Eligible Assets Database on 5 October 2005. The sample of EEA bonds used for benchmarking was selected by taking all the corporate and credit bonds issued by EEA

21 This effect should only be relevant if the asset will effectively be used as collateral under the chosen risk control measures and handling solutions. If, for instance, the handling solution is extremely inconvenient, or if the haircuts applied to the asset are extremely high, eligibility may not lead to practical use of the asset as collateral and would therefore be hardly relevant.

Table 8 Information on the set of bonds used for the analysis

Rating	Number of EEA bonds	Number of non-EEA bonds	Number of EEA issuers	Number of non-EEA issuers
AAA	220	18	43	5
AA	348	27	63	8
A	624	50	171	14
TOTAL	1192	95	277	27

Source: ECB Eligible Assets Database.

entities. Bonds issued during 2005 were removed as well as bonds having a residual maturity of less than a year since bonds near maturity tend to have a volatile option-adjusted spread. A number of bonds with extreme spread volatility were also removed. Finally, the EEA sample was adjusted to match the relative rating distribution of the non-EEA bonds. The rating classes are Bloomberg composites, i.e. averages or lowest ratings.[22] Tables 8 and 9 show information on the sample of bonds that were used in the analysis.

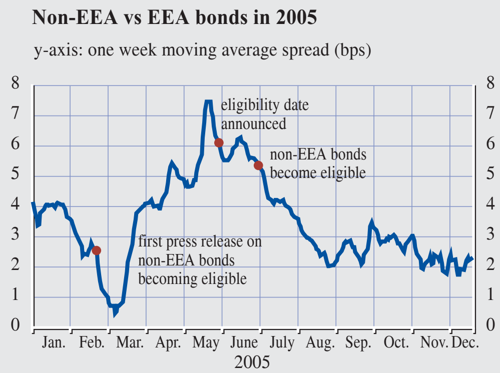
Chart 3 shows a plot of average daily yield spreads in 2005 between non-EEA and EEA issuers. The spread is calculated by comparing average option-adjusted bid spreads between bonds from non-EEA and EEA issuers. The use of option-adjusted spreads makes bonds with different maturities and optionalities comparable. The resulting yield differential is quite volatile, ranging between 0.5 and 7.5 basis points during the year. The upcoming eligibility of bonds from non-EEA issuers was originally announced on 21 February, but the eligibility date was not yet published at that stage. The eligibility date of 1 July was announced in a

Table 9 Country distribution of bonds from non-EEA issuers

Issuer residence	Number of bonds
Canada	3
Japan	5
USA	87

Source: ECB Eligible Assets Database.

Chart 3 One-week moving average spread between non-EEA and EEA issuers in 2005



Sources: ECB Eligible Assets Database and Bloomberg.
Note: The spread is calculated by comparing average option-adjusted bid spreads between bonds from non-EEA and EEA issuers (see Table 8). The option-adjusted spread for each security is downloaded from Bloomberg.

second press release on 30 May. Following each of these dates the spread seems to be decreasing, but, in fact, it had already been doing so prior to the announcements. Therefore, it is difficult to assign the effects to Eurosystem eligibility. Overall, the level of spreads does not seem to have changed materially from before the original eligibility announcement to the last quarter of the year. To identify the possible source of the changes, one may note from Table 9 that most of the non-EEA bonds are in fact issued by US-based companies, which suggests that the main driving forces behind the evolution of the spread are country specific factors. Especially the

22 The Bloomberg composite rating (COMP) is a blend of Moody's and S&P ratings. If Moody's and S&P ratings are split by one step, the COMP is equivalent to the lower rating. If Moody's and S&P ratings are split by more than one step, the COMP is equivalent to the middle rating.

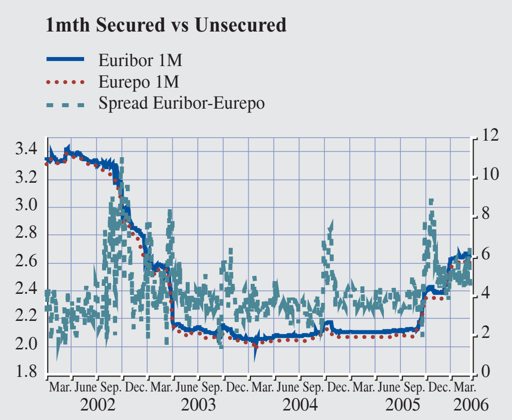
major credit events during the second quarter of the year, such as problems in the US auto industry, can be assumed to have caused the widening of the spread during that period. It may therefore be concluded that one cannot find any evidence of an eligibility premium attributed to non-EEA bonds by the decision of the Eurosystem to accept them as collateral.

(2) SPREAD BETWEEN COLLATERALISED AND UNCOLLATERALISED INTERBANK REPO OPERATIONS

Another possible indicator for the eligibility premium is the spread between interbank uncollateralised deposits and repo operations, which is normally in the range of 3 to 5 basis points for the relevant maturity (see Chart 4). It can be argued that a bank can save the spread between unsecured and secured borrowing if it has eligible collateral. Thus, the spread between the two kinds of borrowing corresponds to the value of having collateral eligible for interbank operations. Of course, this reasoning directly holds only for the large majority of banks (in the AA and A rating range), which can indeed refinance at close to EURIBOR rates. For the few worse-rated banks, the eligibility premium will be higher. Also, this measurement only holds in normal times: in case of liquidity stress, the spreads should widen. This is indeed what seemed to have happened in 2002, as Chart 4 suggests. This was the period in which, in particular, the German banking system was considered to be under stress, including rumors of liquidity problems of individual banks, which led to a sort of flight into collateralized operations and the spread surpassed 10 basis points at the end of 2002 (the spreads have also widened more recently in relation to upcoming expectations of interest rate increases by the ECB). A further caveat is that the set of eligible assets for standard interbank repos ("General Collateral"[23]) is a sub-set of the one eligible for central bank operations, and central bank and interbank repos have some other differences impairing the comparison between the two.

Chart 4 Spread between the one-month EURIBOR and one-month EUREPO rates since the introduction of the EUREPO in March 2002

(rate, percentages, left-hand scale; spread, bps, right-hand scale)



Source: EUREPO (http://www.eurepo.org/download/Eurepo_Chart_July05.pdf).

(3) SECURITISATION TO HAVE MORE CENTRAL BANK COLLATERAL

Finally, according to anecdotal evidence from the euro area, a few banks have securitised assets with the sole purpose of making them eligible as central bank collateral. Current estimates are that such securitisation would have cost them around 3 basis points (per annum). The fact that this phenomenon has been observed only rarely, but that more banks have assets suitable for similar securitisation, suggests that other banks are not willing to pay the 3 basis points for obtaining eligible assets. Again, this indication of the eligibility premium is subject to some caveats, as not all banks may hold sufficient assets suitable for securitisation and since the cost of securitisation may be higher for some banks.

The three estimates above consistently indicate that the eligibility premium deriving from being eligible as collateral for Eurosystem operations is, as a maximum, in the order of magnitude of a few basis points only. However, again, the following caveats to these estimates should be highlighted:

23 "General Collateral" according to the EUREPO definition is any euro area government debt (see http://www.eurepo.org/eurepo/eurepogc.html).

- In times of financial tensions, the eligibility premium will be much higher. One may view ample collateral availability as an insurance against the consequences of financial instability.

- For lower-rated banks (e.g. banks with a BBB rating), the value of the eligibility feature is likely to be systematically higher.

- The low eligibility premium in the euro area is also the result of the ample availability of collateral. If availability were to decrease or demand increase, the premium would increase as well.

3.3 EFFECTS ON ISSUANCE

The preceding analysis has maintained as simplifying assumption that the amounts of securities of different types are given. However, issuance activity should react to yield effects of eligibility decisions. First, there may be a substitution effect and debtors will seek to fund themselves in the cheapest way; thus, eligible instruments substitute, over time, ineligible instruments. Second, agents may decide to issue, in the aggregate, more debt since the lower the financing costs, the greater the willingness to issue debt should be. While the substitution effect could, at least in theory, be significant even for an eligibility premium of only a few basis points, the second effect would require more substantial changes in yields to be relevant. Here, it suffices to note that the assumption (maintained so far) of a zero elasticity of issuance to yield changes caused by eligibility decisions biases any estimate of the eligibility premium to the upside, particularly in the long term. In the extreme case of infinite elasticity the only consequence of a changing eligibility premium would be on the amounts issued, not on yields.

3.4 COLLATERAL FOR CENTRAL BANK OPERATIONS AND FOR INTERBANK REPO MARKETS

A last remark can shed light on the specific eligibility premium that derives from the fact that some assets are only eligible for central bank operations and not for operations in the private repo markets. For this purpose, it is interesting to jointly consider, on the one hand, the difference between the collateral accepted in the euro area for standard interbank operations (so-called General Collateral, or GC) and that eligible for Eurosystem operations and, on the other hand, the relationship between the rates of interest prevailing on the Eurosystem and on the GC market operations.

As regards the first point, while GC essentially includes all central government bonds of the euro area, and partially Jumbo Pfandbriefe (e.g. for Eurex repos), Eurosystem collateral is, as seen above, much wider, including many other fixed income private instruments and some non-marketable claims. In four countries, bank loans to corporations are also eligible and these will become eligible in the entire euro area starting in 2007.

With regard to the relationship between the interest rates prevailing on the two types of operations, the striking fact is that they are so close, both in level and in behaviour.

In particular for short-term Eurosystem main refinancing operations (MROs), Bindseil et al. (2004) calculate, for the one-year period starting in June 2000, the average spread between weighted average rates on these operations and, inter alia, repo rates. They note (on page 14) that the former are, on average, marginally lower (0.487 basis point) than the latter. This is surprising since, as stated earlier, the set of collateral eligible for interbank operations is smaller than the one for central bank operations. The result of a very close relationship between the two types of rates is confirmed by more recent observations, as illustrated by the following chart comparing the one week

Chart 5 Spread between the one week EUREPO rate and the weighted average MRO rate

(i.e. EUREPO minus MRO tender rate, in basis points)

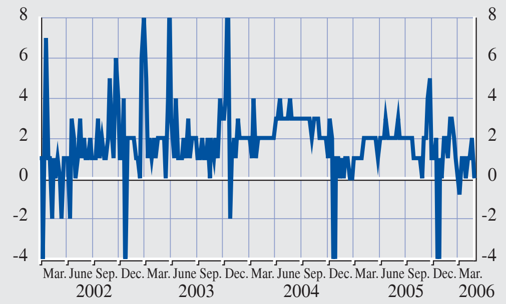


Chart 6 Spread between the three-month LTRO and the three months EUREPO rate

(weighted average LTRO rate minus 3 months EUREPO rate, in basis points)

EUREPO rate with the weighted average MRO tender rate. EUREPO rates tend to exceed MRO rates by mostly one or two basis points, also reflecting that EUREPO rates are offered rates, with a typical spread in the repo market of around 1-3 basis points.

One can interpret this result as meaning that the relevance of "collateral arbitrage", i.e. using for central bank operations the assets not eligible for interbank operations, is relatively limited, otherwise competitive pressure should induce banks to offer higher rates to get liquidity from the Eurosystem rather than in the GC market. However, it should also be recalled, as noted above, that there is a tendency to use over-proportionally less liquid, but highly rated, private paper, such as bank bonds and ABSs, in the Eurosystem operations. Furthermore, Bindseil et al. (2004) have argued that the specific characteristics of Eurosystem MROs lead to "bid shading", i.e. to lower bid rates relative to the case of certainty about allotment results, and thus that the impact on rates from differences in the collateral sets may actually be relevant, but neutralised by an independent opposite effect.

Interestingly, the relationship between the rates prevailing in the Eurosystem's three-month longer-term refinancing operations (LTROs), which have been studied by Linzert et al. (2004), and those determined in three months private repo operations, such as reflected in EUREPO, is rather different from that prevailing for MROs. On average, the weighted average rate of LTROs was 3 basis points above the corresponding EUREPO rate in the period from March 2002 to October 2004 (see Chart 6), with some notably higher values. If bid shading is weaker in LTROs, it could be concluded that this spread, which is small but not insignificant, is a better measure of the effect deriving from the difference between the two sets of collateral.[24]

Whatever conclusion is reached about this complex issue, there may be good reasons why a central bank should accept a wider range of collateral than private market participants:

– Central bank collateral serves monetary policy implementation and payment systems, the smooth functioning of which is socially valuable. While in the interbank market uncollateralised operations are always an alternative, central banks need, for the reasons spelled out in the introduction, to stick to collateralisation. A scarcity of collateral, even if temporary, could have very negative consequences and needs to be avoided, even at the price of having "too much" collateral in normal times.

– As a consequence of the size of central bank operations, it may be efficient to set up

24 See also Ewerhart et al. (2005) for an analysis of the relevance of collateral for bidding behaviour in central bank operations.

specific handling, credit assessment or risk mitigation structures which would be more difficult to set up in the context of interbank operations.

– Finally, there is no guarantee that the market establishes efficient collateralisation conventions, since the establishment of these conventions involves network externalities (see e.g. Katz and Shapiro (1985) for a general presentation of network externality issues). Thus, the central bank, as a large public player, could positively influence market conventions. For instance, trade bills became the dominant financial instrument in the interbank market in the 18th, 19th and early 20th century in the United Kingdom and parts of Europe (see e.g. King (1936), Reichsbank (1910)) because central banks accepted them for discounting.

4 CONCLUSIONS

This paper has presented a simplified, logical framework for establishing a central bank collateral system and provided some applications relating to the case of the Eurosystem. A collateral framework should ensure that the risk taken in refinancing operations is in line with a central bank's risk tolerance. This implies that if the central bank accepts different types of collateral, it should apply differentiated risk mitigation measures to ensure that the risk remaining after the application of these measures complies with its risk tolerance, whatever asset from the list of eligible collateral is used. Once the necessary risk mitigation measures have been defined for each type of asset, the central bank can rank the asset categories according to their cost and then set a cut-off point in accordance with the demand for collateral.

The paper stresses, however, that the collateral framework needs to strike a balance between precision and simplicity and that therefore any existing framework is to be seen as an approximation to a theoretically optimal design. Therefore, its actual features have to be periodically reviewed and, if necessary, modified, in the light of experience (i.e. in particular in the light of the actual use of the different types of collateral) and resulting concentration risks. Another fundamental component of this review and adaptation process are the criticisms and suggestions from analysts and market participants.

If the collateral framework and associated risk mitigation measures follow the above-outlined methodology, one should not speak of its possible *distortion* effect on asset prices. There may well be an impact, but not a distortion, given that the central bank has properly optimised its collateral framework. Still, it is interesting to assess the effects of the collateral framework on the prices of eligible assets, in particular to get an idea of the size of the "eligibility premium", i.e. of the spreads, ceteris paribus, between eligible and ineligible assets. While the eligibility premium is likely to change over time, in the case of the euro area the broad range and large amount of eligible collateral are likely to limit it. Some empirical measures, the limitations of which need to be stressed, consistently indicate an average level of the eligibility premium of only a few basis points. However, this premium will of course be different for different assets and possibly also for different counterparties. In addition, it could rise with an increase in the demand for collateral, particularly if there were to be a financial crisis, or if the supply of available collateral were to shrink.

Overall, the criticism that the collateral framework of the Eurosystem biases downwards the yield differentials between securities issued by governments with different ratings finds very little support in the analysis carried out in this paper.

ANNEX
SEGREGATION OF CENTRAL BANK OPERATIONS ACCORDING TO COLLATERAL TYPE VERSUS POOLING

One decision that arises, both for central banks and interbank markets, is whether to segregate operations according to the type of collateral or to pool different types of collateral.[25] Both approaches are applied by central banks. The classical Lombard lending by central banks in the late 19th century allowed for the pooling of the most diverse sorts of collateral (see e.g. Reichsbank (1910)). Today, the Eurosystem and the Bank of England have adopted a pooling approach for their temporary operations. The Fed, by contrast, segregates its open market operations, but allows for pooling in its (quantitatively far less relevant) primary facility. Also the Bank of Japan segregates to some extent its open market operations, while the Banque de France did so prior to 1999.

In the case of segregation, there is an obvious need to ensure consistency between the tender results obtained in operations with different types of collateral. Alternative approaches to this issue can be conceived, depending on which tender procedure is applied. If the temporary operations are conducted as *fixed rate tenders*, the central bank first has to decide whether to set the same tender rate for the different tranches. Alternatively, it could set a market-derived spread, if relevant and observable. It also has to decide how to split up its intended tender amount, and what to pre-announce. It could, for instance, pre-announce that it would allocate 70% to a government security repo tender and 30% to a corporate bond/ABS repo tender. The split could be based on market capitalisation or on a view of credit risks. Alternatively, the central bank could announce that the split would be proportional to the respective bids.

If the temporary operations are conducted as *variable rate tenders*, again various options exist. First, the central bank could, before receiving the bids, announce the overall allotment amount and its split. Then, the marginal rates, possibly different on the different tranches, will result from bidding which is transparent and market-oriented. However, obviously the resulting spread would also depend on the split of allotment amounts and the spreads therefore cannot be seen as a pure market outcome. As a practical example, in its segregated operations, the Fed aims to achieve a level of spreads on the different auctions which is consistent with that prevailing on the private repo market. Alternatively, and less desirably, the central bank may maintain full discretion and decide the allotment on the basis of various considerations after receiving the bids.

How can the central bank decide between a pooling and a segregated approach? Focusing on risk management and efficiency considerations, a pooling system has the general advantage of simplicity and efficiency, both for the central bank and for its counterparties. The segregated approach, instead, has the advantage of reducing the possible impact of central bank operations on spreads (“market neutrality”). In principle, segregation also allows better control of the amounts of the different collateral types received (quantity effect) and the achievement of rates on the temporary operations which are more in line with those prevailing in private repo operations (price effect). By segregating the operations and by setting an appropriate split between the tranches,[26] concentration risk resulting from disproportionate use of some asset category can be addressed directly, as well as the risk of generating interest rates out of line with market rates. The relevance of this argument obviously depends on whether indeed undesired concentration would arise without tranching. This can be seen in practice when monitoring the collateral framework, in particular whether banks use in a disproportionate

25 An example of a pooling solution in the interbank market is the Xemac service offered by Clearstream.

26 Alternatively, this could also be achieved in fixed rate tenders with tranches whose relative size is driven by the relative size of bids, but with a pre-announced spread that makes the tranche with the collateral for which the central bank fears concentration risk relatively unattractive.

way some assets. While some disproportionate use will always occur, the question is whether this justifies additional complexity to address it.

If, contrary to what was assumed in this paper, risk mitigation measures cannot equalize the residual risk of different collateral types, then a higher interest rate could be an appropriate compensation for operations secured by more risky collateral, which would argue in favor of segregation. However, such a view may blur the fundamental distinction between monetary policy implementation, which is not profit-oriented, and investment operations, which are.

In conclusion, the issue of pooling versus tranching is a difficult one, which certainly deserves further research.[27]

27 The Federal Reserve System (2002, pp. 3-37) also addresses this issue: "An additional option would be to conduct separate auctions for different pools (or tranches) of collateral. For example, the Federal Reserve could restrict eligible collateral in one subset of an auction to the more-liquid or more-marketable types of collateral eligible for discount window borrowing and hold a separate auction for less-liquid or non-marketable types of eligible collateral. Indeed, tranches for each auction could be delineated even more finely for various categories of collateral, yielding a large number of separate sub-auctions within the auction framework. Holding separate auctions for different tranches of collateral could increase the Federal Reserve's operational costs of implementing the auction credit facility. And holding auctions for narrower collateral pools might increase the likelihood that supply constraints for collateral would restrict the feasible size of any auction. There is also some risk that auctions based on narrow categories of collateral could be misinterpreted as a form of credit allocation. In the absence of separate auctions based on different tranches of collateral, banks would probably submit their less-liquid and less-marketable assets as collateral to the Federal Reserve. As long as banks have an abundance of collateral that could be used to secure advances from the auction credit facility, however, they would probably post as collateral those less-liquid or less-marketable assets that are operationally easiest for them to deliver. If they are not set appropriately, the differential haircuts the Federal Reserve applies to different types of assets might influence the types of collateral pledged."

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